NYUGAT-MAGYARORSZÁGI EGYETEM, ERDŐMÉRNÖKI KAR, VADGAZDÁLKODÁSI INTÉZET,
MAGYAR FOGOLY KUTATÓ CSOPORT
UNIVERSITY OF WEST HUNGARY, FACULTY OF FORESTRY,
INSTITUTE OF WILDLIFE MANAGEMENT, HUNGARIAN PARTRIDGE RESEARCH GROUP

PERDIX VIII

Proceedings of an International Symposium on Partridges, Quails and Pheasants in the Western Palearctic and Nearctic held in Sopron, Hungary 26th - 29th October 1998

Magyar Apróvad Közlemények

Hungarian Small Game Bulletin

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Borítóterv
SHMILLIÁR DÓRA

A belső címlapkép, amely a PERDIX VIII. Szimpózium emblémája volt
MURAY RÓBERT festőművész alkotása

A szimpóziumon előadásokon és posztereken bemutatott madárfajok szövegközi képei
KÓKAY SZABOLCS alkotásai

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PREFACE

Prof. Dr. Zs. Kovács
Vice-Rector
UNIVERSITY OF SOPRON

PERDIX VIII, the **EIGHTH INTERNATIONAL SYMPOSIUM ON PARTRIDGES, QUAILS AND PHEASANTS** chose SOPRON as its venue in 1998. On behalf of the host institution, the UNIVERSITY OF SOPRON, let me wish a hearty welcome to all the distinguished participants from the different countries of Europe and overseas.

I would like to take the privilege to shortly introduce to you our University, its history, present, and plans for future. As many of you may know, our history goes back to 1735, when the MINING OFFICER'S SCHOOL of the HABSBURG empire was established in the town of SELMECBÁNYA, today belonging to Slovakia. The school, known from 1770 as the Imperial and ROYAL MINING ACADEMY, integrated in its curriculum the important parts of silviculture, land survey and timber conversion, besides the elements of mining and metallurgy. In 1807 the INSTITUTE OF FORESTRY was established within the Academy, starting soon an independent forestry education. The MINING AND FORESTRY ACADEMY and was moved to SOPRON after World War I, when two-thirds of the country, including SELMECBÁNYA was annexed to other countries. The COLLEGE OF MINING AND FORESTRY OF SOPRON, making part of the UNIVERSITY OF TECHNOLOGY AND ECONOMICS OF BUDAPEST between 1934 and 1949, and independent thereafter, had to give up its FACULTIES OF MINING AND METALLURGY in the 50's for political reasons. After the failure of the 1956 Revolution, a large percentage of our university teachers and students emigrated. Many moved to Vancouver, B. C., Canada, where they established the HUNGARIAN DIVISION OF FORESTRY FACULTY. In 1962 the UNIVERSITY OF FORESTRY AND WOOD SCIENCES was established in Sopron, with FACULTIES OF FORESTRY and WOOD TECHNOLOGY. After 1972 the FACULTY OF SURVEYING AND LAND MANAGEMENT was added. In 1996 the name was changed to the "UNIVERSITY OF SOPRON". This was the result of a number of new degree programmes that have been added recently: environmental engineering, industrial design, economics among others. More importantly for us, the INSTITUTE OF WILDLIFE MANAGEMENT was established in 1994 and the degree programme of wildlife management started. This institute is also a workshop of wildlife-related research and is hosting the HUNGARIAN PARTRIDGE RESEARCH GROUP and the HUNGARIAN WATERFOWL RESEARCH GROUP.

Dear Guests! Let me wish all of you, on behalf of the UNIVERSITY OF SOPRON, a successful symposium, discussions and study excursions, and enjoy the pleasant environment that the town and its surroundings offer.

GREETING OF THE ORGANIZER

Prof. Dr. S. Faragó
Dean, Faculty of Forestry
UNIVERSITY OF SOPRON

Dear Sirs and Mesdams, Dear Participitans of Our Symposium

It is a great pleasure for me to greet you here in Sopron, one of Hungary's most beautiful cities. Three years have passed since the time when we decided in Dourdon (France) to arrange the Symposium PERDIX VIII in Hungary. After the long period of preparations, here we are assembled again.

Will you please allow me to express my respectful greetings to the participants of our Symposium seated in the presidium:

- Prof. Zsolt **KOVÁCS**, vice-rector of the SOPRON UNIVERSITY
- Mr. István **PINTÉR**, head of the DEPARTMENT OF GAME MANAGEMENT AND FISHERY IN THE MINISTRY OF AGRICULTURE AND COUNTRYSIDE DEVELOPMENT,
- Dr. Richard **POTTS**, director-general of the GAME CONSERVANCY TRUST,
- Dr. John **CARROLL**, leader of the IUCN PARTRIDGE, QUAIL AND FRANCOLIN SPECIALIST GROUP,
- Dr. Christos **THOMAIDES**, president of the IUGB.

It is a pleasure for us that the afore-mentioned illustrious personalities have accepted our invitation and grace our Symposium with their presence.

The history of Perdix Symposium began in the United States as the first five meetings of this kind were organized there, devoted exclusively to grey partridge. The term "Hungarian partridge" applied in the U.S.A. for identifying the species mentioned afore is welcome to us, -it seems to be quite unnecessary to explain why. In order to discuss the situation, biology and management of this species, experts assembled at the following places and dates:

1977: Minot (north Dakota)
1980: Moscow (Idaho)
1983: Cambellsport (Wisconsin)
1987: Regina (Saskatchevan)
1989: Manketo (Minesota)

PERDIX VI was organized in Fordingbridge in 1991, its host being the GAME CONSERVANCY TRUST. In addition to partridges, also quails and francolins were dealt with.

PERDIX VII took place in Dourdan (France), organized by the OFFICE NATIONAL DE LA CHASSE. Topics were focussed on partridges, quails and pheasants of the Western Palearctic and the Nearctic. It was at the latter meeting that we undertook organizing PERDIX VIII in Sopron (Hungary).

Now the organizer of PERDIX VI: Dr. Richard POTTS is sitting here at our meeting. Having been present at each of the meetings, he symbolizes continuity in the history of Perdix Symposium as well as in research work on partridge. Dick, we request you to expound a few ideas before PERDIX VIII is started.

Dr. POTTS: "PERDIX VIII is in many ways an important bench mark in our understanding of the bird that is still known in many parts of the world as the Hungarian partridge.

The first International Conference on the grey partridge was held in Prague in October 1965. Since that time there has been a series of similar meetings in seven countries, including the seven PERDIX Symposia. This, therefore, is the twelfth such meeting.

At long last, we are meeting in Hungary which has such a rich tradition of success in grey partridge conservation, and a series of unique studies extending over a century, as will become clear.

Since 1965 and that first meeting in Prague, as we all know only too well, the grey partridge has become but a shadow of its former self. In country after country, but not all, numbers have fallen by 80-90% with the ultimate reason being the intensification of agriculture, especially cereal growing. Thousands of other species have been similarly affected, especially insects. Now, however, as first emerged at this conference, there is evidence from France and from the LAJTA Project that adult mortality has increased. Pesticides can be ruled out as the cause, but predators, including raptors, cannot be ruled out. As becomes clear in this volume, there appears to be a twist in the tale."

At the Symposium PERDIX VI (Fordingbridge, 1991) the "PARTRIDGE, QUAIL AND FRANCOLIN SPECIALIST GROUP" was established under the auspices of the SPECIES SURVIVAL COMMISSION OF THE INTERNATIONAL UNION FOR THE CONSERVATION OF NATURE AND

NATURAL RESOURCES (IUCN). I request Dr. John **CARROLL**, leader of the afore-mentioned organization to greet the Symposium on his own behalf as well as on that of the IUCN SPECIES SURVIVAL COMMISSION.

Dr. CARROLL: „The PERDIX series of conferences is a unique ad hoc conglomeration of biologists and conservationists with a passion for a group of birds that transcends political and geographical boundaries. Over the last 12 years, I have been fortunate to have been involved in this conference series since Perdix IV, held in Canada. Although the PERDIX conferences have traditionally focused on management of species that are hunted, conservation has always been the cornerstone theme. It was PERDIX VI held during 1991 in England where the seeds of a Specialist Group dedicated to the partridges and quails were planted. That translated over the next few years into the establishment of the Specialist Group within the SPECIES SURVIVAL COMMISSION, as well as BIRDLIFE INTERNATIONAL and the WORLD PHEASANT ASSOCIATION. In 1995, the group developed the first worldwide action plan devoted to the conservation of the partridges, quails, and francolins. That document has helped to lead the way towards a better understanding of conservation needs and direction for the past 5 years. In 2000, a second action plan is being published. We hope that this document will move us even more rapidly towards our goals of proper understanding and management of our species of concern. Among the groups of species which have the interest of conservationists, the gamebirds are unique in that they include a large number of well studied and common species as well as many threatened and virtually unstudied species. This puts those of us interested in both groups in the unique positions of being able to use the understanding and techniques that we have developed on the common species to better understand threats to the conservation of the many species of which we have little data.

Any biologist with an interest in the conservation of these species is welcome to become a part of the "PARTRIDGE, QUAIL AND FRANCOLIN SPECIALIST GROUP". Our large and rather eclectic group of species suggests to me that a large and rather eclectic group of biologists is needed to provide the knowledge and work necessary to ensure that we do not lose any of these species. It is this group that will show the way to sustainable management of all of the partridges, quails, francolins, guineafowl, snowcocks and turkeys."

Last but not least, on behalf of Hungary as the host of our meeting I request Mr. István PINTÉR, head of the DEPARTMENT OF GAME MANAGEMENT AND FISHERY in the MINISTRY OF AGRICULTURE AND COUNTRYSIDE DEVELOPMENT to present his lecture on game management in Hungary (see in this book).

Dear Sirs and Mesdames,

Surely you have alredy skimmed our Program and seen that representatives of the following countries are participating at the Symposium: Austria, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Poland, Spain, Switzerland, United Kingdom and the U.S.A.

Number of participants amounts to 45 (22 from abroad and 23 from Hungary). 24 lectures will be delivered and 24 posters presented, concentrated primarily on *Perdix perdix* and *Phasianus colchicus*. We consider it a pity that marely few lectures and posters are going to deal with other partridge species and with quail, respectively.

Participants who have brought their manuscripts according to instructions included in the Final Announcement, are requested to hand them over at the registration desk. Those who have not brought their manuscripts are asked to post them as soon as ever possible after returning home.

After the copious instructions presented above, I wish all of our participants to enjoy a useful conference, several substantial talks on professional questions, fine weather on the day of our excursion, and on the whole: a pleasant time in Hungary. Now let us start our effective work!

FAREWELL-SPEECH OF THE ORGANISER

Prof. Dr. S. Faragó
Dean, Faculty of Forestry
UNIVERSITY OF SOPRON

Dear Sirs and Mesdames,

According to our hopes, now we are going to close the Symposium PERDIX VIII after three and a half days of interesting and successful work. Lectures delivered at our meeting have revealed the spectrum characteristic for research on partridge and pheasant, from genetics to population ecology and practical management. Of courese, the investigations mentioned afore complete and strengthen each other and may lead research work to new untrodden paths.

Organizers of all kinds of symposiums are lucky because experts of the respective scope of science call on them, and on the basis of connexions established at the meeting, new conceptions for investigations to be carried out at home or perhaps in cooperation with foreign scientist are developed. At best, - if the organizer is lucky and persevering - conceptions of this kind will be realized.

Such advantageous occasions were provided by the XX. IUGB Congress in Gödöllő (Hungary) in the year 1991. There I became personally acquainted with the co-workers of

THE GAME CONSERVANCY TRUST, and from that time on we have been maintaining regular connexes that are by all means beneficial for us.

Intellectual products of the latter relationship were the following: launching the HUNGARIAN PARTRIDGE CONSERVATION PROGRAM, establishing the HUNGARIAN PARTRIDGE RESEARCH GROUP, activities carried out by the Research Group, two volumes of the HUNGARIAN SMALL GAME BULLETIN presented to you, furthermore two volumes written by me on habitat management and regulation of game populations. Thus, for participating in our Symposium, I render special thanks to DICK POTTS, NICHOLAS AEBISHER and all colleagues representing THE GAME CONSERVANCY TRUST.

For me Fordingbridge is the Mecca of Research work on small game. As it was to be seen, the latter fact possesses historical roots as well. Being a faithful soul, I may make a second pilgrimage to Fordingbridge, forcing the co-workers of the Trust to undertake some more trouble in my behalf.

We render thanks to all participants of the Symposium for their highly valuable thoughts presented in course of our meeting. We promise to keep up the relations that have now come into being. Our aims are identical: enhancing the efficiency of pheasant management and above all: saving the threatened grey partridge, regarded by us "Hungarian partridge". In this way some considerable amount of ammunition will be left here for us after the Symposium. We thank all of you for the latter fact as well.

Dear Sirs and Mesdames,

Thank you for having made it possible for us to be together in course of the three and a half days of the PERDIX VIII Symposium. I wish that our meeting should strengthen you further research work and encourage you to develop new results.

I beg you not to forget Sopron. Will you please return to us as researchers, -all of us being ready for carrying out investigations collectively, too. Furthermore, we are going to welcome you happily if you pay a visit to Sopron with your family members or friends at any time.

Now I declare the Symposium PERDIX VIII closed. I wish you a pleasant journey and hope to meet all of you, at first in Greece in the year 1999 and afterwards in 2001 at the Symposium PERDIX IX.

Good-bye!

SCIENTIFIC PROGRAMME OF THE PERDIX VIII. SYMPOSIUM

Monday 26th October

Session 1: PHEASANT - *Species status,biology, management*

Chairman: CARROLL John (USA)

SAGE, R. and ROBERTSON, P.A. (UK): Pheasant productivity in relation to population density, predation and rearing: a meta-analysis

DRAYCOTT, R.A.H., BUTLER, D.A. (UK) and CARROLL, J. (USA): Spring diet of Pheasants in the UK: implications on the body condition of nesting hens.

ROBERTSON, P.A. and WOODBURN, M. (UK): Movements of female Pheasants (*Phasianus colchicus*) between different territorial males during April

Session 2: PHEASANT - *Biology, introduction and restocking*

Chairman: CSÁNYI Sándor (Hungary)

NYENHUIS, H. (Germany): Influences of landscape structure on distribution and density of the Pheasant (*Phasianus colchicus*) in North West-Germany

CARROLL, J. (USA) and HOLLINS, K. (UK) : Response of Pheasants to predator calls: measuring „wildness" and strain effects

CSÁNYI, S. (Hungary): The effect of hand reared Pheasants on the wild population in Hungary : a modelling approach

CARROLL, J. (USA) and PAPESCHI, A. (Italy): Flight characteristics of three strains of hand-reared Common Pheasants

Session 3: QUAIL - *Biology and genetics*

Chairman: CSÁNYI Sándor (Hungary)

PUIGCERVER, M., RODRIGUEZ-TEIJEIRO, J.D., ZIJLSTRA, W. BONET, V. and GALLEGO, S. (Spain): Indicators of male quality in the call of the Common Quail (*Coturnix coturnix*)

PUIGCERVER, M., GALLEGO, S., RODRIGUEZ-TEIJEIRO, J.D., (Spain), D'AMICO, S. and RANDI, E. (Italy): Hibridization and introgression of Japanese Quail mitochondrial DNA in Common Quail populations: a preliminary study

POSTER SESSION

CSÁNYI, S. and RITTER, D. (Hungary): The current status of Ring-necked Pheasant in Hungary

CSÁNYI, S. and RITTER, D. (Hungary): The current population distribution of Grey Partridge in Hungary

FALUDI, Cs. (Hungary): Changes in Partridge population and its environment in the ABÁDSZALÓK Project (HPCP) in the period 1994-1997

JÁNOSKA, F. (Hungary): Changes in Partridge population and its environment in the HARKA Project (HPCP) in the period 1993-1997

LIUKKONEN-ANTTILA, T., PUTAALA, A. and HISSA, R. (Finland): Effects of the change in diet on the nutritional status of the hand-reared Grey Partridge (*Perdix perdix*)

MOHÁCSI, S. (Hungary): Changes in Partridge population and its environment in the SÁRSZENTMIHÁLY Project (HPCP) in the period 1993-1996

MOHÁCSI, S. (Hungary): Changes in Partridge population and its environment in the APAJ Project (HPCP) in the period 1995-1997

MOLNÁR, Gy. (Hungary): The Game Birds Station in Sződ (Hungary)

NADAL, J., NADAL, J. and RODRIGUEZ-TEIJEIRO, J.D. (Spain): Local sex and age ratios of Red-legged Partridge (*Alectoris rufa*) declining populations in Huesca (Spain)

NYENHUIS, H. (Germany): Effects in predator-prey interaction between the Red fox and the Pheasant in Münsterland

PALOTÁS, G. (Hungary): Relationship between the density and the population dynamics of Grey Partridge and their predators

PAPP, S. (Hungary): Changes in Partridge population and its environment in the DÉVAVÁNYA Project (HPCP) in the period 1993-1997

PAPP, S. (Hungary): Changes in Partridge population and its environment in the NAGYSZÉNÁS Project (HPCP) in the period 1993-1997

PAPP, S. and PÁSKAI, S. (Hungary): The Pheasant Conservation Program in the County Békés

PIS, T. (Poland): Measurements of deep body temperature in the Ring-necked Pheasants by radiotelemetry

PIS, T. (Poland): Circadian deep body temperature rhytms of the Grey Partridge in summer and winter

REITZ, F. (France): The status of Grey Partridges in North-Central of France

REITZ, F. and MAYOT, P. (France): Variability of Grey Partridge dispersion during autumn and winter

SÁFIÁN, Sz. (Hungary): Analysis of Arthropodous food sources on the basis of sampling with D-vac insect exhauster in the LAJTA Project in 1998

SIMON, K. (Hungary): Pheasant management in the area of the Hubertus Hunting Club in Abádszalók

SZENDREI, L. (Hungary): Habitat use examination of Grey Partridge (*Perdix perdix* L.) in natural grassland

SZENDREI, L. (Hungary): The effect of rearing on the natural Pheasant stock in Eastern-Hungary

SZÉL, Gy., KÁDÁR, F. and FARAGÓ,S. (Hungary): Carabid beetles of the LAJTA Project (an agricultural land) in bioindication.

UIMANIEMI Leena, LUMME J, PUTAALA Ahti and HISSA Raimo (Finland): Mitochondrial control region reveals distinct maternal lineages in the European Grey Partridge

Tuesday 27th October

Session 4: GREY PARTRIDGE - *Species biology and population studies*

Chairman: POTTS Dick (UK)

KAVANAGH, B.P, O'GORMAN, EC. and BUCKLEY, K. (Ireland): The Irish Grey Partridge (*Perdix perdix*) conservation strategy : an update.

BRO, E., REITZ F., MAYOT, P. and MIGOT, P. (France) : Diagnosing the environmental causes of Grey Partridge decline in France: a comparative approach.

TOUT, P. and PERCO, F. (Italy): The Grey Partridge in the Region Friuli-Venezia Giuli, NE Italy – recent history and current conservation efforts.

AEBISCHER, N. (UK): Estimating brood production and chick survival rates of Grey Partridges: an evaluation

BAINES, D., LONGRIGG, J. and ANDREW, M. (UK): Factors affecting breeding success of Grey Partridge in the Uplands of Northern England

Session 5: THE HUNGARIAN PARTRIDGE – *The small game management in Hungary*

Chairman: AEBISCHER, Nicholas (UK)

POTTS, R. (UK) and FARAGÓ, S. (Hungary): Partridges in Hungary 1922-1933

RÁCZ FODOR, Gábor (Hungary): Small game management and state budget funding in Hungary

FARAGÓ, S. (Hungary): The LAJTA Project – the pilot project of the HUNGARIAN PARTRIDGE CONSERVATION PROGRAM (HPCP)

SZEMETHY, L., HELTAI, M. and BÍRÓ,Zs. (Hungary) : Situation of predator control in Hungary and the possibilities of predator management

Session 6 : PARTRIDGES – *Biology and genetics*

Chairman: THOMAIDES, Christos (Greece)

ARRUGA M.V. (Spain): Genetic variability in Red-legged Partridge

EFFENBERGER, S. (Austria): Population genetics of *Perdix perdix* in Austria – preliminary results

A presentation introducing the field excursion planed on 28th October

BUSTARDS – Till when ? [MTV (Hungarian TV) NATURA Film – 25' 40"]

FARAGÓ, S. (Hungary): New practice of the Great Bustard (*Otis tarda*) conservation – The MOSON Project

Wednesday 28th October

6.00- 7.00	Travel by bus to Lake Fertő– village Sarród/Mekszikópuszta
7.00- 9.00	Field excursion in the FERTŐ-HANSÁG NATIONAL PARK – Morning fly of Bean Geese, Grey-lag Geese and White-fronted Geese. Presentation of the FERTŐ-HANSÁG NATIONAL PARK
9.00-10.30	Travel to the LAJTA Project at Mosonszolnok
10.30-12.00	Presentation of the LAJTA Project
12.00-14.30	Travel to Mosonmagyaróvár and lunch in the *Hotel Szt. István* accept the invitation of LAJTA-HANSÁG JOINT STOCK COMPANY
14.30-16.00	Presentation of the MOSON Project
16.00-18.00	Homeward travel to Sopron
19.00-	**Conference banquet**

Thursday 29th October

Session 7 : GREY PARTRIDGE - *Habitat and population management*

Chairman: FARAGÓ, Sándor (Hungary)

O'GORMAN, C., KAVANAGH, B.P. and ROCHFORD, J. (Ireland): Home range and habitat use by the endangered Grey Partridge (*Perdix perdix*) in the Irish midlands

KAVANAGH, B.P. (Ireland): The reintroduction of the Grey Partridge (*Perdix perdix*) to Irish Farmland: towards a methodology

FISCHER, C. (Switzerland): Fallow strips created for Partridges: are they attractive to the Red Fox and other predators ?

Summary and closing of the Symposium PERDIX VIII.

LIST OF PARTICIPANTS

- **AEBISCHER**, Nicholas - United Kingdom, The Game Conservancy Trust, Fordingbridge
- **BAINES**, David - United Kingdom, The Game Conservancy Trust, Fordingbridge
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- **KOVÁCS**, Zsolt – Hungary, University of Sopron
- **KŐHALMY**, Tamás – Hungary, Institute of Wildlife Management, University of Sopron

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- **O'GORMAN**, Conor - Ireland, Biology Division, Royal College of Surgeons in Ireland, Dublin
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- **PINTÉR,** István - Hungary, Department of Game Management and Fishery, Ministry of Agriculture and Regional Development, Budapest
- **PIS**, Tomasz - Poland, Institute of Environmental Biology, Jagiellonian University, Kraków
- **PUIGCERVER**, Manuel - Spain, University of Barcelona, Barcelona
- **RÁCZ FODOR,** Gábor - Hungary, Department of Game Management and Fishery, Ministry of Agriculture and Regional Development, Budapest
- **REITZ**, Francois - France, Office National de la Chase, Anffargis
- **SAGE**, Rufus - United Kingdom, The Game Conservancy Trust, Fordingbridge
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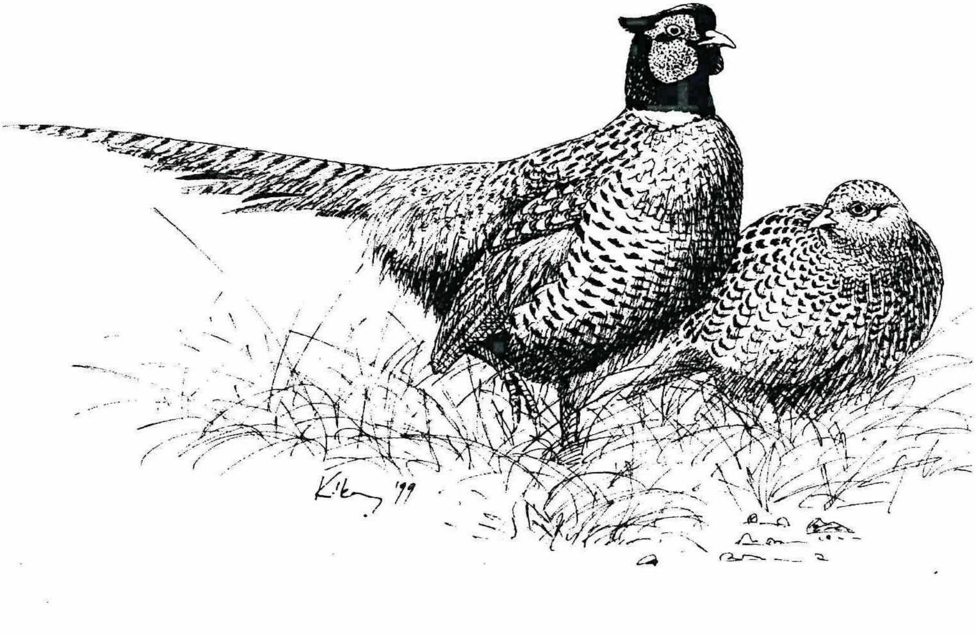
- **WOODBURN**, Maureen - United Kingdom, The Game Conservancy Trust,Fordingbridge

Session 1:
PHEASANT - *Species status, biology, management*

Session 2:
PHEASANT - *Biology, introduction and restocking*



PHEASANT PRODUCTIVITY IN RELATION TO POPULATION DENSITY, PREDATION AND REARING: A META-ANALYSIS

Sage, R.B. [1] **and Robertson, P.A.** [2]

[1] The Game Conservancy Trust, Fordingbridge, Hants, SP6 1EF, UK.
[2] Central Science Laboratory, Sand Hutton, York, YO41 1LZ, UK.

KEY-WORDS: Pheasant, population density, productivity, predation, rearing, meta-analysis

ABSTRACT

SAGE, R.B. and ROBERTSON, P.A.: PHEASANT PRODUCTIVITY IN RELATION TO POPULATION DENSITY, PREDATION AND REARING: A META-ANALYSIS. Studies of pheasant populations in Europe and North America were reviewed. From 27, we obtained estimates of hen pheasant numbers in spring, of autumn chicks fledged and details of game management for 32 sites over, on average, 2.8 years per site. Only studies with no significant change in pheasant density through the period of study were included. These data were used to investigate the relationship between spring densities and productivity, as measured by the autumn counts.

For the dataset as a whole, we found that pheasant productivity was not dependent on spring density. We then attributed all studies to one of three management categories, either wild bird studies in areas with no predator management, wild birds in areas with reduced predator populations, or areas where hand-reared birds were released. Investigation of these relationships identified differences between groups. In particular, for wild populations with no predator management, we found evidence of a density dependent effect of spring hen density on individual productivity. For wild pheasants with few or no predators, we find that productivity is higher than with predators, and is either not affected by breeding density, or weakly so. Where releasing was undertaken, productivity was low.

We discuss these results in the context of the analytical methods used, density dependent effects found in other gamebird species and the role of predation and releasing in population regulation.

1. INTRODUCTION

In this paper, we use spring and autumn count data for pheasants to explore the broad relationships between population size, management and productivity during the summer. We draw on count data for a range of studies and pool them for regression analysis. In particular we aim to compare productivity between sites that undertake different management practices in relation to the releasing of hand-reared birds and predation control. Previous studies indicate that both releasing hand-reared birds and predators reduce productivity (ROBERTSON AND DOWELL, 1990; REYNOLDS *ET AL.*, 1988; TAPPER *ET AL.*, 1996).

We also search for evidence of density dependence. Density dependence can be defined as the dependence of per capita population growth rate on present and/or past population densities (MURDOCH AND WALDE, 1989). Most ecologists now agree that after removing the effect of density independent factors such as bad weather, the relationships between births, deaths and movements in a population will to some extent depend on the population size. The difficulty however is to accumulate sufficient data to investigate density dependant trends in productivity that are inevitably obscured by density independent processes or by long term population trends due to gradual changes in habitat. The latter is a particular problem in modern times due to ongoing anthropomorphic changes to the countryside. Long term data sets are therefore most likely to detect density dependence (HASSEL *ET AL.*, 1989) and there are a number of studies that have achieved this (SINCLAIR, 1989). Most of these use spring count data for single species, such as the sparrow hawk (NEWTON AND MARQUISS, 1986). Some have investigated data for several species at a single site, for example, NEWTON *ET AL.* (1998) who used census data from one woodland for 20 years to show density dependent regulation for five woodland passerines. For game birds, long term spring and autumn count data have been used to detect density dependent population regulation in, for example, bob-white quail (ROSEBURY, 1979) and partridge (POTTS, 1986).

For pheasants no suitable long-term data sets have been examined. There are however numerous studies of pheasants which include assessments of spring and autumn population size. In this paper, we use count data from the literature and previously unpublished census data from The GAME CONSERVANCY TRUST to investigate the relationships between spring and autumn pheasant population size at 32 sites simultaneously. We only use data from sites where population size was not rapidly changing, and where more than one years' data is available, a mean figure is used so that between-site effects (comparing the ratios of spring to autumn population size between sites) only are investigated. Within-site effects, i.e. differences between years, are not considered. By including a management factor, we are able to investigate the effect of predator control and the effect of releasing pheasants on these relationships (ROBERTSON AND DOWELL, 1990). This paper then, contributes to the general topic of density dependence in ecology, and to the specific topic of the effect of predation and releasing on pheasant populations.

2. MATERIAL AND METHODS

2.1. DATA SET

We referred to studies of pheasant populations from Europe and North America from the 1940's onwards and to previously unpublished GAME CONSERVANCY TRUST data. From this, we obtained estimates of hen pheasant numbers in spring, of autumn chicks fledged and details of game management for 32 sites over, on average, 2.8 years per site (see **Appendix 1** for reference list). Sometimes methods were not explicit, especially in older studies, and in general we extracted data from studies that used a variety of assessment methods from census to searches. The purpose here however is to investigate general relationships from the data set as a whole and standardisation is less important than coverage. In particular it is the relationship between spring and autumn numbers at each site that are of interest. Consequently data were not rejected on the basis that the method was different from the census method used today (TAPPER, 1988), or where the data were from relatively short term studies. However, studies with a significant change in pheasant density through the period of study were not included (i.e. relatively unstable populations where regressions of numbers against time were significant).

2.2. ANALYSIS

These data are plotted, first as chicks per spring hen against spring hen density. Intuitively, if the slope of a regression line on this plot is negative and is significantly different to zero, then a density dependent effect has been identified. Although superficially appealing, such a test is not appropriate due to analytical problems, in particular the occurrence of the number of spring hens in both dependent and independent variables. This violates the assumptions of statistical independence (see Discussion). A more rigorous procedure is to plot total autumn chick numbers against spring counts of adult birds for each site. If no density dependent effect were apparent in this regression of chicks against adults we would expect the estimate of the slope to be not significantly different to 1.0.

While problems associated with non-independence are avoided, standard tests of this regression may also be inappropriate in certain circumstances (see Discussion). We therefore use as a final step, a severe test described by SOUTHWOOD (1978) that involves a second regression of adults against chicks (i.e. swapping axis) and calculating a second regression coefficient. If both coefficients depart from 1.0, then density dependence has been identified.

We used this procedure to detect density dependence for the complete data set of 32 sites, and then for each of three groups according to management category. These were either wild bird studies in areas with no predator management, wild birds in areas with reduced predator populations (including some island studies or where active predator control was conducted) or areas where hand-reared birds were released (these have little or no effective predator control). Active predator control was defined as sites at which tunnel traps or similar practices were used. POTTS (1986) used this definition to distinguish areas that were properly keepered, arguing that the time and effort involved in maintaining a line of tunnel traps was indicative of thorough keepering. Regressions of these three plots allow general predictions of productivity in relation to management category. All data were log-transformed and analyses were undertaken using *SYSTAT* (WILKINSON, 1990).

3. RESULTS

The data for productivity in relation to spring hen density for the 32 sites by management category are shown in **Figure 1.** No estimates of regression slopes for these data are provided as no reliable test for their significance is available (see methods). The figure does however illustrate the tendency for productivity to increase at sites with no releasing and with predator control.

Figure 2. presents chicks against adults per unit area for all site types simultaneously. The slope of this regression did not significantly differ from 1.0. However, adding a co-variate to distinguish management category identified significant differences between groups ($F_{2,28}$=18.39, P<0.001). Considering regressions of each category in turn (**Figure 3**.), sites with reduced predators and sites with releasing demonstrated slopes significantly different from 1.0. However sites with wild populations and predators had a slope of 0.656 ± 0.126 and differed significantly from 1.0 (see **Table 1.**). Using SOUTHWOODS (1978) test, plotting adults against chicks to calculate a second regression coefficient, the slope for this category was not different to 1.0.

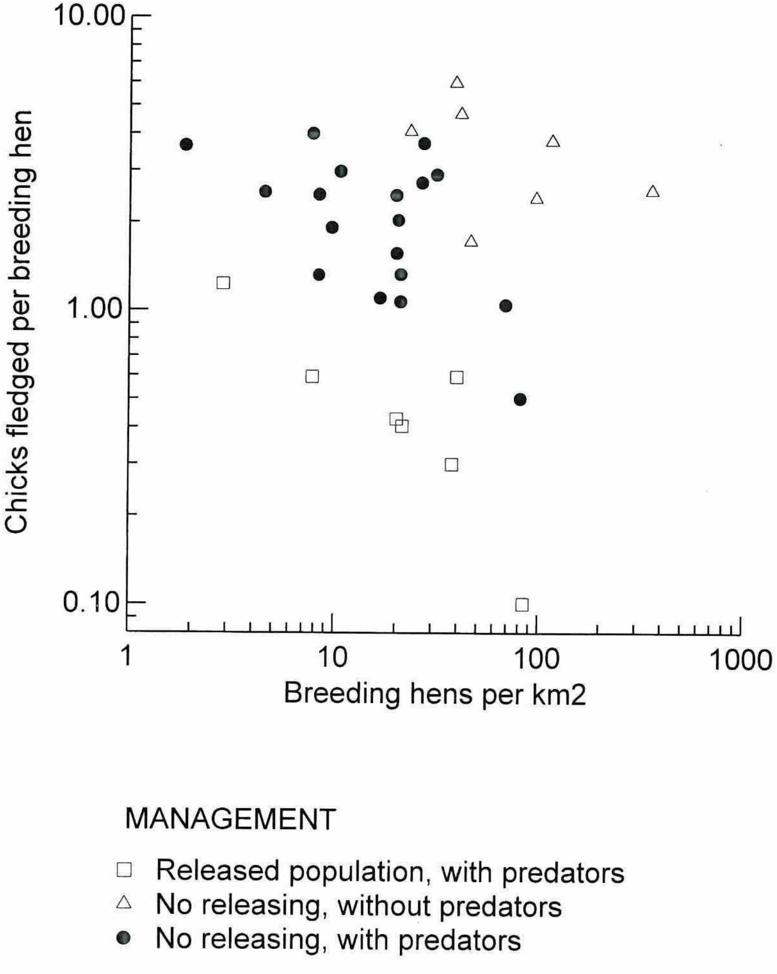


Figure 1: The relationship between chicks fledged in the autumn per breeding hen and the density of breeding hens in the spring for the 32 sites in this study. Axes are logged. Sites are allocated to one of three management categories. Regression slopes are not shown for analytical reasons (see text).

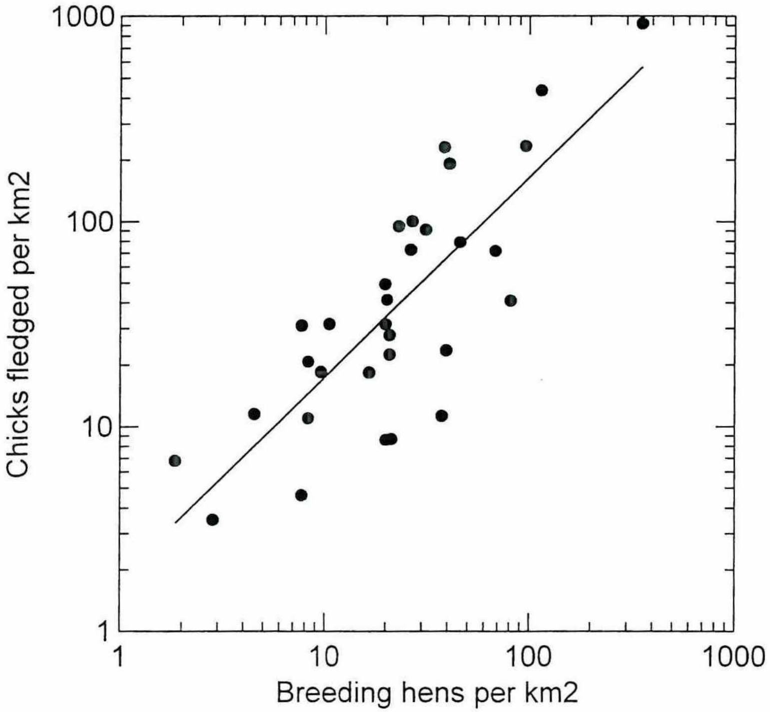


Figure 2: The young to old ratio for the 32 study sites with regression line. The slope is not different to 1.0 ($F_{1,30}$=1.254, P=0.272, see **Table 1**.).

Table 1: Tests of significance.

Category	Chicks ~ adults
All sites (**Figure 2**)	$F_{1,30}$=1.254, P=0.272
Released population (**Figure 3**)	$F_{1,5}$=4.475, P=0.088
Wild population without predators (Figure 3)	$F_{1,5}$=0.903, P=0.386
Wild population with predators (Figure 3)	$F_{1,16}$=7.406, P=0.015

SOUTHWOOD (1978) test

Site type	Adults ~ chicks
Wild population with predators	$F_{1,16}$=0.056, P=0.815

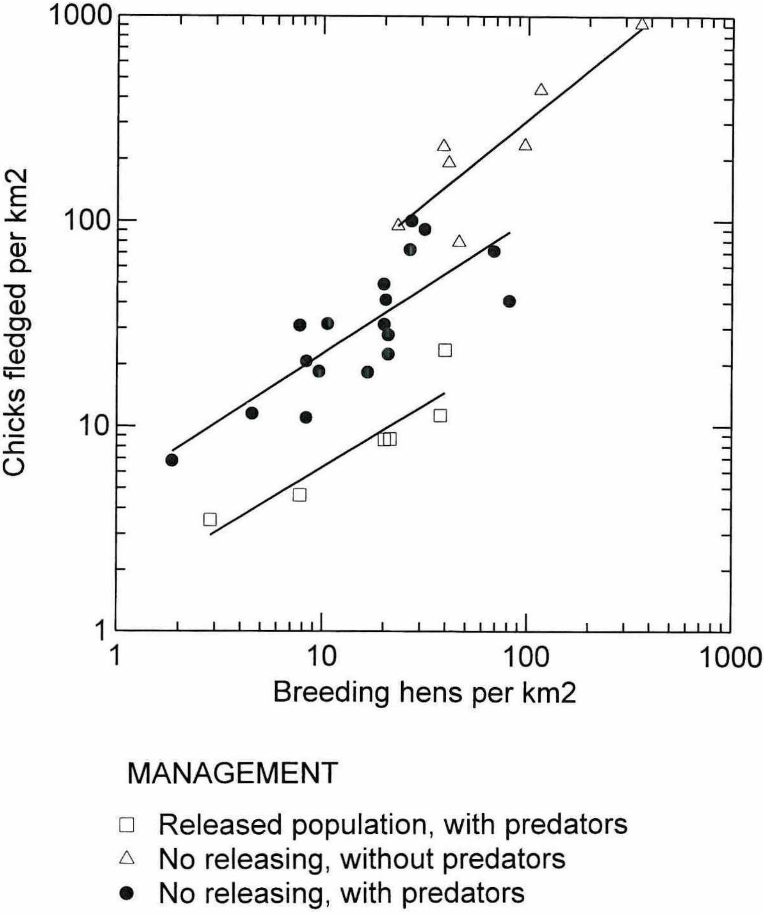


Figure 3: The young to old ratio for the 32 study sites with regression lines for each management category. Slope 3 is significantly different to 1.0 ($F_{1,16}$=7.406, P=0.015, see **Table 1**.)

These results suggest differences in pheasant chick production between sites in relation to predator abundance and rearing, with an equivocal effect of density for wild populations with predators (see Discussion). For the purposes of illustration, **Figure 3.** indicates that the mean rates of chick production in populations of 10 hens per km^2 were: for wild populations without predators, 4.75 chicks per hen; for wild population with predators, 2.24 chicks per hen; and for released populations, 0.60 chicks per hen.

4. DISCUSSION

Due to their economic value, there have been many studies of pheasant population dynamics. Of particular interest is chick production in relation to population size, which is to the game manager, the main indicator of the harvestable surplus. To the biologist who wishes to identify factors that may influence productivity it is necessary to consider population models in relation to management. In this meta-analysis we identify significant differences in rates of chick production between pheasant populations in relation to the release of hand-reared birds, predator abundance, and possibly spring density. It is worth considering each of these effects in turn.

Effects of releasing

A comparison of releasing in this study suggests that productivity on the sites where hand-reared birds were released was lower. There are several plausible explanations for this. The suggestion is that it is the birds themselves, having been reared and released, that has suppressed their ability to fledge a brood (HILL AND ROBERTSON, 1988, ROBERTSON AND DOWELL, 1990). The data may also reflect the lower potential of the releasing sites to provide suitable habitat for pheasants (HOODLESS *ET AL.*, in press).

Effect of predator abundance

Sites with low predator abundance had the highest rates of chick production. This is in accordance with other studies that suggest that predation may suppress gamebird and waterfowl production in a density dependant manner. For example POTTS (1986), used 17 years of data from five sites in southern England to show density dependant regulation of productivity for grey partridge by comparing nest success with nesting density. He concluded that predation was by far the most important cause of nest losses (eggs or hen). In ducks, HILL (1984) identified a weak density dependent relationship between nest predation and density. More recently REDPATH AND THIRGOOD (1997) described density dependent predation of red grouse by raptors during the breeding season in Scotland.

The inclusion of island studies in our low predator abundance category must also be considered. Island populations have reduced prospects for dispersal and this may partly be the cause of the high densities encountered here. However their island status alone does not explain the high chick production and our data supports the conclusion reached by others (see above and REYNOLDS *ET AL.*, 1988; TAPPER *ET AL.*, 1996; NEWTON, 1993) that a reduction in predation is responsible.

Density dependence

The effect of spring density on productivity for sites with no releasing but with predators is not clear although our results suggest a density dependant effect. Providing statistical evidence of density dependence and hence population regulation is difficult to do, primarily because standard tests of significance are inappropriate (TURCHIN, 1995). This arises mainly because regressions of time series data of the form N_t (number of animals at time t) on N_{t-1} (number of animals at time t-1), from a randomly walking population will have a slope that is biased downwards, i.e. they may well suggest density dependence when it may not exist at all.

Methods have been developed for long-term data sets of annual census data that overcome these problems. The methods recommended by TURCHIN (1995) involve predicting the biased slope inherent in the data, accounting for it, and then testing for significance in the remaining slope. However, the game bird census data used here, unlike data for many other animals, include assessments of breeding populations in spring and of adult and young populations in autumn. We therefore have two population assessments per year. Furthermore, as indicated, most investigations of density dependence involve time series data, i.e. within-site population trends. The data presented in this paper provide a between-site comparison only. Consequently, an analysis of the type suggested by TURCHIN (1995) is not appropriate.

The two-stage procedure we used to test for density dependence is not ideal and in particular it is not sensitive – as SOUTHWOOD (1978) put it, 'a failure to detect density dependence using this method in no way proves its absence'. We would argue therefore, that while our analysis does not demonstrate a predation related density dependant effect of population size on productivity for sites with predators and without releasing (because the slope of the inverted regression was not different to 1.0), there is some evidence to suggest that there is. In particular, it is notable that in the first regression analysis of chick density as the dependent variable for all sites, the slope estimate was not significantly different to 1.0, yet for the subsequent analysis for sites with predators and without releasing only, it was. In conclusion, for wild pheasant areas with predators, while it is acknowledged that no conclusive result has been achieved, there is evidence that sites that had higher densities of pheasants had lower rates of chick production than sites that had low densities of pheasants. Furthermore, the sites that had no or few predators did not exhibit the same density dependent response. ROBERTSON AND ROSENBERG (1988) concluded that most gamebird populations exhibit some degree of density dependence in their growth rates.

5. CONCLUSIONS

We demonstrated differences in pheasant chick production between sites in relation to the effects of hand rearing and predator abundance. We suggest that the release of hand-reared birds suppresses natural productivity through the poor breeding success of released individuals and that rearing often occurs in areas with poor habitat. Predation is known to be one of the main causes of breeding failure in pheasants and in the absence of predators, productivity increases.

A better understanding of density dependant effects in pheasant populations is required both on a within and between site basis. Analyses of density dependence are improved with more data. TURCHIN (1995) estimates that the probability of detecting density dependence in a population increases with the size of the data set so that a 10 year run of data, will, roughly speaking have a 10 % chance of detecting density dependence whereas over 30 years the probability increases to 60 %. In this metapopulation analysis, it could be argued these equate to data for 5 to 15 sites (depending on management category), because we have two population assesments per year. On this basis the analysis of the regression slope for wild sites in the presence of predators was of a suitable size whereas the regressions for the other two slopes were not. We intend to add data to these datasets to expand on this between site investigation and to initiate a within-site study at some of our long-term study sites.

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SPRING DIET OF RING-NECKED PHEASANTS (*Phasianus colchicus*) IN THE UK: IMPLICATIONS FOR THE BODY CONDITION OF NESTING HENS

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KEYWORDS: body condition, cereal grain, diet, pheasants, supplementary feeding, United Kingdom

ABSTRACT

DRAYCOTT, R.A.H., BUTLER, D.A. and CARROLL, J.P.: SPRING DIET OF RING-NECKED PHEASANTS (*Phasianus colchicus*) IN THE UK: IMPLICATIONS FOR THE BODY CONDITION OF NESTING HENS. In a previous study we found in a population of pheasants in southern England that the diet of females prior to nesting was an important factor determining their body condition and subsequent breeding success. This study aimed to determine the vegetative component of pheasant diet in spring by analysing faecal droppings collected from 1km transects at each of 15 sites in March and April 1996 and 1997 in southern, central and eastern England. All sites actively managed the pheasant populations for the purpose of hunting. Some sites released pheasants while others concentrated on wild management. Arable farming was the principal land use on all sites. Some sites extended their winter feeding program into spring, while others ceased feeding when the hunting season ended on 1st February. The growing shoot tips of cereal crops was the most important dietary component in March and April, representing approximately 75% of all fragments. Cereal grain was the second most important fragment. More grain was present in the diet in March than April, (22% in March, 8% in April, P=0.05). The presence or absence of supplementary feeding was the most important factor determining the proportion of cereal grain in the diet (P=0.029). Where there was no supplementary feeding, grain represented only 2.5% of all fragments. Wild seeds and broad-leafed plant fragments were also found but in relatively low quantities (seeds: 0.65% in March and 6% in April), (broad-leafed plants: 2.5% in March, 7.5% in April). The diet of birds on non-feed supplemented sites contained few foods with a high calorific value. Previous research would imply that the body condition of hen pheasants fed this calorie-deficient diet would be poor, and could have a negative impact on overall breeding performance. We suggest that modern arable farming has created an environment where birds cannot find enough suitable natural foods during spring to enable them to build up fat reserves prior to nesting and brood rearing. We recommend that gamekeepers and wildlife managers continue to feed pheasants until the end of April. Grain should be provided (either via feed hoppers or with specially sown food plots) in breeding territories of pheasants which are typically adjacent to woodland edges, hedgerows or reed filled dykes.

1. INTRODUCTION

In the UK there is extensive rearing and releasing of pheasants (*Phasianus colchicus*) by sporting estates each year to supplement the wild stock for hunting, (CARROLL *ET AL.* 1997). Although over-winter mortality is high, due to hunting and predation, many hand-reared pheasants survive to the following breeding season. Several authors have compared the breeding success of wild and hand reared pheasants, (BRITTAS *ET AL.*, 1992, HILL AND ROBERTSON, 1988 and LEIF, 1994), and all concluded that wild birds were considerably more productive than reared birds. Reared birds are more vulnerable to predation during the nesting season and produce a quarter as many fledged young as wild birds, (HILL AND ROBERTSON, 1988)

The poor survival and productivity of reared pheasants occur due to a combination of factors including poorly developed predator avoidance behaviour, parasitic infection and reduced body condition (DRAYCOTT *ET AL.*, 1998). ROBERTSON (1994) found that reared hen pheasants in Great Britain can lose up to 40% of their April body mass if they produce a brood and DRAYCOTT *ET AL.* (1998) found that reared hen pheasants can lose up to 50% of their fat reserves between February and April. This loss of fat reserves was associated with the cessation of supplementary feeding of cereal grain after the hunting season, as body condition was maintained in birds collected from other areas of the same estate where supplementary feeding continued into the spring. HOODLESS *ET AL.* (1998) compared the diet of birds provided with supplementary wheat grain with a group of birds on the same estate where the diet was not supplemented. The cereal grain component of the diet represented about 45% in the fed areas of the estate while in the unfed areas it represented <1% of faecal fragments. This is in contrast to studies from the continent and North America where cereal grain was found to be a very important component of the diet: Finland 82%, (PULLIAINEN, 1966), 76% USA, (STROMBORG, 1979) and 15% Hungary, (HAVASI, 1992).

In the UK pheasants are generally fed wheat grain during the autumn and winter, but once the hunting season ends (1st February) this often ceases or is greatly reduced. Withdrawal of this supply coincides with harsh environmental conditions, in particular, cold temperatures and low natural food availability. Increasing intensity of farming and shifts from spring to autumn sowing of cereals and autumn ploughing is thought to have further reduced the availability of high energy seeds, (CAMPBELL *ET AL.*, 1997, DRAYCOTT *ET AL.*, 1997). A diet containing foods with a high calorific value is important during spring as energy requirements increase above maintenance levels, (WISE, 1994). The opportunity for feeding is reduced during incubation and birds use up existing fat reserves, BREITENBACH AND MEYER (1959) demonstrated that 80% of fat reserves can be depleted during the first 20 days of incubation. This study aimed to determine the spring diet of pheasants on a wider scale and assess the importance of spring supplementary feeding.

2. MATERIAL AND METHODS

We conducted fieldwork on 15 study sites in southern, central and eastern England. All sites were involved in pheasant management and hunting. They ranged from intensively reared commercial shoots through to exclusively wild bird shoots. We concentrated our studies within a $1km^2$ study plot within each site. Within the study plot we selected a 1km transect which included all major land use types and collected all pheasant faecal droppings found within a 1m band either side of the transect. We collected samples in March and late April during 1996 and 1997. Droppings were frozen until examination. We analysed samples using the methodology described in (HOODLESS *ET AL.*, 1998) and outlined briefly here. Before examination we mixed the droppings in each sample and washed them through a 212μm mesh to remove fine particles. Three random samples were removed with tweezers and placed in Petri dishes scored with a grid of 144 5mm squares. The contents were examined under 30x magnification and the first 100 vegetative fragments falling on grid intersections were identified. Where fragments overlapped at the sampling point, only the uppermost fragment was recorded. The numbers of fragments for each component were converted to proportions of the total sample. HOODLESS *ET AL.*, (1998) found that <1% of all faecal fragments were comprised of insect/animal matter. In this study <2% was insect/animal matter. Due to the relative unimportance of insects in the diet during early spring and the likelihood of different digestion rates of insect and vegetable matter, all analyses are based on the vegetative fragments of the diet only.

We analysed diet composition data using Analysis of Variance. As the data were proportions we *arcsin* transformed the data to normalise distribution. Faecal components were dependant variables in the analysis. We tested both main effects and interactions between independent variables. We included the following categorical variables: Year, Month, Site, Management (Wild or Reared), and Feeding (presence or absence of supplementary feeding in spring).

3. RESULTS

The relative proportions of faecal fragment types in March and April are shown in **Table 1**. Monocotyledonous shoot tips were the most important food group, particularly those of cereal crops. This was influenced by Site (14,32df, *F*=2.329, *P*=0.024). Month (1,32df, *F*=0.092, *P*=0.764) and Year (1,32df, *F*=0.274, *P*=0.604) did not influence the proportion of monocotyledonous shoots in the diet. The site effect was explained by the presence or absence of supplementary feeding (1,33df, *F*=3.922, *P*=0.056). Management (wild or reared) did not influence the proportion of monocotyledonous shoots in the diet (1,33df, *F*=0.030, *P*=0.864).

Table 1.: The vegetative components in the diet of pheasants on 15 sites in the UK in spring 1996 & 1997.

Component	March %		April %	
	Mean	SE	Mean	SE
Monocotyledonous plants	74.66	4.60	77.63	3.65
Cereal grain	22.20	4.59	8.02	2.88
Grass seeds & weed seeds	0.65	0.28	6.13	2.48
Dicotyledonous plants	2.45	0.50	7.48	2.0

Cereal grains also comprised a large proportion of the diet, (**Table 1, Figure 1.** and **Figure 2.**). Month (1,31df, *F*=4.171, *P*=0.050, **Figure 1**.) and Feeding (1,31df, *F*=5.244, *P*=0.029, **Figure 2.**) both influenced the proportion of cereal grain in the diet. Site (13,31df, *F*=1.169, *P*=0.345), Year (1,31df, *F*=1.529, *P*=0.226) and Management (1,31df, *F*=1.233, *P*=0.275) did not influence the proportion of grain in the diet.

The proportion of weed seed and grass seed fragments in the diet was influenced by Month (1,31df, *F*=7.703, *P*=0.009) and Year (1,31df, *F*=5.356, *P*=0.027). Site (13,31df, *F*=0.765, *P*=0.688), Feeding (1,31df, *F*=0.025, *P*=0.876) and Management (1,31df, *F*=0.206, *P*=0.653) did not influence the proportion of seeds in the diet. The proportion of dicotyledonous fragments in the diet was influenced by Site (13,31df, *F*=2.797, *P*=0.009) and Month (1,31df, *F*=5.051, *P*=0.032), but not by Year (1,31df, *F*=1.389, *P*=0.248), Feeding (1,31df, *F*=0.118, *P*=0.739) or Management (1,31df, *F*=0.001, *P*=0.975). There were no significant interaction effects for any of the dietary components.

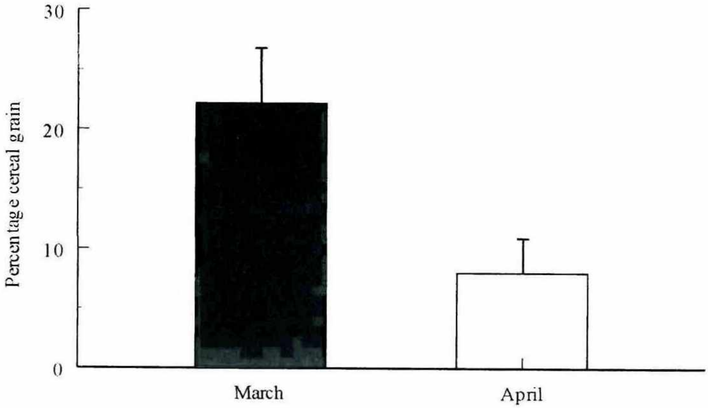

Figure 1.: The proportion (as percentage) of cereal grain in the diet of pheasants in the UK during March and April 1996 and 1997.

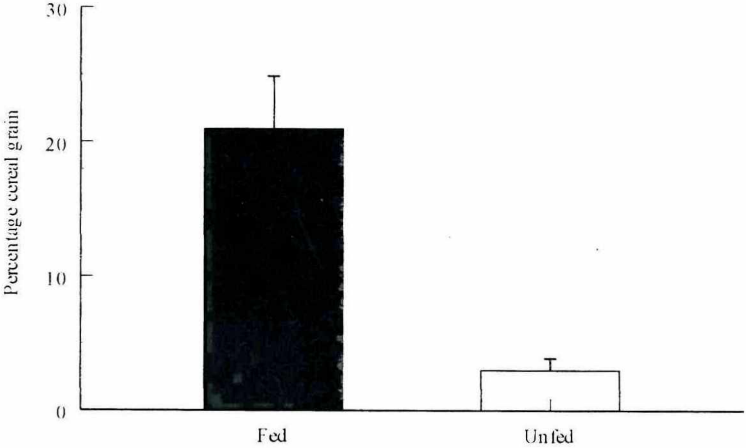

Figure 2.: The proportion (as percentage) of cereal grain in the diet of pheasants on supplementary fed and unfed sites during spring 1996 and 1997.

4. DISCUSSION

Our analysis revealed large variation in the proportion of grain in the diet between sites which continued supplementary feeding into the spring compared to sites where there was no spring supplementary feeding. Grain was virtually absent from the diet in birds collected from unfed sites. This highlights the lack of naturally occurring grain in the farmland environment. On sites where supplementary feeding had stopped before spring, the pheasants appeared to be able to obtain sufficient protein in their diet from growing shoot tips, but that the energy component of the diet, vital in spring was deficient. The difference in proportion of cereal grain in the diet between March and April (**Table 1.** and **Figure 1.**) can be explained by the fact that supplementary feeding on most sites ceased by the end of March or that feeding continued in winter feed sites and not spring breeding territories where birds will have migrated to by April. Although monocotyledonous shoot tips were the most abundant food items, the amount consumed is dependent on the presence or absence of supplementary feeding. The proportion of grass and weed seeds taken increased between March and April (**Table 1.**). This was probably due to a combination of less supplementary grain being available in April and increased availability of wild seeds, particularly those of early seeding grasses. The proportion of seeds taken was also influenced by year. This could be explained by differing weather conditions between years affecting timing of seeding and seed production rate. The proportion of dicotyledonous plant fragments in the diet was influenced by site and month. This was probably to the differences in the proportion of fields sown to dicotyledonous crops (e.g. oilseed rape) between sites and the emergence of seedlings of spring sown crops. The management of the estate (whether it was wild or reared) did not influence the diet of the pheasants. This was contrary to our expectation that the wild sites would have a greater abundance of seeds and naturally occurring grains.

In the UK, cereal grain farming has changed dramatically during the last 30 years. There has been a shift from spring-sown to autumn-sown cereals resulting in a reduced area of over-winter stubble and much greater pesticide and inorganic fertilizer inputs (STOATE 1996, CAMPBELL *ET AL.* 1997). This type of modern farming has led to a vast reduction in natural food availability, especially energy-rich grains and weed seeds for many farmland birds (STOATE 1996, DRAYCOTT *ET AL.* 1997). The level of grain in the diet in our study is much lower than those in a review of continental literature by HOODLESS *ET AL.* (1998) where grain on average represented 73% of the diet.

Our results provide further evidence to our theory that low availability of energy-rich foods on farmland in the UK is affecting body condition of hen pheasants during the breeding season and is an important factor contributing to the poor breeding success of pheasants on many estates. As part of a complimentary study we collected a sample of hen pheasants from each site in April in both years to ascertain their body condition. Hens collected from the supplementary fed sites had significantly larger fat reserves than pheasants from the unfed sites, (DRAYCOTT 1998).

We recommend that gamekeepers and wildlife managers on reared and wild pheasant estates continue feeding hen pheasants into spring, ideally until May, to ensure that sufficient food is available to maintain body condition. The feed sites should be moved from traditional winter feeding sites, which are often in woodlands or blocks of cover, to woodland edges and hedgerows, that are favoured by cocks when establishing breeding territories. Feeding sites should be spaced 50 m apart and in sufficient numbers to allow 1 site per cock territory. Alternatively, sown seed mixtures which would retain seeds through the spring can be provided. Cost of spring feeding per bird is estimated at the equivalent of 1 USD, a figure which would be off-set by the contribution the extra birds fledged would make to the wild stock. It is essential that there is an efficient predation control program and that suitable habitat is provided for breeding gamebirds to ensure that the full benefits of spring feeding are realised.

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MOVEMENTS OF FEMALE PHEASANTS (*Phasianus colchicus*) BETWEEN DIFFERENT TERRITORIAL MALES DURING APRIL

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ABSTRACT

WOODBURN, M.I.A. and ROBERTSON, P.A.: MOVEMENTS OF FEMALE PHEASANTS (*Phasianus colchicus*) BETWEEN DIFFERENT TERRITORIAL MALES DURING APRIL The extent to which female pheasants (*Phasianus colchicus*) move between territorial males during the main mating period in April was assessed using two methods; repeated observations of individually marked females on three areas over four years, and radio-telemetry of 27 females on one area in one year. The former method estimated that females spent, on average, 87,5% of their time with one male, 9,8% with a second and the remainder with a third or fourth male. The radio-telemetry found 92,6% of females remaining with one male throughout April. For both methods the maximum number of males with which a female associated was four. These figures reflect time spent with different males, not the frequency of mating so do no necessarily reflect the proportion of the females' off spring fathered by different males. The estimates may be used to correct censuses based on estimating the harem sizes of individual territorial males.

1. INTRODUCTION

The mating system of the pheasant has been described as harem defense polygyny, where the male establishes an exclusive territory in spring to which are attracted a variable number of females – his harem (TABER 1949, ORING 1982, RIDLEY 1983). The females feed in the presence of the territorial male for about 4-6 weeks, during which time they try to build up their body reserves prior to nesting. While in his territory the male stays vigilant over the females, alerting them to predators and protecting them from harassment from other males. This allows the females to spend more time feeding while out in the open, maximising their energy input while minimising energy output (RIDLEY and HILL 1987).

The main period of territory establishment is during February and March (TABER, 1949; GORANSSON, 1980; RIDLEY 1983), when males can be seen displaying aggressively towards each other. In some cases this aggressive behaviour can result in physical fighting between two males, which is often associated with boundary disputes (TABER, 1949; RIDLEY, 1983; GÖRANSSON, 1984; FROBERG and HELGEE, 1985). Not all males are successful in obtaining a territory (RIDLEY, 1983), and those that do not are termed non-territorial or satellite males (GRAHN *ET AL.*, 1993). These males, who are effectively non-breeders, are often seen feeding in loose flocks in the middle of fields (HILL AND ROBERTSON, 1988). In Britain territories are normally established along woodland edges or along some other type of permanent cover bordering on to open vegetation, such as cereal fields or set-aside (LACHLAN and BRAY, 1976).

By the beginning of April ownership of the territories has been decided, and the territorial males display to attract a harem of females with whom to breed. While males are establishing territory ownership in March, females begin to break away from their large winter flocks and move between different territorial males, presumably choosing whose harem to join, and to subsequently breed with. The structure of these harems is uncertain. Do females settle to breed with one male, or do they visit the territories of a number of different males during the breeding season? Research on the mating system of pheasants found that the first copulations occurred in early April (RIDLEY, 1983). It was suggested, therefore, that movements of females in March were associated with initial mate choice, but by April females select a male with a view to reproduction. Consequently, this paper considers movements of females pheasants between different territorial males during April – not during March.

The degree to which females are faithful to one male has consequences for our understanding of the pheasant mating system (RIDLEY, 1983), and also the use of survey techniques based on estimating the harem size of individual territorial males (ROBERTSON *ET AL.*, 1993). This paper assesses the number of different territorial males with which female pheasants associate during April, the period of peak territorial and reproductive activity. Movement and distance travelled by female pheasants in April, with respect to male territories, and during nesting, are also discussed.

2. METHODS

In this study data from pheasants were collected in two different ways. Firstly, from direct observation of tagged individuals during repeated counts in April. Data were collected from three different study areas over four years. These were Lyons Estate, Co. Kildare, Ireland in 1983 and 1984 (ROBERTSON, 1986); Knoll Farm, Hampshire, U.K. in 1986 (HILL and ROBERTSON, 1988); and West Woodyates Farm, Dorset, U.K. in 1988 (WOODBURN, in prep). In early spring females were caught in walk-in baited funnel traps located around the study areas. Each female was fitted with a plastic poncho-type neck collar or back-tag with coded numbering, enabling individuals to be recognised from a distance using binoculars. Repeat observations of tagged birds were done from a vehicle during the peak period of breeding activity in April – during the two hours after dawn and before dusk, when females were feeding in harems accompanied by the territorial male. Repeat observations of tagged females on more than one occasion provided data on the frequency with which individual females moved between different territorial males.

Secondly, data were obtained from an intensive radiotracking study on one site, Wimborne St.Giles, Dorset, in 1991 (AEBISCHER and ROBERTSON, 1993). On this site birds were again caught during February and March using walk-in funnel traps, and fifty females were fitted with necklace type radio-transmitters (KENWARD, 1987). Throughout April thirty radio-locations were collected from each female at random times during daylight hours. These were used to calculate harmonic mean home ranges (DIXON and CHAPMAN, 1980) using RANGES IV (KENWARD, 1990). A preliminary utilisation analysis (KENWARD, 1987) suggested that 90% contours were most suitable to identify areas of high activity without being heavily biased by a small number of outlying points.

For both methods of data collection, the positions of displaying territorial males (defined as birds with fully erect wattles and pinnae (RIDLEY, 1983)) were recorded in order to map the locations of the territories. In all cases over half of the territorial males in each area were fitted with coded poncho neck collars or back-tags, and remaining males could be individually identified by plumage variations.

For the data collected from direct observations, the maximum number of different territorial males with which one female was seen was four. Four was also the maximum number of territories overlapped by the range of any one radio-tagged female. As such, the null-hypothesis was that any female had the opportunity to choose between four different males and would spend her time at random with each. The expected distribution of observations was then based on a binomial expansion derived from the number of times each female was observed. This allowed a predicted distribution of females to be produced for each study area, giving the expected proportion of females that would be expected to be seen with one, two three or four different males during April, accounting for the different number of times each female was observed.

3. RESULTS

During direct observation of tagged females the number of repeat censuses per area varied between 5 and 18. Of 99 tagged females known to be present on the study areas, 57 were subsequently observed on more than one occasion (**Table 1**.). In **Table 2.** the observed and expected distribution of females between 1, 2, 3 or 4 different territorial males on the four study areas is shown. Given the small expected and observed values in certain cells, the Chi Square, with Yates correction, lumped the females into two groups: those seen with only one male and those seen with more than one male. In all cases the observed figure showed a significantly higher number of females observed with only one male than expected:

Lyons 1983 $\chi^2 = 52.57$, df=1, $P<0.02$,
Lyons 1984, $\chi^2 = 63.92$, df=1, $P<0.01$
Knoll 1986, $\chi^2 = 39.90$, df=1, $P<0.02$,
Woodyates 1988, $\chi^2 = 16.55$, df=1, $P<0.05$

For the radiotelemetry data, 27 of the 50 radio-tagged females established their ranges within the area where the position of all territorial males had been mapped. The female range outlines were then overlapped with the male territories to determine how many different territories was covered by each female range. Although the male territories were quite distinct the female range outlines clearly overlapped with each other, although females who shared the same male did not always have similar ranges. It was found that 93% of female ranges only overlapped the territory of one male, although one female's range was observed to overlap four male territories.

An overall assessment of the proportion of females visiting different numbers of territorial males during April is shown in **Table 3.** Each study area and year were weighted equally. In addition this table also presents the results of the radiotracking data from the Wimborne St. Giles study area, for which no expected distribution could be obtained under

Table 1.: The number of individually tagged female pheasants observed during April transects on three study areas over four years. The number of repeat transects carried out in each year is also shown.

Site	No. tagged females observed at least once	No. tagged females observed more then once	Total observations of females seen more than once	No. of transects
LYONS 1983	18	9	35	18
LYONS 1984	7	5	18	14
KNOLL 1986	62	37	193	9
WOODYATES 1988	12	6	25	5
TOTAL	99	57	271	46

Table 2.: The observed and predicted number of female pheasants seen to associate with 1, 2, 3 or 4 different territorial male pheasants during April on each study area. Predicted values (in parentheses) were derived from the null-hypothesis that each female spent her time at random between four different territorial males.

Site	Number of different males				
	1	2	3	4	Total no. of observations
LYONS 1983	9 (1.32)	0 (4.58)	0 (1.68)	0 (1.45)	9
LYONS 1984	5 (0.37)	0 (2.25)	0 (1.94)	0 (0.44)	5
KNOLL 1986	14 (3.2)	11 (17.7)	9 (12.8)	3 (3.3)	37
WOODYATES 1988	3 (0.43)	3 (2.82)	0 (2.31)	0 (0.44)	6

Table 3.: The proportion of female pheasants associating with 1,2,3 or 4 different territorial male pheasants during April. The results from the direct observations are the mean of the four study years, weighting each study area and year equally. The results from the radiotelemetry are the observed number of male territories overlapped by the 90% harmonic mean home range of each female.

Method	Number of different males				
	1	2	3	4	No. of females
Direct observation	0.875	0.098	0.021	0.006	57
Radiotelemetry	0.926	0.037	0.000	0.037	27

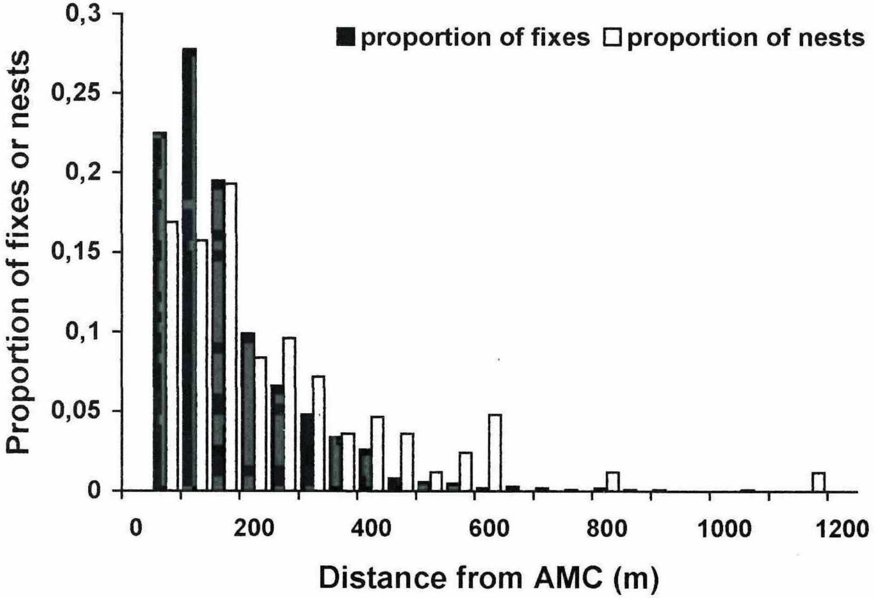

Figure 1. : The proportion of radio-fixes and nests of female pheasants located at increasing distance from the arithmetic mean centre (AMC) of their home range during April.

the null-hypothesis. The data from both sources, direct observation and radiotelemetry, demonstrated that around 90% of females spent their time with only one territorial male during April, and only a small proportion of females visited up to four different males.

On the Wimborne St.Giles study area, as well as recording the number of different male territories the range outlines of the females overlapped with during April, the distance moved by the females was also recorded. This was calculated by using the arithmetic mean centre of the range and calculating the distance that each radio-tracking fix was from this point. The results are shown in **Figure 1.**, where the proportion of radio fixes has been plotted against increasing distance away from the arithmetic mean centre of the range. Considering all the females together, the results indicated that they spent approximately half of their time within 100 metres of the centre of their activity range in April, with rare movements of up to 1000 metres.

Again, using the radiotelemetry data we looked at where females nested in relation to their April home ranges. This was calculated for each female as the distance from the arithmetic mean centre of their April range to the location of their nest site. The results are also shown in **Figure 1**. It was found that half of all the nests were located within 200 metres of the centre of the females' April pre-nesting ranges. None of the females nested in the territory of the male they bred with, but some did nest in the territories of other neighbouring males. We compared the distance distribution of the fixes during the April pre-nesting range with the distance distribution of the nest locations, and found that the two distributions were significantly different, G = 25.223, 5 df, $P<0.001$. The distance categories were combined into 0-100 metres, 101-200 metres, 201-300 metres, 301-400 metres, 401-500 metres, and >500 metres for statistical analysis. The data demonstrated that the difference in the distributions was due to the nests being located significantly further from the arithmetic mean centre of the April pre-nesting ranges than would be expected from the distribution of the fixes.

4. DISCUSSION

Most female pheasants appear to spend the majority of their time with only one territorial male during April. This certainly occurred more often than would have been expected under the null-hypothesis that they would spend their time at random between the territories of four different males. Studies in the U.S.A. by GATES AND HALE (1974) found that at least 19% of females changed males during the breeding season. RIDLEY AND HILL (1987) found that individually marked females were observed on 74% of occasions with one mate, and relationships remained relatively stable after females had settled into their breeding range. Similarly research in Sweden (GÖRANSSON, 1984) also found that female pheasants were faithful to their chosen male after the period of winter flock break-up and initial mate choice.

In this paper the data from direct observations produced the average proportion of time that individual females spent with more than one male, but took no account of variation between females. The results could reflect a high level of promiscuity amongst a small number of females, or a modest level amongst them all. However, the radiotelemetry data suggests that the majority of females do remain with only one male. The studies mentioned above, and this paper, all suggest that female pheasants spend the majority of their time with one male during the pre-nesting period, but a small proportion do occasionally visit the territories of neighbouring males.

The data also suggest that the degree of promiscuity amongst females varied between sites; with Lyons demonstrating the least and Knoll the most. With only three sites it is impossible to draw broad conclusions but it is worth noting that this follows the trend in bird density between sites. Additionally, most cases of females frequently shifting between males on Knoll occurred in one part of the study area where there was a particularly high concentration of both sexes. However, there may be other reasons for the observed movements of females. Radiotelemetry studies of hooded warblers found that almost 80% of females made extra-territorial forays during their pre-incubation stage (NEUDORF *ET AL.*, 1997). The authors suggest that females use these forays, not only to assess male quality or for extrapair copulations, but also to obtain food during the energetically demanding period of egg production.

In this study it should be noted that the estimates reflect the presence of females with different males, not the frequency of mating, and therefore do not necessarily reflect the proportion of a female's offspring fathered by different males. In particular, rape is fairly common in pheasants, typically occurring when a territorial male is distracted and an intruder, often a non-territorial male, attacks his harem (RIDLEY, 1983; ROBERTSON AND HILL, 1988). The frequency of such events could not be assessed by either technique applied here.

The results in this study indicated that both methods of data collection produced broadly similar estimates of the proportion of individuals or time spent with one male. These figures could be used to provide a correction factor for survey techniques based on estimating the harem sizes of individual males. Other studies have assessed harem size in a number of different ways (RIDLEY and HILL, 1987; GÖRANSSON *ET AL.*, 1990; ROBERTSON *ET AL.*, 1993), some taking account of the cryptic plumage of female pheasants, but none include a correction factor for movements of females between different territorial males.

Radiotelemetry of females during April found the birds to be relatively sedentary with 50% of their activity occurring within 100 metres of the range centre. This is consistent with females minimising energy expenditure at this time of year to maximise energy assimilation for egg production and incubation. The females appear to move greater distances to nest, with 50% of nests occurring within 200 metres of the April range centre. This raises a number of issues. It appears that females rarely nest within the territory of their chosen or most frequent male. In this study no occurrences of females nesting within the territory were found, although females were observed to nest in the territory of neighbouring males. As a consequence it is unlikely that male territory selection or mate selection by the females is based on the quality of nesting cover within the territory, supporting the conclusions of other workers (RIDLEY, 1983; ROBERTSON, 1996). Despite typically nesting outside of the male territory, distances from territory to nest site remain relatively small. This suggests that surveys of April female numbers in an area are likely to be a close reflection of the number of females later nesting in the vicinity, an assumption of survey techniques relating pheasant densities to different aspects of habitat quality (ROBERTSON *ET AL.*, 1993; ROBERTSON, 1998).

From a habitat management viewpoint, these results stress the need for suitable nesting cover to be found in close proximity to the male territory. It appears unlikely that males establish territories in relation to quality of nearby nesting cover (RIDLEY, 1983; GÖRANSSON *ET AL.*, 1990; ROBERTSON, 1996). Female pheasants appear to select a mate on the basis of male quality, not the availability of nesting cover (RIDLEY, 1983; GÖRANSSON *ET AL.*, 1990; ROBERTSON, 1998). If the provision of suitable nesting cover can improve rates of nesting success (LINDER *ET AL.*, 1960; GATES *ET AL.*,1970; DUMKE and PILS, 1979) then it would appear important for managers to ensure that territory sites and nesting cover are placed in close proximity to each other. This work would suggest that nesting cover should be placed within 200 metres of the male's territory if it is to be effectively utilised by the females.

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INFLUENCES OF LANDSCAPE STRUCTURE ON DISTRIBUTION AND DENSITY OF THE PHEASANT (*PHASIANUS COLCHICUS*) IN NORTH WEST-GERMANY

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KEY-WORDS: landscape structure, distribution, density, North West-Germany

ABSTRACT

NYENHUIS, H.: INFLUENCES OF LANDSCAPE STRUCTURE ON DISTRIBUTION AND DENSITY OF THE PHEASANT (*PHASIANUS COLCHICUS*) IN NORTH WEST – GERMANY. The effects of land use on distribution and density of the pheasant in a territory of 3,75 million ha hunting-grounds (64 districts and townships) are investigated. Here, pheasant data amount to 70% of the total German hunting bag. For the 64 cases, from 1989/90 to 1996/97, the bag for 1000 ha hunting area per annum was computed with seven independent variables of land use and parameters of soil quality in factor analysis for each of the eight years. The factor loadings for the eight variables were plotted as time-files in diagrams. In each analysis 4 features (components) of characteristic landscape structure were extracted: Factor 1= coastal region: This landscape shows the high marked variables of pasture land and soil quality. Factor 2 = in the low mountain range high loaded woodland variables and low values of traffic areas indicate a negative effect. Factor 3 = urban areas: Reducing values of traffic areas determinated this factor. Factor 4 = agrarian lowlands: Increasing maize field and pasture valuations have a positive effect on these birds, but a drop in beet and potatoe fields is shown in the eight-year period. Oscillations in the time-files of variable valuations in 1991/92, when the population approximated rather low data, are discussed.

1. INTRODUCTION

This paper presents information on basic research in official pheasant bags in a territory of North West-Germany, a region which shows the main records in the total Federal Republic. A dramatic decrease in numbers of these birds has been discussed in all regional States (Länder), after the severe winter 1978/79 (ENGEL, 1993; SPITTLER, 1995). During the last decade, bags declined to a minimum in all hunting areas where the pheasant is found. From this situation the following questions arose: Is there a relation between the downward trend of pheasant abundance and the typical kind of countryside? Can mathematical analysis provide satisfactory statement for possible correlations of land use with the pheasant populations? Factor analysis efforts created useful results on roe deer and brown hare populations in the same territory (NYENHUIS, 1998; 1998a). Assuming that it is not possible to find data in accordance with the real population (GOSSOW, 1976), to show the influence of features in large, wide landscapes, we managed the best we could – using the bag records.

2. MATERIAL AND METHODS

The abundance of pheasants (hunting bags) was calculated for 1000 ha hunting grounds in 35 North West-German districts and 29 townships during the period of 1989/90 to 1996/97. The results were correlated in 8 factor analyses with six variables of land exploitation (percentage share of area) and corresponding parameters for soil quality. During this process, environment variables were used with their percentage at the respective hunting area for each different district. The average values for the 64 cases are read as follows: grain fields (wheat, barley, rye, triticale) = 17,2%, maize fields = 7,3%, pasture land = 19,0%, root crops (different beet species and potatoe cultivations) = 3,9%, traffic areas = 11,9%, woodland and forest = 18,0% (Statistics, 1992; 1995; 1996). The numerous registrations of soil quality reach to 80 points, however, 49 points as an average (Atlas der BRD, 1958).

Based on practical knowledge on criteria for establishing factors for different animals under similar environmental requirement, only „Principal Components Analysis“ with an unrotated factor matrix came up with satisfactory results (BACKHAUS *ET AL.*, 1994). Iterations to construct factor features led to four components of typical landscapes (regions) in this North-Western territory: 01 coastal region, 02 low mountain range, 03 urban areas, 04 agrarian lowlands. Calculations and figure-plots were established in the Information center – University of Osnabrück – under the application of „Statistical Package for the Social Sciences“.

3. INVESTIGATED REGIONS

The northern region of this investigation, situated near the North Sea coast, neighbouring the North East-Netherland and following the river Weser in the East shows particular high shares of pasture land within the hunting area (Wesermarsch district = 77%). Here, (see **Figure 1**.) pheasants are shot as mapped in the first and second group. The districts in the southern part of the map show extremly low bags with 3 to 25 birds per 1000 ha and list woodland shares between 25% and 50%. According to relief maps, this region is characterized by the low mountain range with altitudes up to 468 metre. The elements of the third component – hunting grounds near urban areas – marked with initial letters in most cases, register self-evident shares of traffic areas, if the township is very small, up to 35% Gelsenkirchen (G) and Herne (H). Particulary the banks of the river Rhine and the coastal

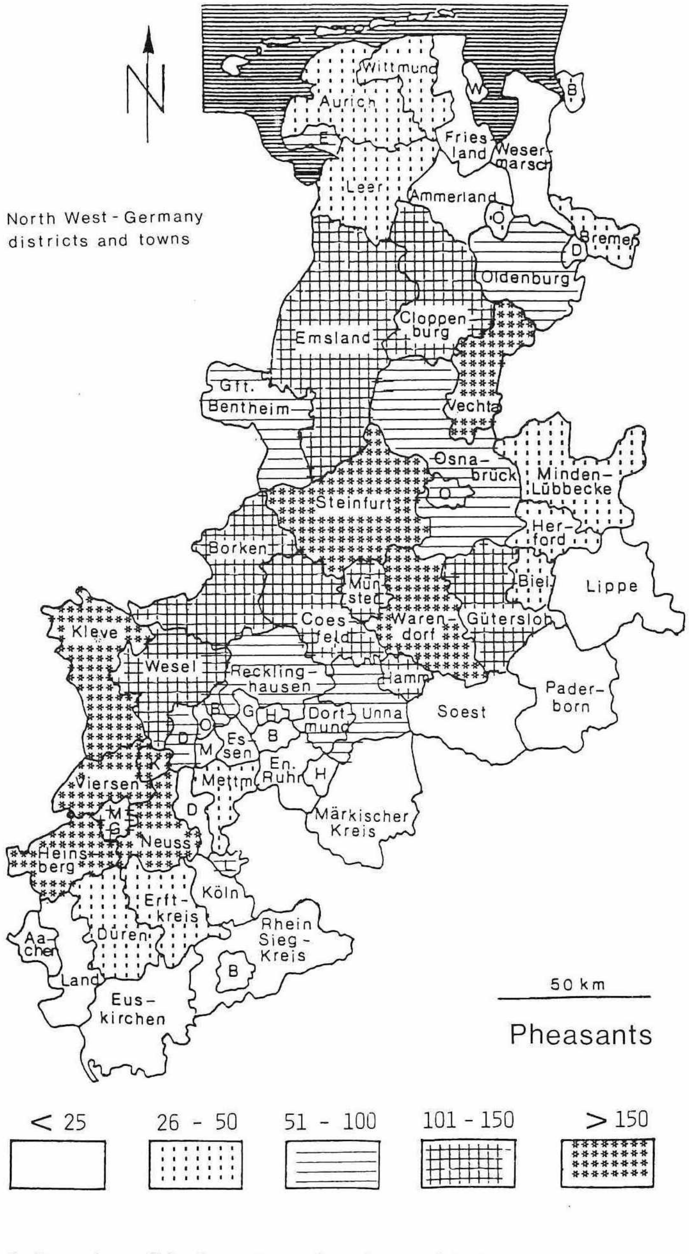

Figure 1: Location of the investigated territory with the distribution and density of the pheasant bags per 1000 ha hunting area – season 1989/1990

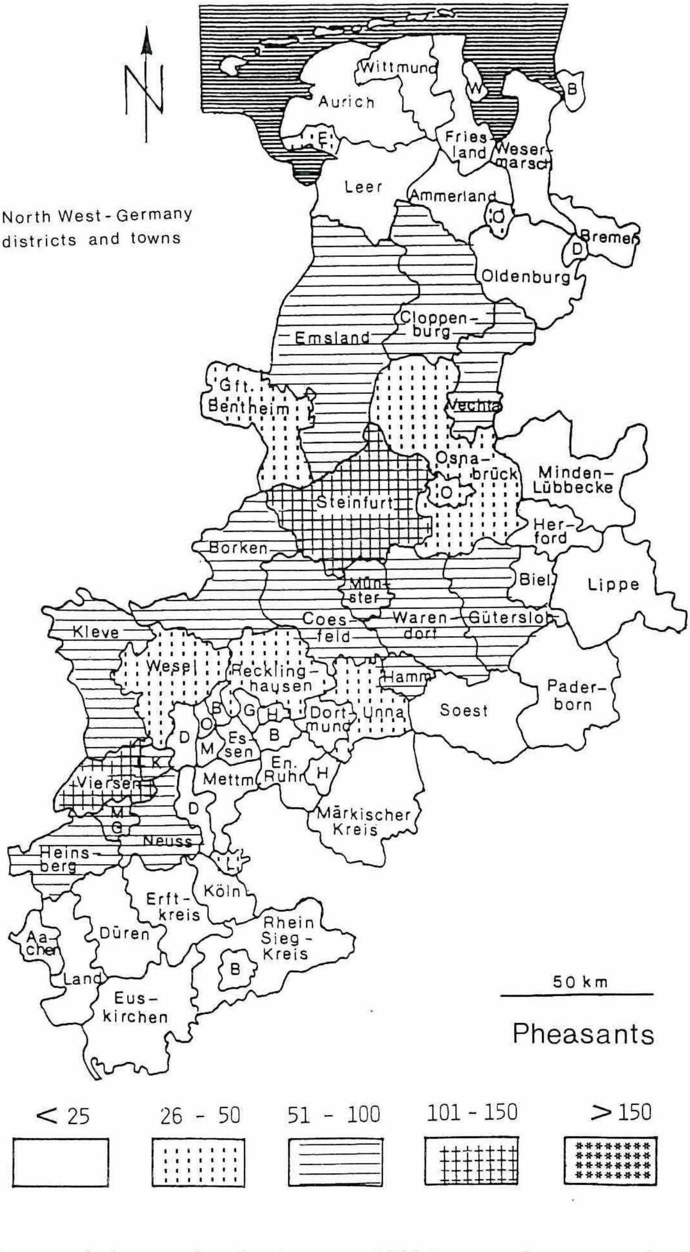

Figure 2: Decreased pheasant hunting bags per 1000 ha area. Contrary to the first figure, the total bag still counts 50% -season 1996/1997

town areas, in fertile plains, show growth of early potatoes and beets just as other plants which are not included in the statistics. The pheasants' main habitats are located in the open agrarian lowlands, geographically the largest region, where the bags register between 51 and more than 150 pheasant shots in 1989/90. In the plains of this region, the share of grain and maize fields is very high. It is here where pheasants should grow contrary to other regions. In comparison with the mapped bags in 1996/97 (**Figure 2.**), the population development demonstrates a decline of 50% against the previous bag in1989/90. During this period, a syncrònization of pheasants growing less, all over the different located districts and townships, seems to has happened.

Incidentally, the mean value of the total territorial bag per 1000 ha counts 66 pheasants in 1989/90, decreased to 44 animals in 1991/92, rose up to 59 birds in 1992/93 and finally sank to 33 pheasants shot during the last two years of the eight-year period.

4. RESULTS

The evaluation of the individual effects of the seven landscape variables, the values of factor loadings with a spread from +1,00 to -1,00, are plotted as time-files together with the bag valuations in four diagrams (**Figure 3. and 4**). The corresponding final results of the ecological model can be divised into super position, central position about the zero-axis and lower than average position.

4.1. NORTH VERSUS SOUTH

In the region of the North Sea coast, the values of soil quality and pasture land are in super position for the first component, followed by the time-file of root crop areas (**Figure 3.**). The pheasants line shows a downward trend which corresponds to the real bag. However, during the season of 1991/92 the line shows a peak, which corresponds to a small upward trend of the maize field values, a precarious situation, as the correlation with other variables declined in this season, during which it was not possible to bag such large numbers of pheasants as before. The influence of grain variable increased at the end of the period and insignificant wood areas show lower values than the average.

An extreme example is given in the feature with the high loaded woodland variable. Here, in the southern low mountain range of North Rhine-Westphalia, altogether nine districts and townships had to be excluded from maps and calculations, due to the complete loss of

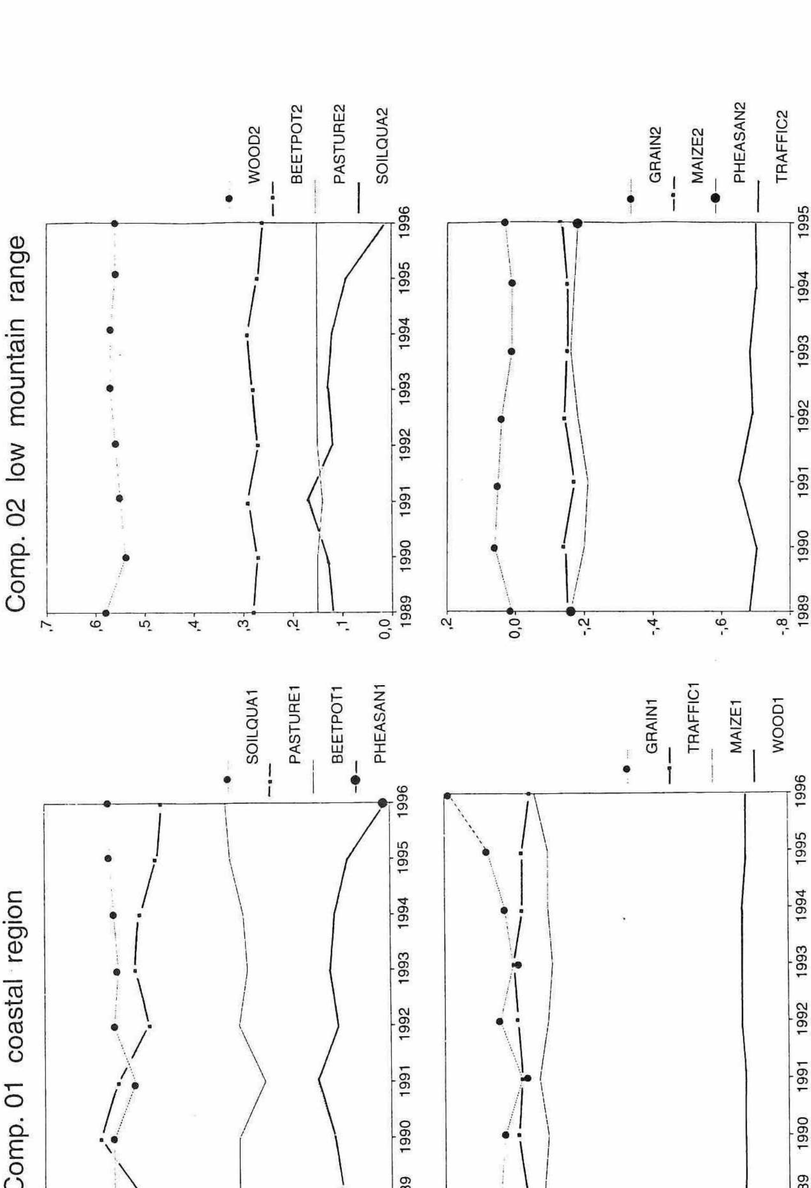

Figure 3: Relation of factor loadings for the first and second component, the pheasants lines show values about the average

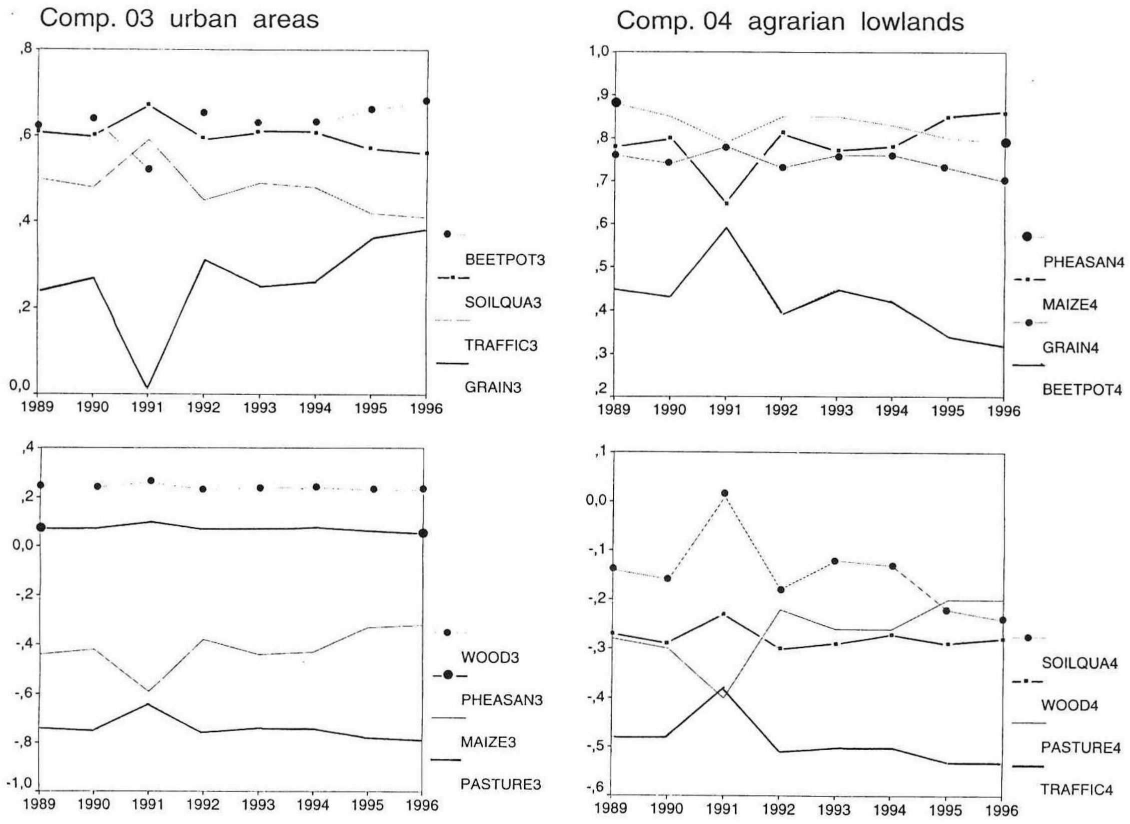

Figure 4: Time-files of variables for the third and fourth component (factors) – the pheasant bags in the lowlands load very highly in this system

their poor pheasant populations. Only sparcely we can detect a downward trend of soil effects until the end of the period.

Influences on these animals become also evident in small upward movements of traffic areas, root crop fields and soils‘ quality in the 1991/92 season. These results correspond to suitable habitat conditions in townships with woody hunting grounds.

4.2. TOWNSHIPS AND AGRARIAN LOWLANDS

The urban areas do not represent a coherent region. The townships where the pheasants are shot are situated in hunting grounds in all parts of the territory. The values of variables for beet, potatoe cultivations and traffic areas, within their corresponding quality of soil, take up the first position of the spectrum of the eight time-files **(Figure 4.)**. The files in this diagram clearly show the evident increase in influence on the pheasant by the three agrarian areas of root crop, grain and maize. In the 1991/92 season, the same three variables demonstrate quite evidently a considerable decline in their effects on pheasant abundances. However, pasture land, with lower mark than average, traffic areas and soil quality suggest for an upward movement of their influence on the birds with their peak in the time-files in the precarious season. The rows of pheasants and the woodland loadings, situated in a central position near the zero-axis, do not show legible responses during the eight years.

Particular cases in this territorial analysis are the wide plains of agrarian lowlands, where the most important pheasant habitats are found. Here, in the fourth component, an unalterable combination of relationship with the highly pronounced pheasant line demonstrates the maize variable with growing positive influence and the decreasing grain variable marked light in effect. In congruency with the root crop curve, but at lower level, the tendency of the soil quality shows down in the time-file. The pasture land curve with its increase in influence should not be underestimated. For 1991/92 we find two low bottoms, maize areas and pasture land decline remarkable in this diagram. These are above all variables which are responsible for habitats preferentially used by pheasants. On the other hand, the computer findings show peaks in effects on pheasants in the time-files of grain areas, certainly with lightweight, in the root crop and soil quality files as well as in woodland and traffic areas which show their growing effect on environmental features in the noticable season.

5. DISCUSSION

The pheasant is a bird of open arable landscape. Areas completely covered with wood and those without water are uninhabited areas. The individual ranges of use for wheat, maize areas, hay-fields and shrubland indicate strong preferences of pheasants for this types of cover (BEHNKE, 1976; BOYD AND RICHMOND, 1984) – extremly mapped by the third to fifth group in **Figures 1. and 2**. From 1947 to 1985, the farmland of this region with high density of pheasants was consolidated, by splitting up into individual districts. These circumstances were mainly responsible for the decline in populations of these birds. Five spot-checks in the Land of North Rhine-Westphalia, where the percentage of consolidated land in 30 districts was correlated with the pheasant bags per 1000 ha hunting area may serve as an example. The coefficients are as follows: 1975 r = 0,43; 1980 r = 0, 23; 1985 r = 0,20; 1990 r = 0,19; 1995 r = 0,17 (NYENHUIS, in press). Could it be that drainage in combination with the consolidation of farmland had damaged the pheasant cover? The increased drainage which took place from 1948 to 1950 in the Great Lakes Region (USA) destroyed game habitat at rapid rate, al-though much of this land was not cultivated (MCCABE *ET AL.*, 1956).

On the other hand, farmers used excessive quantities pesticide in the period of the 80's. However, the German Minister of Agriculture stated at a symposium of landowners in Osnabrück (winter 1998): The annual increase in applying of plant-protective agents could be reduced up to 50% in the Federal Republic consumption. This statement of costs' is not very encouraging. It is well known that herbicides have a dramatic impact on insect and other arthropod fauna, densities are reduced by 50% (POTTS, 1986). The diet of pheasant chicks during their first week of live consists almost exclusively of invertebrates, primarily their larvae and eggs (BEHNKE; 1976; WARNER, 1984). We noticed the conspicuous results of land use variables in 1991/92. Continuous research over 36 years found very low temperature in the month of May and lowest temperatures in June when the chicks were born (e.g. NYENHUIS, this volume). The development of insects could not take place, chick mortality hindered recruitment.

In the morning of 2nd June 1991, the local German weather stations reported: Bremen 0,8 °C; Münster-Osnabrück airport 1,1 °C; Essen 2,8 °C; Düsseldorf 4,1°C and Aachen 3,9 °C. Now, we are able to understand why the characteristics of hunting grounds showed so many increasing and decreasing variables of environmental changes in urban areas (**Figure 4.**), mostly at the banks of the rivers Rhine and Ruhr, and figures which result for the agrarian lowlands.

Predation on pheasant eggs by mustelids can have an effect on density of these birds. The same phenomenon appears in the increase of goshawks (*Accipiter gentilis* L.) and the buzzard (*Buteo buteo* L.), both protected since 1969. Recently, the population of the red fox (*Vulpes vulpes* L.) increased immensely as a result of rabies immunization. Egg and chick losses can be large (ENGLUND, 1965; CREUTZ, 1978), especially in wooded hunting-grounds where in recent years red fox bags are greater than that of all small game together. With regard to the density relationship of pheasant and red fox bags in this territory of 64 districts and towns, we calculated correlation coefficients for the eight-year period of research: 1989/90 r = -0,12; 1990/91 r = -0,30; 1991/92 r = -0,28; 1992/93 r = -0,30; 1993/94 r = -0,37; 1994/95 r = -0,28; 1995/96 r = -0,40; 1996/97 r = -0,36. Computer outputs of mean values for total territory were 8 foxes in 1989/90 and about 18 red foxes shot and caught per 1000 ha hunting area in 1996/97. In all, we can conclude that the ecological web containing plant communities, dependent invertebrates and pheasants with their chicks as well as predators, has got ladders.

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RESPONSE OF PHEASANTS TO PREDATOR CALLS: MEASURING "WILDNESS" AND STRAIN EFFECTS

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KEY-WORDS: Pheasant, predator call, rearing, strain effect, United Kingdom

ABSTRACT

CARROLL, J.P. and HOLLINS, K.: RESPONSE OF PHEASANTS TO PREDATOR CALLS: MEASURING "WILDNESS" AND STRAIN EFFECTS. In the United Kingdom there has been a great deal of concern over the potential impacts of rearing on the flight characteristics of common pheasants *Phasianus colchicus* during driven shooting. A number of theories have been proposed that might explain this phenomena including changes in behaviour of the birds has occurred because of rearing. The suggestion being that the rearing systems used in the United Kingdom are making the birds more "tame." In the United Kingdom, numerous "strains" of pheasants have been released over the last few years which are purported to exhibit "wilder" behaviour resulting in superior flying. We used a tape-recorded raptor call as a "wildness" model to elicit various anti-predator behaviours from 5 strains of the common pheasant. We selected a standard British game farm strain of pheasant, a recently imported "American" strain purported to be "jumpy or wild," a strain derived in the early 1990s from wild "Fen" stock (Fenlands of England) for which smaller size was selected to be used as breeding stock over 4 years, imported Scandinavian pheasants, and Japanese-cross pheasants for behavioural analysis. We reared the birds together, under identical conditions, to control for rearing effects on behaviour. At ages 4, 8, and 12 weeks we randomly selected groups of 5 birds including each of the strains and place them in an observation pen. We played a tape-recorded buzzard *Buteo buteo* call for 30 seconds and then monitored behaviour for 3 minutes. We classified behaviours as crouching, alert, fleeing, feeding, resting, and walking. Using compositional analysis we found that behaviour differed from random at age 4 weeks ($P < 0.001$), 8 weeks ($P < 0.001$), and 12 weeks ($P < 0.001$). Strain effect on behaviour was only significant at age 4 weeks ($P = 0.002$). Individual behaviour appeared to be influenced by the other birds within the 5-bird groups tested together for all three age classes ($P < 0.001$). Using the predator call as a model for measuring "wildness" in hand-reared pheasants we were not able to distinguish among genetic strains other than in the youngest age class. It appears that anecdotal observations of "jumpy" pheasants possibly explaining perceptions of better flight might be more related to environmental influences on behaviour and observer expectations rather than true genetic differences among the strains.

1. INTRODUCTION

There has been growing concern in Great Britain about the quality of flight of reared pheasants *Phasianus colchicus* during driven shooting (ROBERTSON *ET AL.*, 1993; CARROLL *ET*

AL., 1997). Explanation for this problem and possible solutions generally fall into questions of genetic problems, rearing management problems, and shoot management problems (MAJEWSKA *ET AL.*, 1979; PIELOWSKI, 1981; HILL AND ROBERTSON, 1988; ROBERTSON *ET AL.* 1991, 1993; CARROLL *ET AL.*, 1997). The influence of domestic livestock management has directed much emphasis on modifying or searching for superior genetic strains of pheasant. The most common solution has been the importation and breeding of numerous "exotic strains" of the common pheasant. The connection between strains or subspecies of the common pheasant and behaviour and flight have been made many times in the past (TEGETMEIER, 1882; BARTON, 1912).

Previous research has suggested that there might be some genetic component to flight performance (ROBERTSON *ET AL.*, 1993, BAGLIACCA *ET AL.*, 1996, D. WISE person. comm.); however, others (CARROLL *ET AL.*, 1997) have found other factors to be more important.

CARROLL AND PAPESCHI (this volume) suggested that some of the perceived strain differences in flight performance might be due more to behavioural differences rather than morphological differences. Anecdotal observations suggest that some strains are "wilder," "jumpier," or "flightier" than others even when reared in captivity. This is usually defined in terms of the bird's response to human activity near pens resulting in typical anti-predator behaviours. It is then assumed that "wilder" pheasants will be more likely to flush earlier and fly higher when driven over hunters. In this study, we used an experimental approach to test the possibility of strain level differences in behaviour which might account for the differences in flight characteristics of common pheasants in driven shoots.

2. METHODS

We obtained five strains of pheasants from commercial game farmers and gamekeepers in England. The "game farm" strain was obtained from a commercial source that has had a closed breeding stock for many years. The "American" strain came from an estate which imported the stock several years before from a breeder in Wisconsin, U.S.A., and these birds are supposed to be derived from pheasants caught in the wild in China during the early 1990s. The third strain was obtained from a breeder who used wild caught "Fen" pheasants from the Fenlands of eastern England. These were bred over four years and selected for smaller size and "wilder" behaviour. Scandinavian pheasants are first generation stock obtained from commercial sources in Denmark. The Japanese cross pheasants are first generation crosses between the Japanese green pheasant *Phasianus versicolor* and standard English gamefarm pheasants.

Day-old chicks of the five strains were placed in standard communal rearing facilities and colour marked on the throat with indelible ink until they could be ringed for individual identification. Later they were housed communally in outdoor runs over grass. At ages 4, 8, and 12 weeks we removed groups of 5 pheasants representing each of the strains and placed them in an isolated grass run. We positioned a hide adjacent to that run and allowed the birds to adjust for 10 minutes. We then played an audio-tape of a buzzard *Buteo buteo* call for 30 seconds. At the end of the 30 seconds and at 30-second intervals for 3 minutes we recorded instantaneous observations of the behaviour of each bird. We classified behaviour into the following 6 groups:

Alert – Bird was in upright position with head cocked and moving to look for danger.
Crouch – Bird hid in vegetation with legs and head pulled close to body.
Flee – Bird running or flying away from predator call.
Walk – Bird undertaking normal pacing around pen.
Feed – Bird pecking at ground vegetation or taking food from feed hopper.
Rest – Bird in normal roosting position.

We converted the response of each bird during the 30-second intervals to proportion of time exhibiting each behaviour. We used compositional analysis (AEBISCHER *ET AL.*, 1993) to compare observed behavioural response with proportions of behaviours expected by random chance. We chose to use this approach rather than comparing behaviours to "control" normal behaviours because we wanted to test the behaviours observed as a result of the predator call, not the magnitude in change of behaviours. Overall behaviour was tested using multivariate analysis of variance (MANOVA) using an F-ratio estimator of WILK's Λ for each age group. We then tested strain and group effects using MANOVA including both factors as independent variables. We used a step down approach to identify the most important relationships between strain and the dependent variables following TABACHNICK AND FIDELL (1989).

3. RESULTS

We tested 45 5-strain groups at age 4 weeks, 41 groups at age 8 weeks, and 38 groups at age 12 weeks. Overall behaviour after playing the raptor tape differed from random for the 4 week-old chicks ($\Lambda = 0.060$, $F = 695.4$, 5,220 df, $P < 0.001$), 8 week-old chicks ($\Lambda = 0.058$, $P = 651.5$, 5,200 df, $P < 0.001$) and 12 week-old chicks ($\Lambda = 0.057$, $F = 611.3$, 5,185 df, $P < 0.001$; **Figure 1**.).

In all three age classes behaviour differed among groups (4 weeks - $\Lambda = 0.022$, $F = 4.52$, 220,860 df, $P < 0.001$; 8 weeks - $\Lambda = 0.023$, $F = 4.44$, 200,780 df, $P < 0.001$; 12 weeks - $\Lambda = 0.049$, $F = 3.265$, 185,720 df, $P < 0.001$). Only at 4 weeks was there behavioural differences among strains (4 weeks - $\Lambda = 0.781$, $F = 2.22$, 20,571 df, $P = 0.002$; 8 weeks - $\Lambda = 0.875$, $F = 1.07$, 20,518 df, $P = 0.38$; 12 weeks - $\Lambda = 0.868$, $F = 1.04$, 20,478 df, $P = 0.42$). The stepdown analysis revealed that the logratio differences between the alert and walk behaviours were most affected by strain ($F = 5.04$, 4,220 df, $P = 0.001$). None of the other dependent variables were significant ($P > 0.05$) when tested against strain with alert-walk logratio differences entered as a covariate (**Figure 2.**).

4. DISCUSSION

Previously much of the research on gamebird response to predators focussed on learned behaviours rather than possible genetic factors that might be influenced by rearing (DOWELL 1990a,b). We found that there were behavioural differences in predator response among the strains that we tested. However, these differences were only evident at the earliest age class (4 weeks). Genetic differences disappeared for our older age classes (8 and 12 weeks). Among the 4 week-old chicks the most important behavioural differences among strains were the complementary arrangement between alert and walk behaviours. It was apparent that the game farm and Scandinavian strains were much more alert during the 3-minute period following the predator call than the other strains.

We did not test specifically for environmental effects on response behaviours in order to isolate genetic effects; however, our data suggests that individual behaviour within groups which were exposed to the predator call together was influenced by others in the group. This suggests that anti-predator responses can be rather plastic and be influenced over very short time scales. DOWELL (1992) suggested that among younger chicks (6 weeks) of

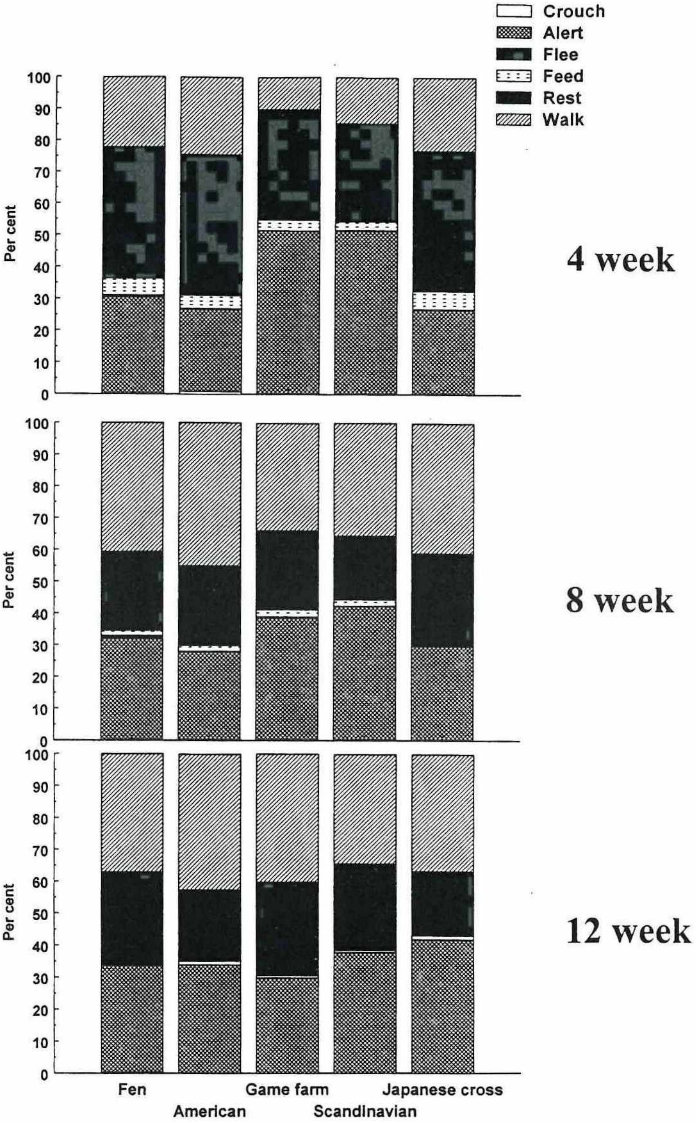

Figure 1.: Behavioural response of 4-12 week-old pheasant chicks for three minutes following a 30 second audio of a buzzard call.

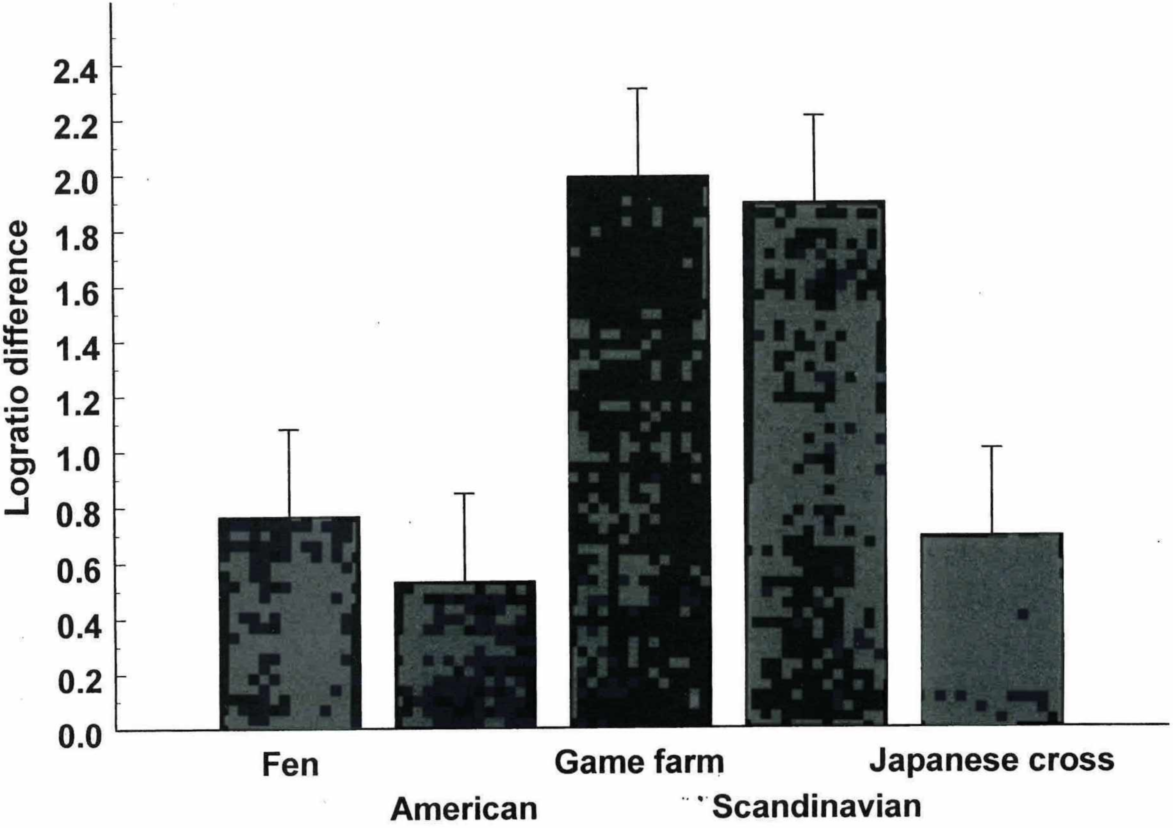

Figure 2: Logratio difference (x±SE) for strain effects on alert versus walking behaviour for 4 week-old pheasant chicks. A positive value indicates that alert bahviour comprised a greater percentage of time compared to walking behaviour during three minutes after a buzzard tape was played

grey partridge *Perdix perdix* more appropriate anti-predator responses were learned from the parent.

Our experiment suggests that the anecdotal observations of "wilder" strains made by many game keepers and commercial game farmers in the United Kingdom may not be genetically based. Our results suggest that environmental factors including very short term effects of neighbours might be more important. However, this does not rule out the possibility that some genetic strains of pheasants might have larger numbers of "wilder" individuals which could cause "wilder" behaviours to spread through flocks of pheasants which are reared together.

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THE EFFECT HAND-REARED PHEASANTS ON THE WILD POPULATION IN HUNGARY: A MODELLING APPROACH

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KEY-WORDS: effect, hand-reared pheasant, wild population, modelling approach.

ABSTRACT

CSÁNYI, S.: THE EFFECT OF HAND-REARED PHEASANT ON THE WILD POPULATION IN HUNGARY: A MODELLING APPROACH. Hand-rearing ring-necked pheasant (*Phasianus colchicus*) and their releases are traditional methods of game management to increase pheasant bags. During the last decades the number of released pheasants ranged between 1 and 2 million birds per year in Hungary meanwhile the pheasant bag and the wild population showed marked decline. To understand the relationship between the wild population (breeding stock), the number of released birds and their hunting recovery, a simple model was developed. Based on the available management data (spring population size, number of released birds, and harvest) and results of different recearch programs (reproduction, recovery rates etc.) the trends of pheasant management were analysed. The simulation results indicated that hunters regularly overestimate 1) the reproductive performance of the wild populations and/or the 2) potential recovery of released birds. Consequently, the wild populations had been seriously over harvested for years, which might contribute to the decline of free-living populations. In order to change the poor status of pheasant in Hungary game managers need better data on population dynamics, recovery of released birds, and should change the methods of releasing pheasants.

1.INTRODUCTION

Since the 1970s ring-necked pheasant (*Phasianus colchicus*) is the most important small game species in Hungary. Pheasant stocks reported in each spring increased until the mideighties parallelled by a huge increase of the number of released birds. Although the number of released birds was continuously increasing, the pheasant populazion has been declining since 1978 and the bag reached its peak in 1977. The decrease of the spring population and the harvest occured in spite of the continuous increase of the releases, which reached their peak (>1.7 million birds) in the late 1980 (**Figure 1**).

Although, authorities realized the problems of the decrease of spring populations and the harvests (TÓTH *ET AL.*, 1983) appropriate actions to change this situation had not been done. Research and proposals were limited to the necessity of improvement of hand-rearing and release methods (NAGY, 1985; NAGY, 1990).

Marking of released birds is the basis to get reliable data on their recovery rate and return of investments. Without this information the afficiency of releases cannot be evaluated, because either *the harvest/released bird ratio* (**Figure 2**) or the *harvest/spring population ratio* (**Figure 3**) confuses the contribution of hand-reared and wild pheasants to the harvest (CSÁNYI, 1994).

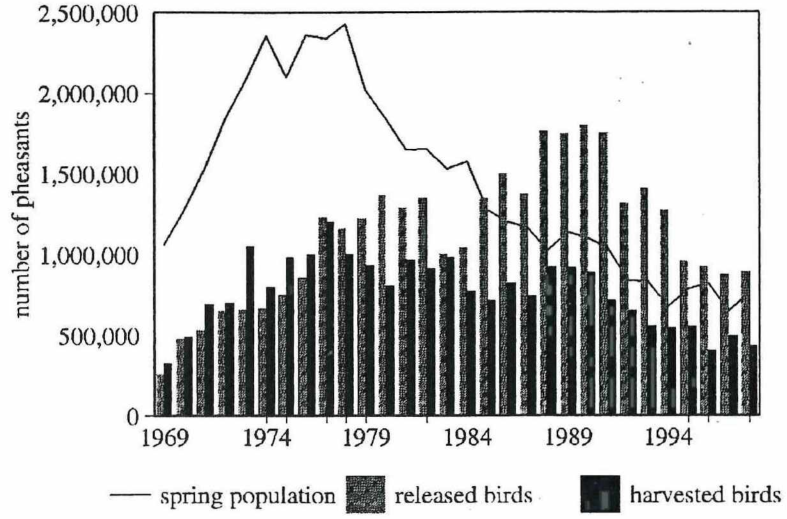

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Figure 1: Pheasant poulation size, releases and harvest in Hungary

Several studies indicated that the survival and the reproductive value of the hand-reared birds are much lower to those of wild birds (ROBERTSON *ET AL.*, 1993; ROBERTSON, 1997) and the effects of hand-rearing on the wild stocks are complex and far-leading in economic and ecological terms (HILL AND ROBERTSON, 1986; HILL AND ROBERTSON, 1987; HILL AND ROBERTSON, 1988b; ROBERTSON, 1990; ROBERTSON AND HILL, 1992). Except for sporadic cases (FARKAS CIT. CSÁNYI, 1987) the appropriate recovery and population data are not available for pheasant populations in hungary.

In the lack of the necessary data modelling can be a useful tool to understand the population dynamics and the identify key processes. In order to evaluate the potential effects of releasing hand-reared birds on the pheasant populations I dveloped a simple spreadsheet model to describe the population dynamics of pheasant stocks. This model ciuld be modified to incorporate the release of hand-reared birds and also for planning the results of this model and to propose solutions to reduce the effects of hand-reared pheasants on the wild populations.

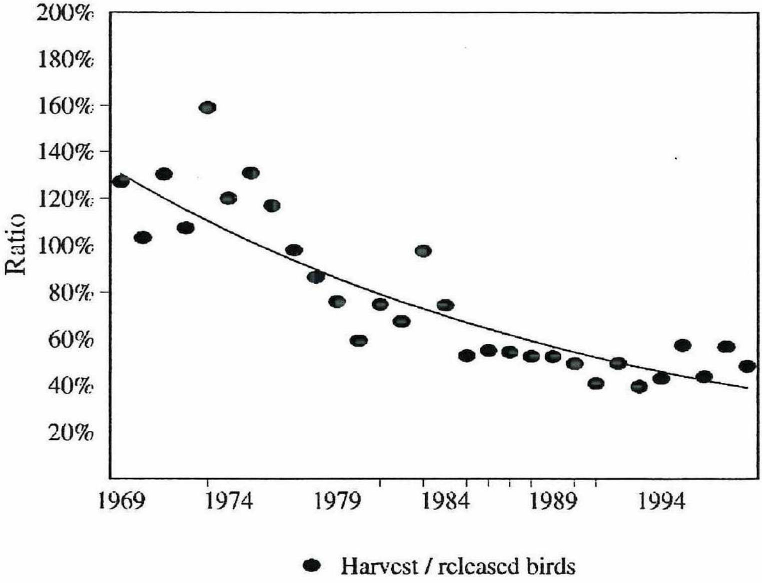

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Figure 2: Trend of the harvest/released birds ratio

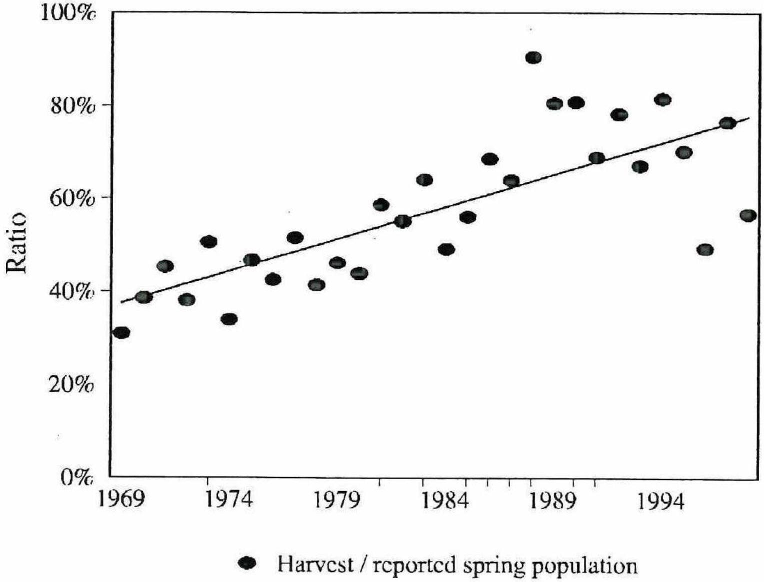

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Figure 3: Trend of the harvest/spring population ratio

1.1.THE MODEL AND THE ASSUMPTIONS

Pheasant population dynamics and the harvestable amount

In order to assess rhe dynamics of the free-living pheasant population I developed a spreadsheet model describing the population changes from year t to $t+1$. The ecpected population size for males is given by Eq. (1) and for females by Eq. (2):

$$M_{t+1}=[M_t \times (1-m_{ms}) + 0.5 \times F_t \times (1-m_{fs}) \times R] \times (1-m_{mw})$$

Equation (1): M_t= number of males in the spring population, year=t; M_{t+1}=number of males in the spring population, year=$t+1$; F_t=number of females in the spring population, year=t; m_{ms}=spring-summer male mortality; m_{fs}=spring-summer female mortality; R=recruitment per female; m_{mw}=fall-winter male mortality

$$F_{t+1}=[F_t \times (1-m_{fs}) + 0.5 \times F_t \times (1-m_{fs}) \times R] \times (1-m_{fw})$$

Equation (2): F_t=number of females in the spring population, year=*t*; F_{t+1}=number of females in the spring population, year=*t+1*; m_{fs}=spring-summer female mortality; R=recruitment per female; m_{mw}=fall-winter male mortality

Assuming that harvesting of the free living (wild) birds takes only the annual surplus of the population (*i.e.* the spring population remains stable from one year to the other) the equations can be rearranged and solved for males (Eq.3) and females (Eq.4) as follow:

$$H_{♂}=[M_t \times (1-m_{ms}) + 0.5 \times F_t \times (1-m_{fs}) \times R] \times (1-m_{mw})-M_t$$

Equation (3): Calculated harvest for males

$$H_{♀}=[F_t \times (1-m_{fs}) + 0.5 \times F_t \times (1-m_{fs}) \times R] \times (1-m_{fw})-F_t$$

Equation (4): Calculated harvest for females.

In the model the hand-reared birds released were treated separately. Their contribution to the harvest was calculated as follows (Eq. 5):

$$H_r=K \times m$$

Equation (5): H_r=the expected recovery of released birds; m=recovery rate; K=number of released birds.

The total planned harvest is the sum of the above amounts (Eq. 6),

$$H_t=H_{♂} + H_{♀} + H_r$$

Equation (6): H_t=total harvest.

Which should be reduced by the loss resulting from wounding (Eq. 7)

$$H_t=H_t \times (1-c)$$

Equation (7): c=rate of wounding.

Assessing the effect on the free-living population

To assess the potential effect of hand-reared birds on the wild pheasant population, one needs data on their recovery and also on their contribution to the total pheasant harvest. Having data on the recovery rate (*m*) we can estimate the share of released birds in the full harvest with Eq. 8:

$$HK = \frac{K \times m}{H_t} \times 100\ [\%]$$

Equation (8): Hk=Proportion of released birds in the total harvest.

It is also possible to calculated the hunting pressure on the wild population (EQ. 9):

$$H_{sp} = \frac{H_t - K \times m}{M_t + F_t} \times 100\ [\%]$$

Equation (9): H_{sp}=hunting pressure on the wild population.

The spreadsheet model and the data

On the basis of the above equations I developed a deterministic spreadsheet model in Corel Quattro Pro 8. The model can be basically used for two purposes: 1) *sensitivity analysis* to evaluate the effect of one or more parameters on a population, and 2) *simulations* to analyse *what if... questions* or varrious scenarios.

In the modelling presented here I used the pheasant management data (spring population, number of released birds, and harvest) available in the game management statistics (CSÁNYI, 1996; CSÁNYI, 1999) for 1969-1998.

Table 1: Values for the population parameters used in the model presented

Sex-ratio of the spring stock	1 male : 4 females
Non-hunting losses for both males and males	
spring-summer	30%
fall-winter	30%
Recovery rate of released pheasants	25%
Recruitment rate (reared young per female)	
weak	1 young/female
medium	2 young/female
good	3 young/female
Wounding loss	30%

The population parameters were collected from the Hungarian and international literature with a preference for data originating from situation comparable with Hungary (e.g. Festetics, 1938; C.T.G.R.E.F., 1972; Nagy, 1984; Anderson *et al.*, 1985; Beklova and Pikula, 1986; Hill and Robertson, 1986; Hill and Robertson, 1988a; Hill and Robertson, 1988b; Robertson, 1990; Mayot, 1991; Leif, 1994; Csányi, 1995; Robertson, 1997; Riley *et al.*, 1998). The parameters used in the simulations presented here are shown in **Table 1**.

2.RESULTS AND DISCUSION

The results of the model show that the pheasant stocks were harvested always above the level of the harvestable amount allowed by the 2 young per female recruitment rate (**Figure 4**). Since 1984 the actual bag had even been closer to the harvestable numbers given for 3 chicks per females recruitment. According to Farkas (cit. Csányi, 1987) 3 chickens per female are typical for good habitats and/or good seasons in Hungarian pheasant populations. It is interesting to note that the potential harvests (especially at higher recruitment rates) are very much determined by the spring population sizes and the number of released birds has less influence on the lines of potential harvest (**Figure 1** and **Figure 4**). This pattern of the potential and the actual harvest of pheasants indicate a strong opportunity for continued overuse of the wild pheasant populations.

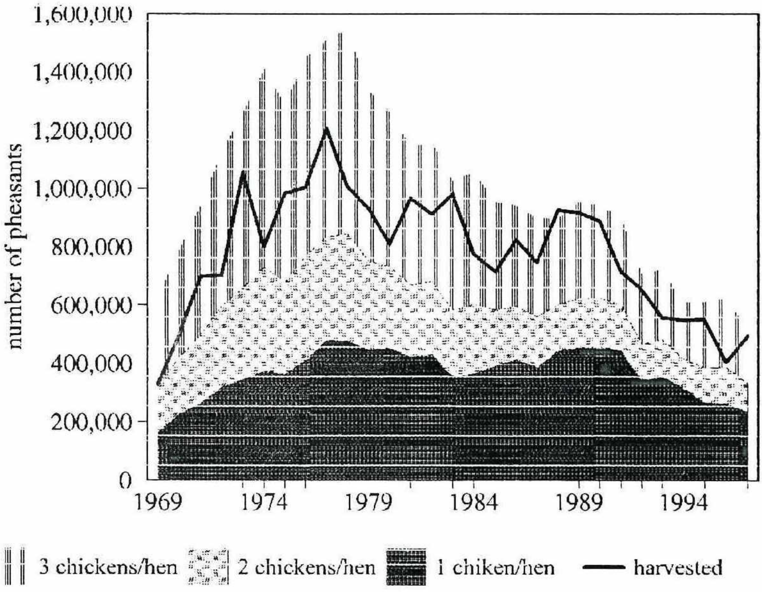

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Figure 4: The annual harvest and the potential harvest calculated with 3 recruitment rates

This tendency seems also to be indicated by the rising trend of the hunting pressure on the spring population as calculated with Eq. 9 (**Figure 5**). Although the points are rather scattered, in the light substantial decrease of the spring population, this pattern supports that the wild pheasant stock might be overused decades.

Parallel with the decrease of the spring population the share of the released birds in the bag showed a twofold increase during the 30-year period investigated (**Figure 6**). This pattern is in agreemint with other studies (e.g. HILL AND ROBERTSON, 1988b; ROBERTSON AND HILL, 1992), which cinfirmed that as a consequence of the declining productivity of the wild pheasant population the harvest becomes release-dependent.

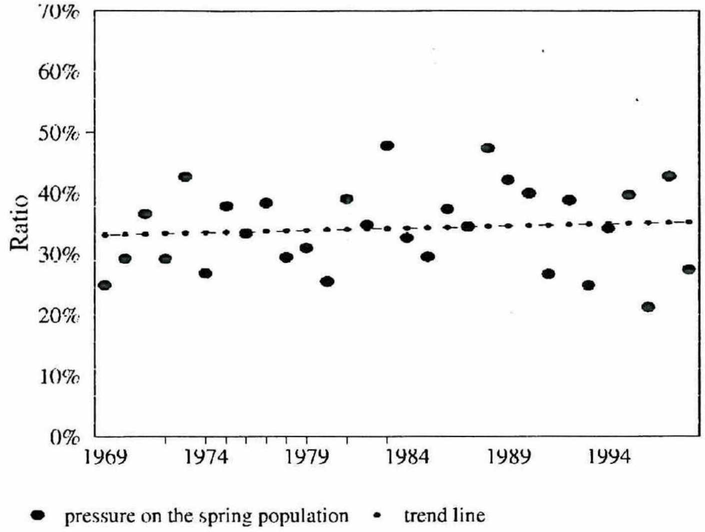

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Figure 5: Trend of hunting pressure on the spring (wild) population

As the recovery of the released birds in unknown there is a high risk to seriously over-exploit the wild pheasant populations. Furthermore, the return of investments is expected and this can also contribute to the over-exploitation of the wild populations. Under the Hungarian system this was increased by shooting pheasant hens and the lack of appropriate information on the status of wild populations. The data presented here is a typical case of this scenario resulting in population crash.

The findings presented here underline that the wise management of game populations Needs the knowledge of basic parameters influencing population dynamics. For an adaptive management of pheasant populations manager need to collect adequate data on the 1) recovery rates of released hand-reared birds, the 2) recruitment rate of the population, and 3) reliable monitoring of population trends.

The release of hand-reared birds has disadvantageous effects on the free-living populations, which can be reduced if the rearing and release methods are changed, especially mass releases are avoided. Negative effects can be reduced if hen shooting is forbidden or if only males are released. An additional benefit of the males-only release is that the costs can be reduced by all of those related to the rearing of females.

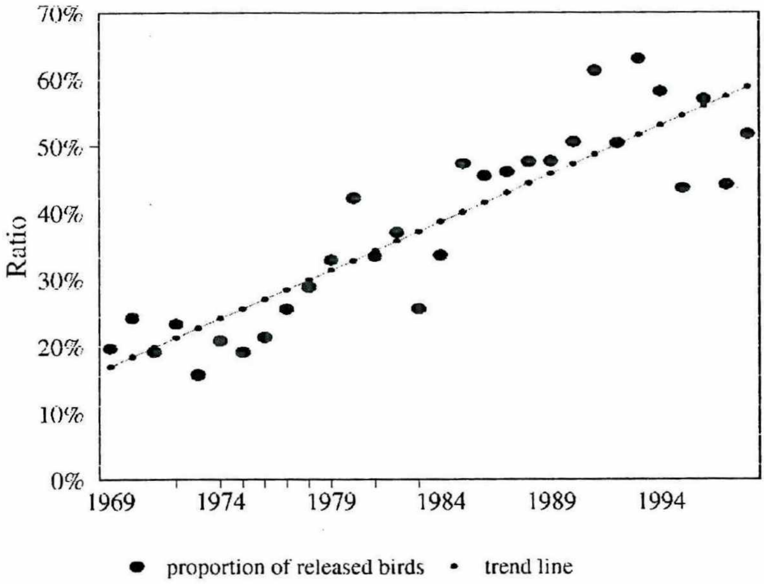

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Figure 6: Trend of the proportion of hand-reared birds in the harvest

In this paper neither habitat management nor the potential role predators and the importance of predator control in small game management have been addressed. Hand-rearing is one element of pheasant management, which should be treated together with the questions of habitat and predator control.

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FLIGHT CHARACTERISTICS OF THREE STRAINS OF HAND-REARED COMMON PHEASANTS

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KEY WORDS: strain, common pheasant, morphometrics, flight

ABSTRACT

CARROLL, J.P. and PAPESCHI, A.: FLIGHT CHARACTERISTICS OF THREE STRAINS OF HAND-REARED COMMON PHEASANTS. In the United Kingdom there has been a great deal of concern over the potential impact of rearing on the flight characteristics of pheasants (*Phasianus colchicus*) during driven shooting. Numerous "strains" of pheasants have been released over the last few years and some are purported to be superior flyers. We monitored flight characteristics of three strains of pheasant found in the UK using controlled releases to assess the genetic basis of this question. We selected a standard gamefarm strain of pheasant, a recently imported "American" strain, and a strain derived in the early 1990s from wild "Fen" stock (Fenlands of England) for which smaller size was selected to be used as breeding stock over 4 years. We reared the birds together, under identical conditions, to control for rearing effects on flight performance. At age 17 weeks we made morphological measurements of each bird just prior to flight testing. We allowed each bird to flush individually from a standard point between two parallel fences in field. A video camera recorded the initial flight, which we used to measure take-off angle, while observers monitored total time wings were flapped before gliding. The strains differed in body weight for both females ($P = 0.002$) and males ($P < 0.001$), however only females differed for tarsus length ($P = 0.001$), and neither sex differed for wing length and wing area. All of the morphological measurements were positively correlated. Analysis of covariance revealed that strain, sex, and body weight to wing area ratio were not related to take-off angle. Only body weight to wing area ratio was significant for explaining flap time ($P = 0.03$). Take-off angle and flap-time were positively correlated ($P = 0.004$). The data suggests that when pheasants flush under controlled conditions then strain is not a good predictor of initial flight performance. This occurs despite the differences among strains in morphology and potential wing load characteristics. The anecdotal observations of superior flying strains of pheasants must then be related to some other factors which may or may not be genetically controlled at the strain level.

1. INTRODUCTION

Over the last few years there has been growing concern in Great Britain about the quality of flight of reared pheasants (*Phasianus colchicus*) during driven shoots (ROBERTSON *ET AL.* 1993, CARROLL *ET AL.* 1997). A number of explanations for this have been proposed which can be grouped under the general categories of genetic problems, rearing management problems, and shoot management problems (MAJEWSKA *ET AL.* 1979, PIELOWSKI 1981, HILL and ROBERTSON 1988, ROBERTSON *ET AL.* 1991, 1993, CARROLL *ET AL.* 1997). This concern among the shooting public has tended to focus on genetic problems possibly related to many generations of captive rearing as is done in Britain. Over the last few years the solution has been the importation and breeding of numerous "exotic strains" of the common pheasant.

Previous research has suggested that there might be some genetic component to flight performance. ROBERTSON *ET AL.* (1993) found that "wild" strain pheasants flew marginally better than gamefarm pheasants on one estate. In controlled flight trials BAGLIACCA *ET AL.* (1996) found that females had greater take-off angles, but that males flew faster. In a trial of 7 pheasant strains, D. WISE (person. comm.) found that strain was a predictor of some flight characteristics. However, in a study of shoots on 24 estates in England, CARROLL *ET AL.* (1997) suggested that characteristics of each drive within an estate and hunter perception were most important.

An understanding of the mechanisms of flight performance of pheasants will require both controlled experimentation and field studies. In this study, we used an experimental approach to test the flight performance of three "strains" of pheasants which had been reared together in order to test the genetic component of these purported differences in flight characteristics.

2. METHODS

We obtained three strains of pheasants from commercial game farmers and gamekeepers in England. The "gamefarm" strain was obtained from a commercial source that has had a closed breeding stock for many years. The "American" strain came from an estate which imported the stock several years before from a breeder in Wisconsin, U.S.A., and these birds are supposed to be derived from pheasants caught in the wild in China during the early 1990s. The third strain was obtained from a breeder who used wild caught "Fen" pheasants from the Fenlands of eastern England. These were bred over four years and selected for smaller size and "wilder" behaviour.

Day-old chicks of the three strains were placed in standard communal rearing facilities and individually marked so they could be distinguished. Later they were housed communally in outdoor runs over grass. At age 17 weeks, we selected birds (gamefarm, n = 21; American, n = 22; Fen n = 22) from the pen and each was placed in a cylindrical release box which allowed the bird to be placed in one end and flush from a standard point at the other end. This was set at a 45° angle between two parallel fences to allow the bird to run up the cylinder and flush from the top toward a target of trees across a field. We used a video camera to measure initial take-off angle and observers in the field monitored initial wing flap-time in seconds. Take-off angle represented the flight angle relative to flat ground. Flap time was the total number of seconds before the bird began its glide.

We used analysis of covariance to identify relationships between take-off angle and flap time with strain and sex. Morphological measurements included strain, sex, body weight, tarsus length, wing length, tail length, wing area, and ratios of tarsus length, wing length, and wing area to body weight. The last three characteristics should provide an index to how heavy a bird is compared to its skeletal size and potential wing loading for take-off. We included order of flight in the experiment to control for potential bias related to disturbance and time of day.

3. RESULTS

Although the birds were all the same age we found differences in morphology among the strains. For females, body weight (F = 8.09, 2,30 df, *P* = 0.002) and tarsus length (F = 9.57, 2,30 df, *P* = 0.001) varied among strains (**Figure 1**); however, wing length (F = 3.02, 2,30 df, *P* = 0.06) and wing area (F = 1.57, 2,30 df, *P* = 0.23) did not (Figure 1). In males, body weight (F = 16.7, 3,30 df, *P* < 0.001) varied among strains, but tarsus length (F = 2.78, 2,30 df, *P* = 0.08), wing length (F = 1.085, 2,30 df, *P* = 0.35), and wing area (F = 2.24, 2,30 df, *P* = 0.12) did not (**Figure 1**).

Ratios of body weight to tarsus length differed among strains (F = 12.67, 2,60 df, P < 0.001), and sexes (F = 54.92, 1,60 df, P < 0.001) and an interaction of strain and sex (F = 3.45, 2, 60 df, P = 0.04; **Figure 2**). Ratios of body weight to wing length and wing area varied by strain (wing length, F = 17.06, 2,60 df, *P* <0.001; wing area, F = 14.15, 2,60 df, *P* <0.001; **Figure 2**) and sex (wing length, F = 61.85, 1,60 df, *P* < 0.001; wing area, F = 25.28, 1,60 df, *P* < 0.001). There were no interaction effects between strain and sex for wing length (F = 1.91, 2,60 df, *P* = 0.16) or wing area (F = 2.29, 2,60 df, *P* = 0.11).

All of the morphological variables were highly correlated (**Table 1**). Therefore we selected body weight to wing area ratio as the morphological variable which we thought would have the most biological relevance to our flight models.

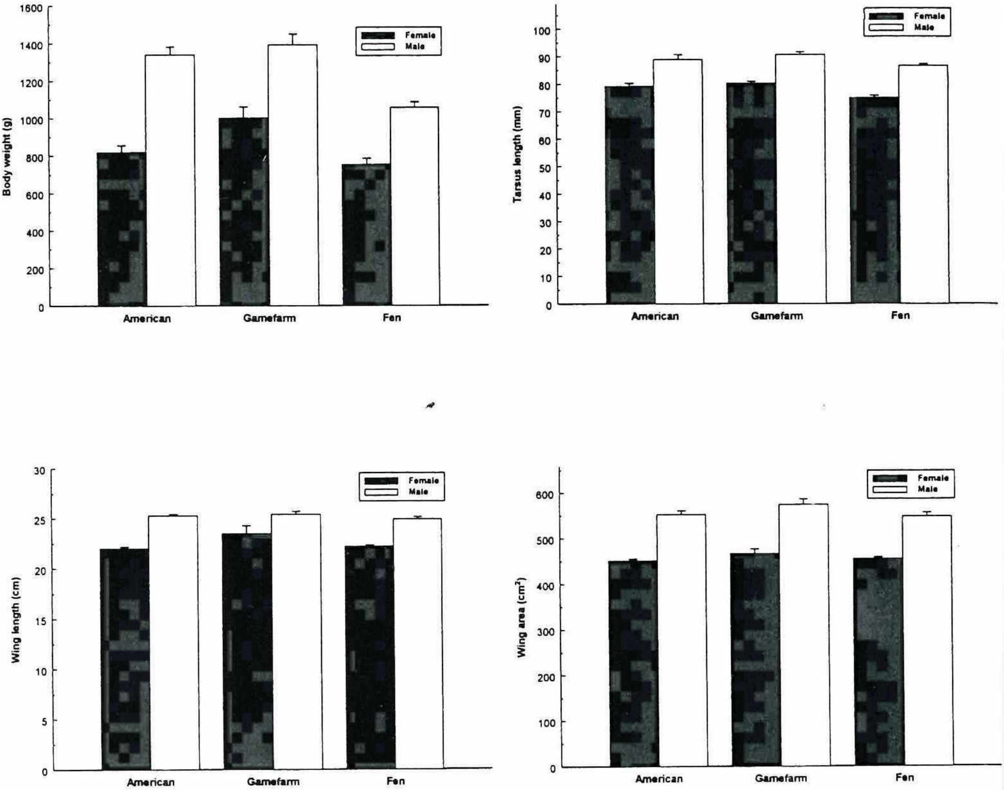

Figure 1. Body weight, tarsus length, wing length and wing area ($\underline{x}$ ± SE) of three pheasant strains reared together at age 17 weeks.

Mean take-off angle for all pheasants was (49.3° ± 1.66 SE, *n* = 62) and mean flap time was (5.9 sec ± 0.27 SE, *n* = 65). Take-off angle and flap time were correlated among all birds (r = 0.367, $\square^2$ = 8.44, 1 df, *P* = 0.004; **Figure 3**). Analysis of covariance revealed no relationship between our factor variables, covariates and take-off angle **(Table 2; Figure 4)**. The only significant variable describing flap time was body weight to wing area ratio (**Table 2, Figures 4,5**).

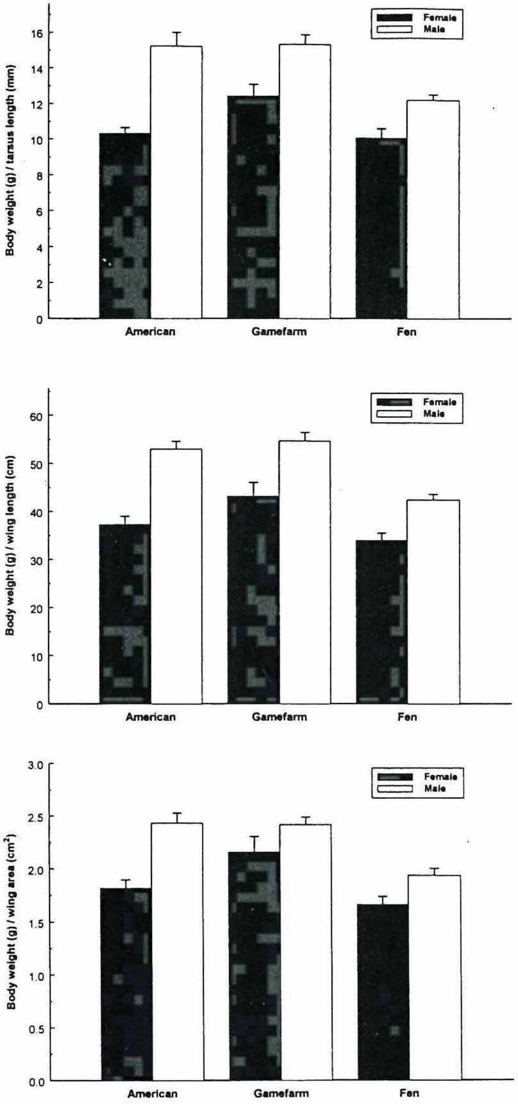

Figure 2. Body weight to tarsus length, wing length, and wing area (x ± SE) of three pheasant strains reared together at age 17 weeks.

Table 1. Correlation matrix and Bonferroni probabilities of morphological measurements for 3 strains of common pheasants measured at age 17 weeks.

	Body Weight	Tarsus length	Wing length	Wing area	BW/TL	BW/WL	BW/WA
Body Weight	-	0.770**	0.629**	0.727**	0.958**	0.973**	0.727**
Tarsus Length		-	0.616**	0.789**	0.562**	0.709**	0.574**
Wing Length			-	0.763**	0.547**	0.444*	0.394*
Wing area				-	0.604**	0.604**	0.379*
BW/TL					-	0.952**	0.923**
BW/WL						-	0.947**
BW/WA							-

* $P < 0.05$

** $P < 0.001$

Table 2. Analysis of covariance of take-off angle and wing flap time of three strains of common pheasants at 17 weeks of age. Strain and sex were main factors and body weight to wing area ratio and order were covariates.

	Take-off angle			Flap time		
Variable	df	F	P	df	F	P
Strain	2,54	1.56	0.22	2,57	0.62	0.52
Sex	1,54	0.37	0.55	1,57	0.00	0.99
Strain*sex	2,54	0.918	0.92	2,57	0.86	0.43
Body weight / wing area	1,54	0.56	0.56	1,57	4.71	0.03
Order	1,54	0.75	0.75	1,57	0.31	0.58

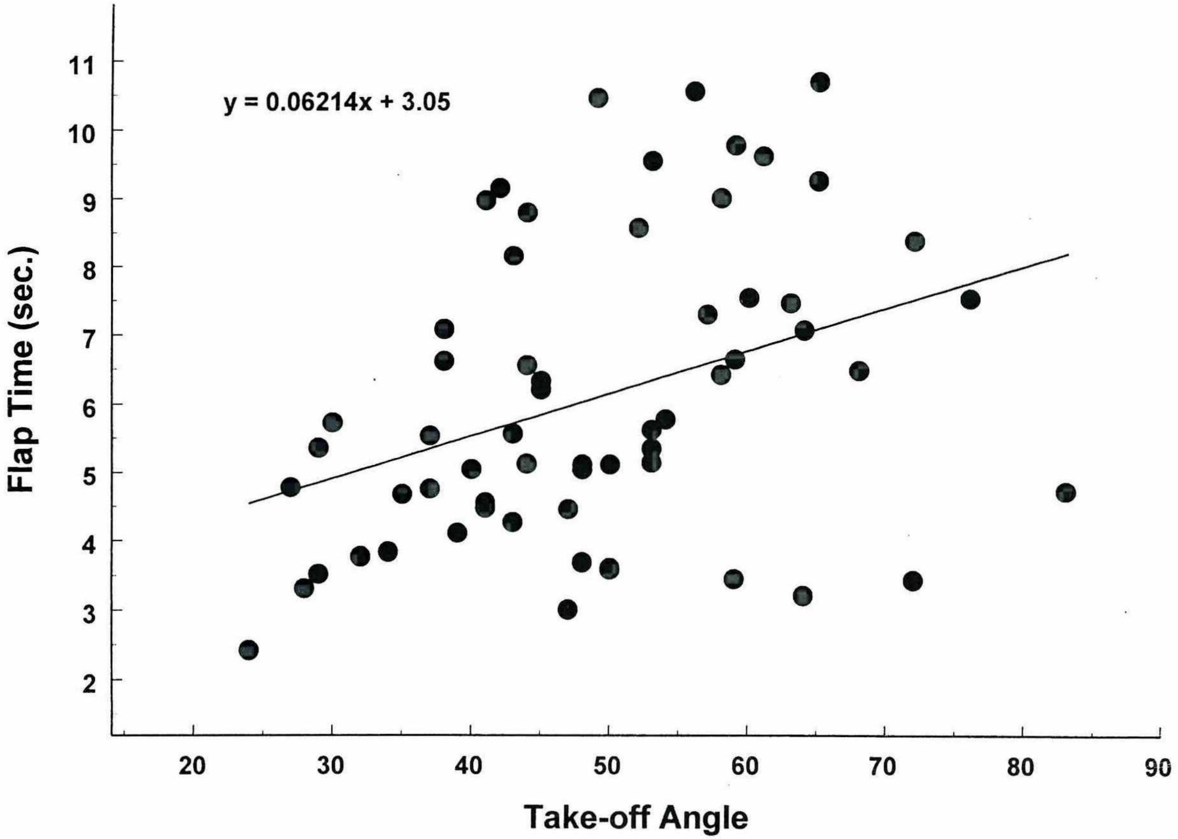

Figure 3: Relationship between take-off angle and flap time of pheasants (n = 58) during controlled release at age 17 weeks.

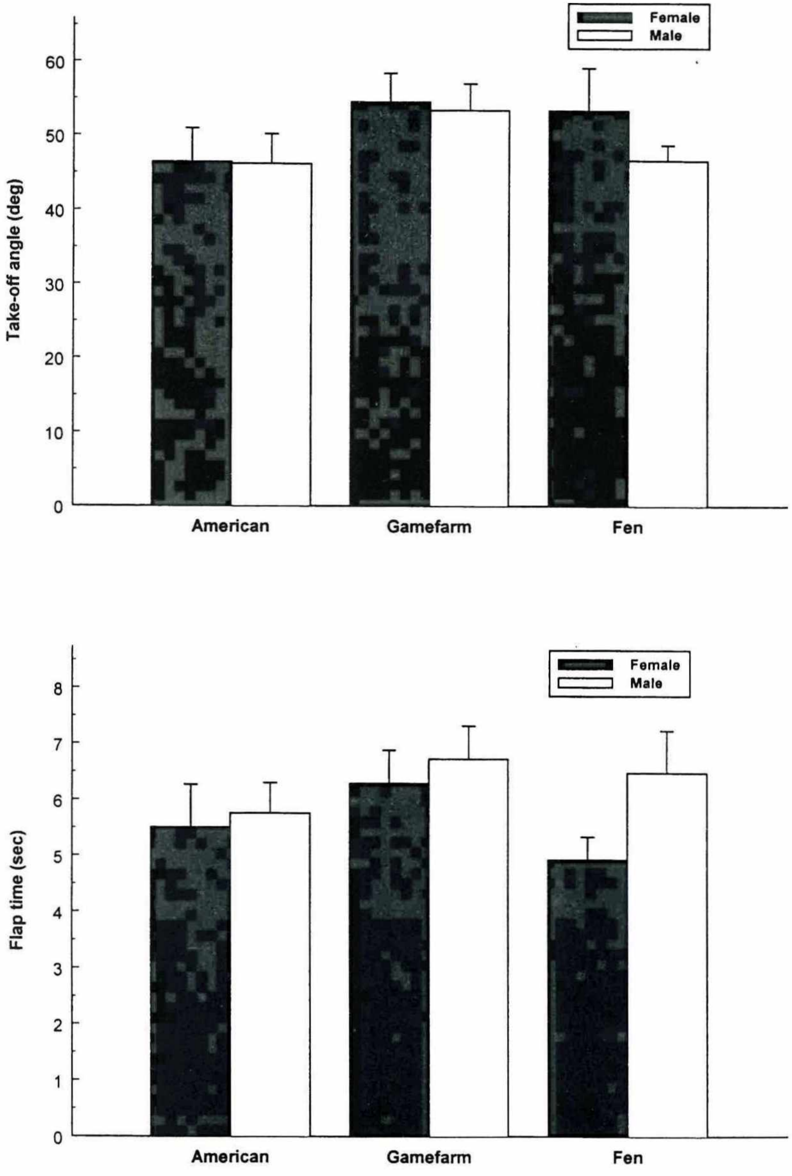

Figure 4. Take-off angle and wing flap-time (x̲ ± SE) of three pheasant strains during controlled release at age 17 weeks.

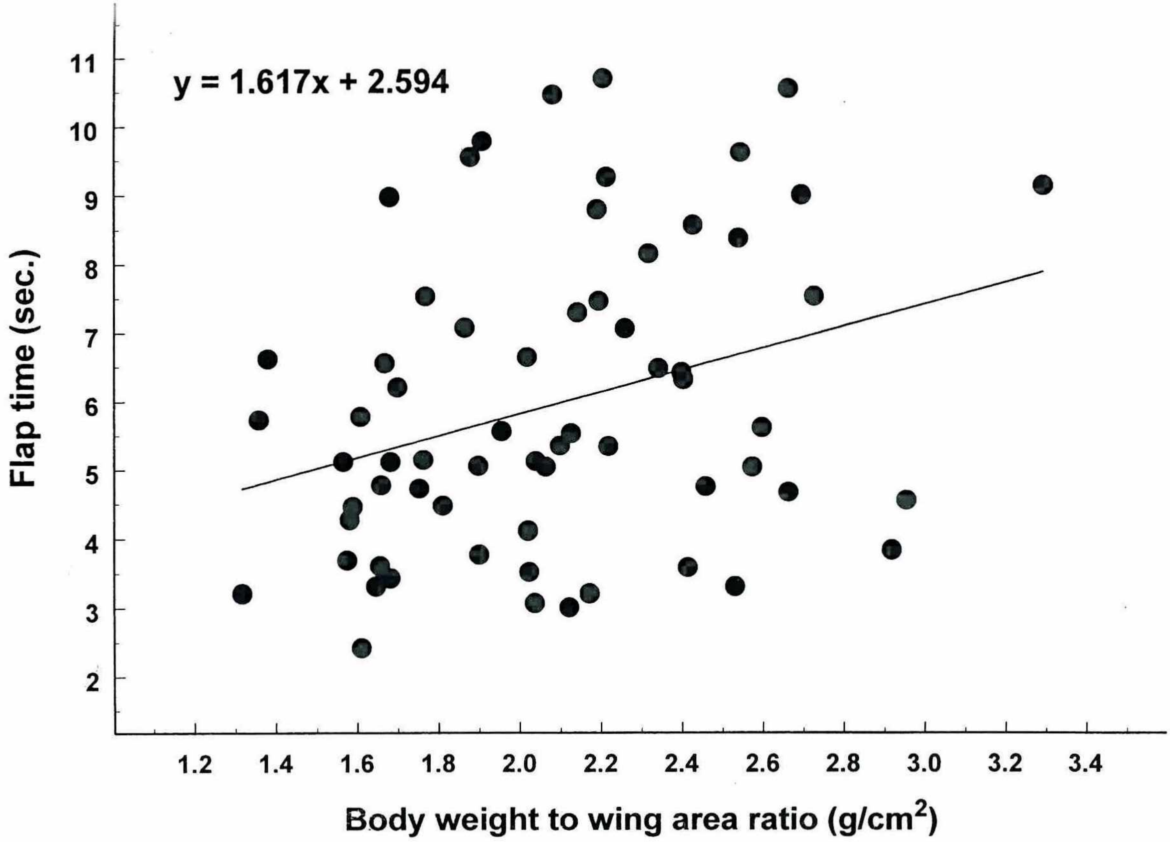

Figure 5: Relationship between body weight to wing area ratio and wing flap-time before gliding of pheasants ($\underline{n} = 65$) during controlled release at age 17 weeks.

4. DISCUSSION

We found that some of the widely reported morphological differences among strains of common pheasants do exist. However. the definition of size and how various morphological components vary among strains also differ widely. For example, selection of smaller pheasants over four years in one strain had significant effect on body weights of both sexes in those birds, but less of an effect on tarsus or wing length. We also found that differences among the strains also varied by sex. Selection of smaller Fen birds appeared to reduce the body weights of males much more so than females. We believe that gamekeepers and shooting people in Great Britain are using body weight as the primary size feature rather than actual skeletal differences. Selection for changes in morphology is probably a common feature of pheasant rearing in Britain whether the breeder knows it or not. However, comparing the large size of the "American" strain to the gamefarm strain suggests that this selection process is not very strong. When a breeder strongly selects for smaller (e.g. lighter body weight) birds, as has been done with the Fen strain, then body weight and wing loadings can be reduced.

Our data suggest that when pheasants flush under controlled conditions then strain nor any of the morphological characteristics we measured are good predictors of take-off angle. This occurs despite the rather large differences among strains in size and potential wing load characteristics. The fact that the one significant variable in the flap-time model was body weight to wing length ratio suggests that perhaps the pheasants use wing flapping to compensate for higher wing loadings. Previously, in field studies, CARROLL *ET AL.* (1997) could not make any connection between morphological characters and flight scores of pheasants. However, ROBERTSON *ET AL.* (1993) found that smaller "wild" strain pheasants flew marginally better than gamefarm pheasants.

There are a large number of potential explanations for why there is an apparent decline in the quality of flight performance of reared pheasants in Great Britain (CARROLL *ET AL.* 1997). Our data suggests that when local condition factors are controlled and we isolate one level of genetic variability, that of the strain, we cannot differentiate flight quality. However, this study identified only one potential aspect of flight performance. Other factors that we did not measure might also be important in affecting the way pheasants fly during driven shooting.

The anecdotal observations of superior flying strains of pheasants must then be related to some other mechanisms which may or may not be genetically controlled at the strain level. We suggest that behavioural mechanisms suggested by our results be investigated further.

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EFFECTS IN PREDATOR-PREY INTERACTION BETWEEN RED FOX AND PHEASANT IN MÜNSTERLAND (GERMANY)

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KEY-WORDS: Red Fox, Pheasant, predator-prey interaction, Germany, Münsterland

ABSTRACT

Nyenhuis, H.: EFFECTS IN PREDATOR-PREY INTERACTION BETWEEN RED FOX AND PHEASANT IN MÜNSTERLAND (GERMANY) : The population of the pheasant (*Phasianus colchicus*) in Münsterland, Germany, shows two cycles of abundance (hunting bags) during the time from 1961/62 to 1996/97. During this 36 year time-file, the red fox (*Vulpes vulpes*) bag stagnated until the end of the 80's,however,increased immensely after 1986/87 with two peaks at file' end. PEARSON's correlations with the species' bag-files and 36 time-files of monthly weather data found out effects between the animal populations and also weather influences. Up to 10 weather variables could be applied in linear multiple regression analyses. In the following, we present correlation coefficients ®, standardized regression coefficients (Beta) and T-values.The red fox population from the previous year, represented by the bag from the previous year, is mostly responsible for the population increase. The second step, the pheasant bag, shows a remarkable negative value as a consequence of pheasant's decline in relation to the 36 year period. The highest significant result with the pheasant bag is the simple correlation of temperature in the month of June, whereas 10 variables spectrum should also be regarded, during the bird's breeding period.This appears to be responsible for the development of invertebrates brood, under the aspect of the temperature in May.Many warm, dry and sunny days in the summer months give rise to an increase of the population, particular in August, when chicks of a second brood are born.The favourable influence of the pheasant population of the previous year as well as the negative red fox effect are of high importance in the birds table of ecological variables.

1. INTRODUCTION

The red fox' good choice is adapted to the population dynamics, consequently the density of its prey. The foxes' bill of fare reaches from worms and mice up to fawns and ripe plums. Papers on ecology of the red fox in relation to small animals point to a dependence of predation on environmental conditions. In fact, something is known about foxes' preying upon gamebirds by analysis of faecal material and stomach contents (LAMPIO, 1953; BEHRENDT, 1955; GOSZCZYNSKI, 1974; REYNOLDS AND TAPPER, 1995). Only few estimates on the effects of red fox bags on small game hunting bags were made in Germany (FRANK, 1970; SPITTLER, 1972; NYENHUIS, 1996). With this paper, we attempt to present estimates of the red foxes and the pheasants in a large biotope preferentially used by these birds. In order to receive a complete ecological model under mathematical aspects, we had to compute the animal abundances together with the data of weather conditions. The independent variables of temperature, rainfall and sunshine indicate the pheasant‘s dependence during the winter, spring and summer months on weather conditions. However, detailed records which would allow to determine the influence of conditions at their daily best or worst are not suitable in this study for models format. We also refrained from showing equally interesting correlations with the autumn months when the birds are bagged, because they mainly determine hunting success and perhaps hunting pressure.

2. STUDY AREA

The study was carried out in the Münster region, preferentially densely populated by pheasants (51°30`- 52°32`N, 6°25`- 8°20`W, **Figure 1.**). The ca. 505,000 ha hunting grounds are covered by 16% woodland. Deciduous forests with oak (*Quercus robur*) and beech (*Fagus sylvatica*) cover 50% of the wooded area. Arable land amounts to 61%, 38% of which is used for maize and corn-cob-mix (*Zea mays*) growth. About 17% of the hunting area is cultivated as pasture land (STATISTICS, 1995). In this type of lowland agricultural landscape – mainly sandy podzol, brown podzolic soils on Pleistocene and Holocene sand – the annual precipitation amounts to 770 mm, and the temperature to 9,6°C with 1,9°C in the month of January (mean values for a 36year period of research).

3. MATERIAL AND METHODS

As an indicator for the pheasant and red fox populations we used the hunting bags including the seasons 1961/62 to 1996/97, placed at our disposal by the office of Dr. H. SPITTLER (Forschungsstelle für Jagdkunde, Bonn). These records from the territory of Münster (Münster, Borken, Coesfeld, Recklinghausen, Steinfurt, Warendorf districts and the townships of Gelsenkirchen and Bottrop) were added to 36 year time-files. These chronologies were established for PEARSON correlations® with series of the 12 month weather data (temperature °C, precipitation mm and sunshine hours – ANONYMUS, 1961 to 1996), by using mean values from weather stations Münster and Bocholt. Together with the bags of the previous years, 10 weather variables could be applied in two linear multiple

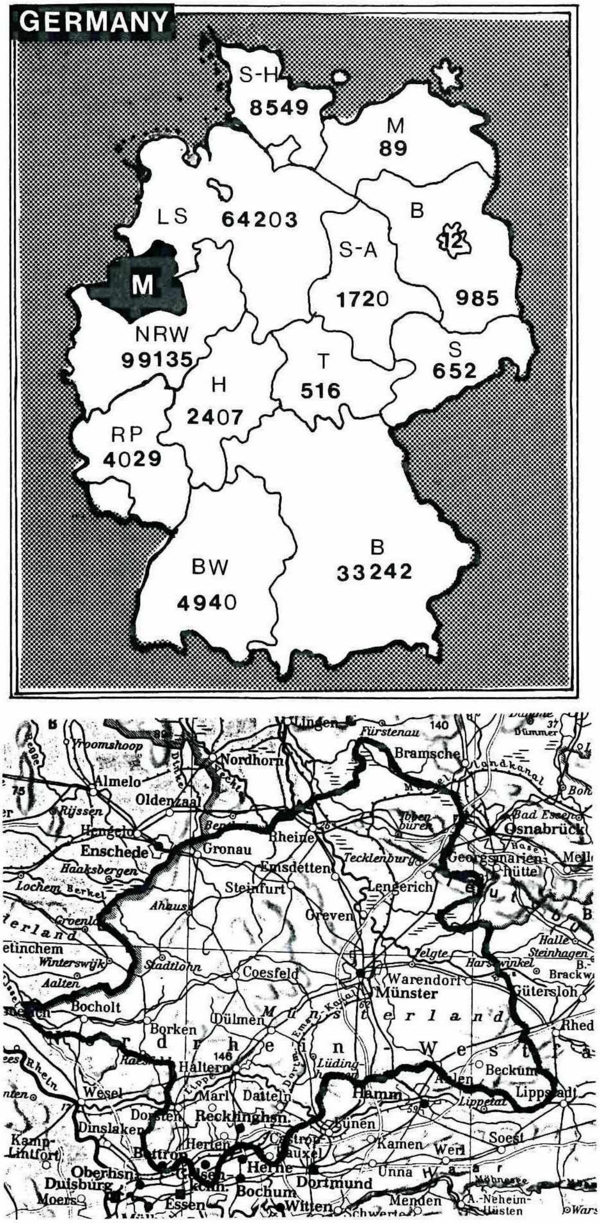

Figure 1.: Location of the study area (M = Münsterland) in the Federal Republic of Germany. Numbers refer to pheasant bags in the Federal Land's hunting season 1996/97 (after DJV Handbuch Jagd 1998,).

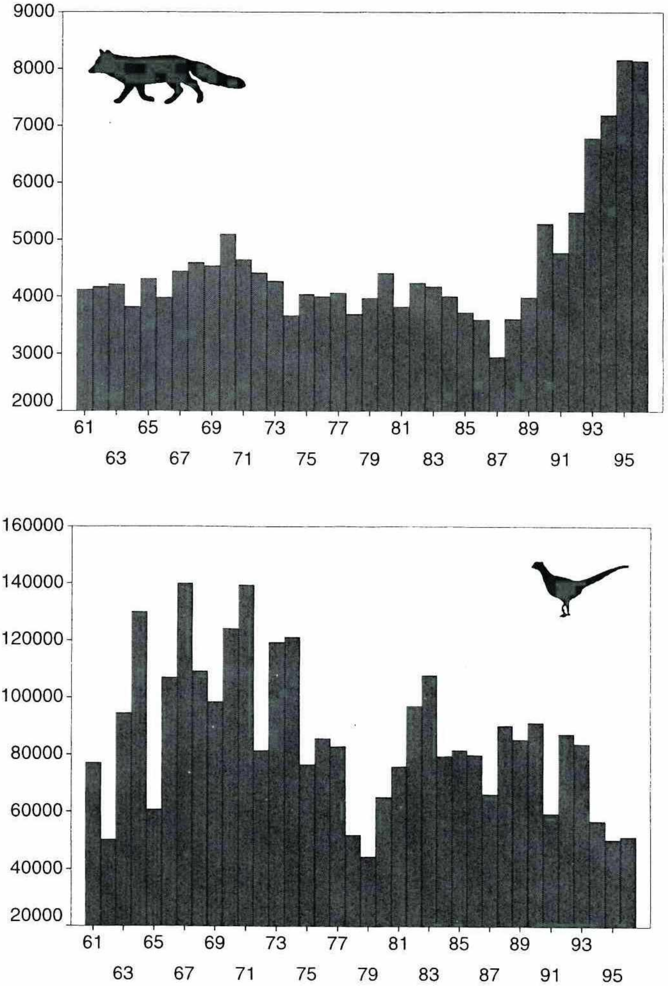

Figure 2.: Red fox hunting bag (above) and pheasant bag (below) in the territory of Münsterland from1961/62 until 1996/97.

regression models (KIM AND KOHOUT, 1975). In order to explain the share of variable influences, it is essential to calculate them in accordance with the standardized regression coefficients (Beta) and the T-values. Following the regression tests, the most important ecological results are scheduled in tables. Calculations and time-series were drawn at the Information center - University of Osnabrück - using SPSS-7,5 programs on windows NT.

Hunting bags 1961/62 to 1996/97

One can compare the animals' bag-ratios (**Figure 2.**), where the mean value of the pheasant shots amounts to 87450 birds, and that of the fox 4578 shot and caught du- ring the same period. Almost 140000 pheasants could be bagged in the seasons 1967/68 and 1971/72. The maximum in the red fox diagram amounts to 8168 animals in the 1995/96 hunting season. With regard to the pheasant bags, there is good reason to believe that the population on several hunting grounds was supported by release of hand-reared birds.

4. RESULTS

A characteristic feature of the area investigated, a parklike landscape, is the cause for the fact that the red fox density is not very high whereas the established pheasant population grew stronger here than anywhere else. The PEARSON correlations were known, 76 coefficients gave information on each relation. Though the number of variables is sufficiently high, the multiple regression program, which draws variables in a satisfying line, came to a stand still with the maximum of 12 variables (**Tables 1. and 2.**). Nevertheless, in any case, the quadratic R amounts to more than 0,50 (50%) of variance explained (red fox = 0,68 and 0,63 in the pheasant table).

For comparison, the estimated regression values of pheasant bags with those of the foxes and weather data were drawn in **Table 1**. These coefficients varied in their percentage from 3% to 10,6%. High valuations are found in the relation with the pheasants of previous year and rather the same result was achieved with the red fox bag. There are calculations of three winter months of medium percentage with a negative influene of precipitation in January and in the month of March. Sunshine hours still show a remarkable effect by the PEARSON correlations in February, however, the lowest positive relation was noted in the Beta announcement. During spring, three of five values are below on the average. Obviously, the population of pheasants is highly favoured by temperature increases in the month of May.

Table 1: Linear multiple regression of the pheasant R = 0,79. R = multiple correlation coefficient, PEARSON's r, Beta = standardized regression coefficient, mm = precipitation, °C = temperature, shs = sunshine hours, * significant, ** highly significant.

Variable	r	T	Beta	= %
Pheasant of previous year	0,37*	2,21	0,34	9,2 %
Red fox	-0,14	-1,82	-0,33	9,0 %
January mm	-0,34*	-1,21	-0,22	6,0 %
February °C	0,21	0,71	0,11	3,0 %
March mm	-0,33*	-1,27	-0,21	5,7 %
April °C	-0,05	-0,85	-0,14	3,8 %
April shs	0,08	0,85	0,15	4,1 %
May °C	0,31*	2,14	0,39	10,6 %
June °C	0,35*	0,42	0,11	3,0 %
June shs	0,29*	1,18	0,31	8,4 %
August °C	0,24	1,34	0,36	9,8 %
August shs	0,22	0,82	0,24	6,4 %
Residuals			0,77	21,0 %

Table 2.: Linear multiple regression of the red fox R = 0,83. For explanations, see **Table 1**.

Variable	r	T	Beta	= %
Red fox of previous year	0,85**	3,68	0,61	25,8 %
Pheasant	-0,14	-1,58	-0,24	10,2 %
January °C	0,18	-0,35	-0,07	3,0 %
January shs	0,23	-0,16	-0,03	1,2 %
February °C	0,20	1,19	0,20	8,5 %
February mm	0,02	0,36	0,06	2,5 %
February shs	-0,11	-0,35	-0,06	2,5 %
May °C	0,28*	1,38	0,20	8,5 %
May mm	-0,19	-0,55	-0,08	3,4 %
June mm	-0,16	-1,08	-0,15	6,4 %
July °C	0,39**	0,32	0,08	3,4 %
July shs	0,34*	0,63	0,18	7,6 %
Residuals			0,40	17,0 %

The negative influence of higher temperature on the pheasant in April should not be ignored. Sunshine hours in June seem to correspond with the temperature valuation of the previous month. Plenty warm and sunny days, highly determined by the temperatures, are favourable for the birds' population growth in August.

By weighting of the regression model, compared to significantly strong relationship, the red fox estimations show the conducive influence of the previous year population (**Table 2**.). The pheasant single correlation with the fox bag, lower than the average, was transformed by the regression program to an effect of second spread in the red fox table. Temperature and sunshine reveal as lowest but negative effects on the fox in January. On the other hand, temperature and precipitation are favourable for the predators in February. In the same month sunshine shows a negative correlation. The positive effects of climate factors on the pheasant densities in May and June is paralleled by the value of temperature effect on the fox in May. Precipitation does have a negative influence on the fox during this season. The highest estimates in PEARSON correlation with the temperature comes to a rather low positive result of Beta valuation in July, but a more significant factor in the red fox spectrum is the favourable effect of sunshine hours in this early summer month.

5. DISCUSSION

Predator and prey interrelationships together with weather conditions raise many questions. The immense red fox increase counts highest valuations compared with the 60's and 70's years. This stands for a successful offspring production and indicates the availability of adequate diet. It becomes evident, that the fox's influence on pheasant population is reflected similarly by the pheasant's influence on the fox population. This implies that the fox's preying on these birds is responsible for the large decline in pheasant density, today even more than ever (SPITTLER, 1972; VON SCHANZ in ARTOIS and BOUCHARDY, 1986). REYNOLDS *ET AL.* (1988) published 20 year curves of bag records from Southern Jütland during pheasant bag increase and one of the red fox decline during the increase of rabies from 1964 to 1974. For studies on the red fox population it might be interesting to know, that in the main rutting time, when temperature and sunshine play an important role for the survival of the fittest adult pheasants, the same weather factors stand for negative influences on the predator population in the month of January.

During winter seasons, losses of gamebirds, particulary those of non-migrating birds like the pheasant, can be dramatic. However, extremely low temperatures like during the „cold spell" of early 1963, when many pheasants died (ASH, 1964), and a severe winter like 1978/79 could be regarded as exceptional for the Westphalian lowland of the Münster area. In January 1993, 1994 and 1995 snow falls amounted to 109 mm in the study region (**Figure 3**.), a maximum of 21 days was snow covered so that pheasants had to scratch their way through

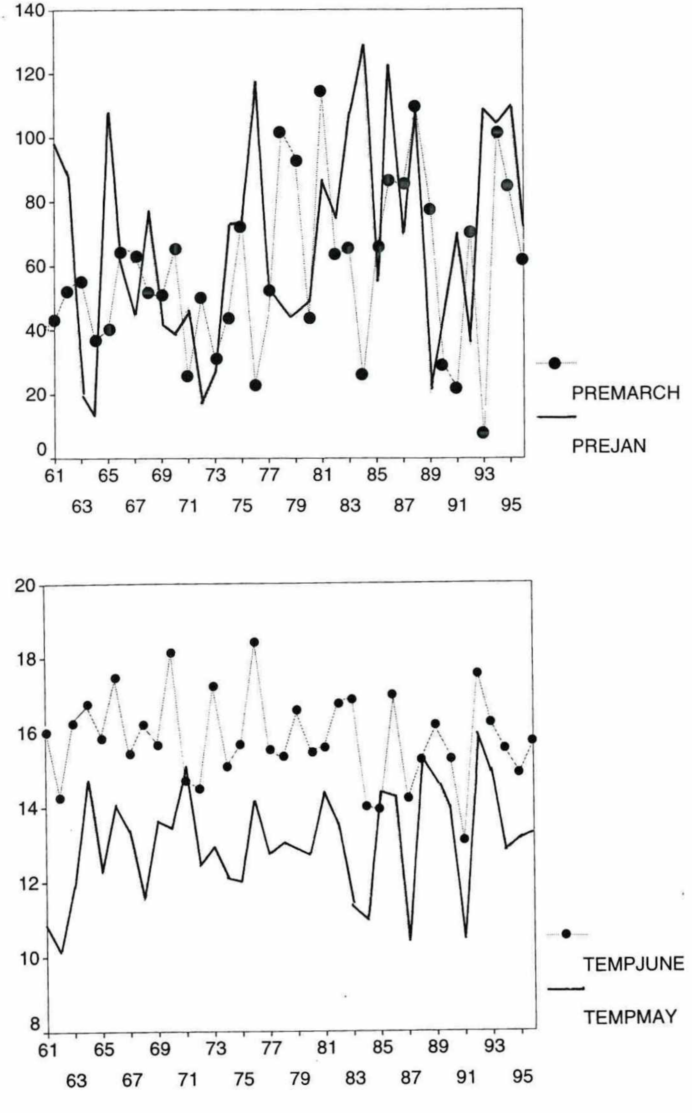

Figure 3.: Time-rows of precipitation mm (above) and temperature °C (below) in different months, mean values measured in Münster and Bocholt weather stations from 1961 to1996.

the soft snowcover, looking for food on fields of autumn sown wheat, barley and rye. Neither temperature nor snow appeared to be a problem in recent years. The cock pheasant courtship usually starts in the month of March, copulations, however, take place mostly in April (DIEZEL und MÜLLER-USING, 1970). Might it be that these higher temperature in April have a negative effect on pheasant recruitment efficiency? Calculations with a pheasant bag-file of western Lower Saxony show a more significant negative correlation with the temperature variable of this month (r = -0.36). During the female egg-laying and the development of invertebrates, the temperature has a favourable effect on the birds‘ population in the month of May. The data series therefore (**Figure 3.**) correspond with the birds‘ bag-file. KROLL (1973) and BEHNKE (1980) reported for the chicks‘ hatching success, that warm and sunny weather is favourable in June. Relations between lowest temperature in June 1991, after a lapse of 36 years (**Figure 3**.), and the decline of the birds‘ bag compared with the influences of different land use are discussed by NYENHUIS (this volume). Weather is an important factor for determining annual variations in the invertebrates‘ level. Plant bugs are more abundant during chicks‘ hatch if temperature in May does not drop below 12°C on average. In any case, low temperature will increase energy needs. For example BERGMANN (1987) explains the high energy demands of nidifugous birds as temperature dependent. Also protein diet favours the growing of the chicks at faster rate, so that they are able to fly and to escape ground predators earlier. In our study area there are mustelid hunting bags of highest density per ha hunting area, compared with other regions in the Federal Land of North Rhine-Westphalia. Polecat (*Mustela putorius*), Stoat (*Mustela erminea*) and Weasel (*Mustela nivalis*) register increasing hunting bags (NYENHUIS, 1998). In June 1998, adverse weather conditions in Münsterland area, during the chicks‘ hatching, influenced also chick mortality. In favourite pheasant habitats between Osnabrück and Münster, we often found females with only one chick.

Other density-dependent factors are also the predators. Clutch losses and preying on the brooding female will be important causes‘ for the decrease in pheasant population. In case of replacement clutches, if the first nest has been destroyed, chicks may hatch in the month of August. So it will not be a surprise that temperature and sunshine appear as favourable factors in this month. On the other hand, the release of young sensitive farm-bred birds happened mainly in August. A modern study of released pheasant influence on the wild population was made by KAMIENIARZ (1993), who selected cases where the efficiency of releasing farm-bred birds was constantly dropping. These are areas of intensive agricultural use and those with forests where large numbers of predators are present, where it seems necessary to stop releasing. In Münsterland hunting-grounds, where the pheasant is mainly shot, hunters consider it necessary to release hand-reared birds (SPITTLER, pers. com.). Thus, wild stocks will be protected because wild populations will not be overutilized. Here, releasing of hand-reared birds is permitted by prohibition from 1992 later than 1st of August. Like in Hungary the rate of artificially reared pheasants declined from 60% (NAGY, 1986) to 34% and 47% (SZENDREI, 1996), a decline of released birds in North Rhine-Westphalia can give reference to the decrease of the pheasant hunting bag during this study last three years.

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WINTER MEASUREMENTS OF DEEP BODY TEMPERATURE IN THE RING-NECKED PHEASANTS BY RADIOTELEMETRY

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KEY-WORDS: circadian rhythm, body temperature, telemetry, pheasant, *Phasianus colchicus*, winter.

ABSTRACT

PIS, T., GÓRECKI, A. and KOZIK, B.: WINTER MEASUREMENTS OF DEEP BODY TEMPERATURE IN THE RING-NECKED PHEASANTS BY RADIOTELEMETRY. The circadian rhythm of deep body temperature of the pheasant was studied by radiotelemetry. We conducted the study in winter 1993 and used four one-year-old males. We analyzed our data sets by autocorrelation method. 24-hour rhythm of deep body temperature was observed in all animals. The amplitude of the rhythm (difference between the lowest and the highest temperature in each cycle) was 2.3°C, on average. Results are indicative of the endogenous rhythm of birds` body temperature.

1. INTRODUCTION

The rhythms of body temperature in animals focus interests from two large groups of researchers: those who study the regulation of temperature and those who study biological rhythms (ASCHOFF, 1983; REFINETTI and MENAKER, 1992). The telemetric studies of deep body temperature over long periods have to date been conducted mainly in rodents: mice and voles (*Microtus arvalis*) (ISHII *ET AL.*, 1996), European hamsters (*Cricetus cricetus*) (WEINER and GÓRECKI, 1975; WOLLNIK and SCHMIDT, 1995), golden hamsters (*Mesocricetus auratus*) (REFINETTI, 1994; BROWN and REFINETTI, 1996), ground squirrel (*Spermophilus tridecemlineatus*) (REFINETTI, 1996). Only a few of such studies regard birds, and particularly game birds. The pheasant (*Phasianus colchicus*) is the most popular game bird species in Poland; the first introduction efforts date back to as early as the 18th century. High mortality among pheasants during winter has attracted attention of researchers (HILL and ROBERTSON, 1988; KAMIENIARZ, 1990). In the second half of summer, the pheasants change their plumage and build up fat reserves (HILL AND ROBERTSON, 1988). It seems, however, that these processes do not increase the thermal conductance in winter compared with summer (GÓRECKI and NOWAK, 1990). Our basic objective was to investigate the changes of deep body temperature of pheasants in winter.

2. MATERIALS AND METHODS

The experiments involved four one-year old male pheasants (*Phasianus colchicus* L.) (designated P1, P2, P3 and P4) with body mass approx. 1,300 g each. The birds were obtained from a specialised breeding farm at Strazów near Rzeszów (South-eastern Poland). The measurements of deep body temperature were conducted in January 1993. The design of radio-transmitters followed the pattern of electronic blocking generator (WEINER and GÓRECKI, 1975). Each transmitter was placed in a hermetic polyethelene case and coated with wax. The cylindrical transmitters had 32 mm length, 12 mm diameter and weighed approx. 4 g each. Prior to the implantation they were individually calibrated in an isotonic saline with accuracy to the nearest 0.1°C. The transmitters were then implanted into the peritoneal cavity of the four birds under local anaesthesia with 2% solution of lidocaine hydrochloride. The recording of deep body temperature commenced one week after implantation. The birds were placed in separate cages (1 m in length, 1.2 m in diameter) arranged in an open aviary. Each cage was encircled by a receiving antenna. The signals from the transmitters were received on medium wavelength at 1,200 - 1,500 kHz frequency range, by portable radio receivers. During the measurements the birds were fed *ad libitum* wheat grain and granulated dicotyledon plant fodder, and provided with water and snow. The measurements were recorded every hour and at down and dusk, at every half an hour. Each measurement was repeated to avoid errors. The deep body temperature measurement were coupled with recorded measurements of ambient temperature, using a PT-217 digital thermometer (Elmetron, Poland) with accuracy to the nearest 0.1°C. Night (dark phase) lasted approximately 15 hours (from 4.30 PM to 7.00 AM). The analysis of time series was performed by autocorrelation taking into account data from equal 1-hour long intervals. The method is based on that, if there exists rhythmicity in a data set, then the data points in a subset of a given length (period) will have the highest correlation with the chosen length corresponds to the true length of the cycle (REFINETTI, 1993). Values given in text and tables are mean ± S.E.

3. RESULTS

Ambient temperatures dropped during night hours and raised during the day (**Figure 1.**). The highest temperature, recorded in the first day of the experiment was about 0°C, the lowest, about -13°C in the fourth day of the experiment (**Figure 1.**). The autocorrelation analysis revealed almost ideal 12-hour cycle of body temperature (**Table 1., Figure 2.**). The highest values of correlation coefficients were 0.90 ± 0.104 for P2 pheasant and 0.91 ± 0.103 for P4 pheasant (**Table 1.**). The average level of the deep body temperature (an arithmetic average for all temperatures in a cycle) ranged from 40.7°C in P2 pheasant to 41.4 °C in P3 pheasant (**Table 2.**). The amplitude of body temperatures (as difference between the highest and the lowest temperatures in a cycle) ranged from 2.0 °C in P1 pheasant to 2.6°C in P2 pheasant (**Table 2.**).

4. DISCUSSION

Telemetric methods allow stress-free (after a short recuperation period) measurements of body temperature under aviary conditions without the necessity to handle them manually. This results in more credible measurements.

The main features of the body temperature cycle in animals include: period, shape (wave form: temporal distribution of low and high temperatures), amplitude (wave height: the difference between the lowest and the highest temperature in each circadian cycle), mean level of the circadian body temperature rhythm (temperature value around which circadian variations are imposed), and phase (low or high) (REFINETTI AND MENAKER, 1992). Some of these parameters, particularly the shape and amplitude may be affected by environmental factors such as ambient temperature and presence or absence of external time cues (ASCHOFF, 1983). Homeostatic control of the body temperature in homoiothermic animals undergoes modulation in 24-hour periods which normally result in a shape reminding of cosine wave and an amplitude within 1 – 3 °C range (REFINETTI AND MENAKER, 1992). In this study, the greatest amplitude of body temperature was 2.6 °C in five days of experiment (**Figure 1.; Table 2:** P2 pheasant). Much greater amplitudes in 24-hour cycle and irregular shapes were found in hibernating animals and those relapsing into torpor (LYMAN *ET AL.*, 1982). Great amplitudes in 24-hour distribution of body temperatures are also known in small passerine birds (REINERTSEN, 1982) and in diving birds (reaching as much as over 5 °C) (WILSON AND GRÉMILLET, 1996).

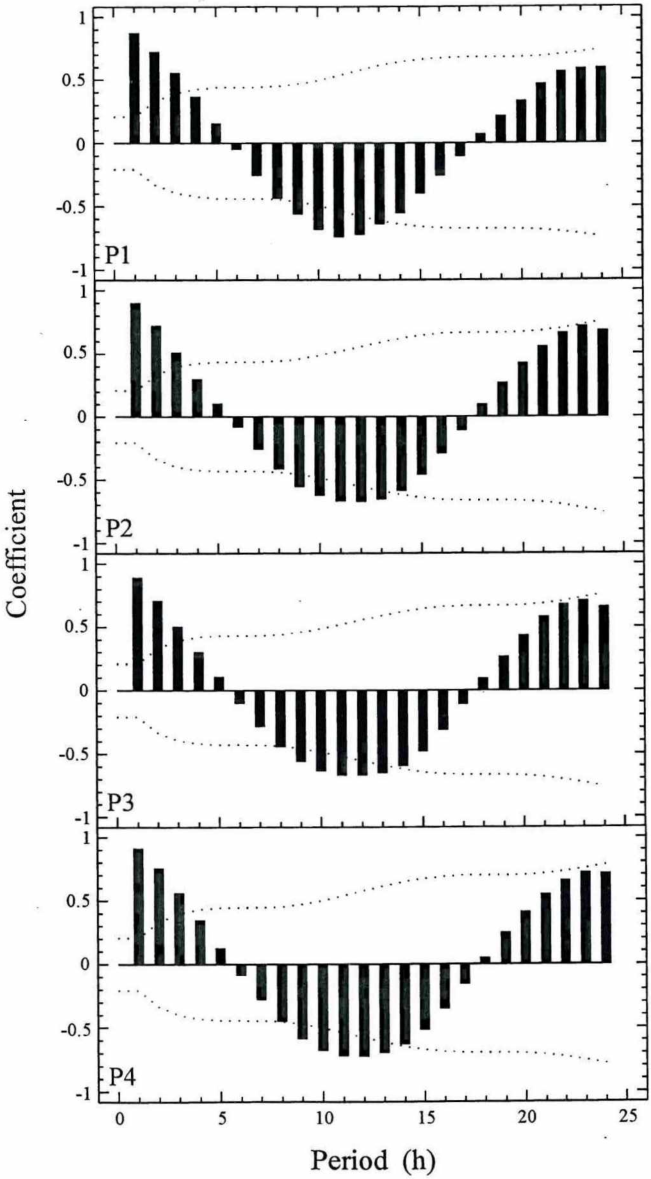

Figure 1.: Five-day section of the records of deep body temperature of four pheasants (P1, P2, P3 and P4) (upper graphs) and ambient temperature (lower graph). The light and dark bars at the bottom of the figure indicate the light and dark phases of the light-dark cycle.

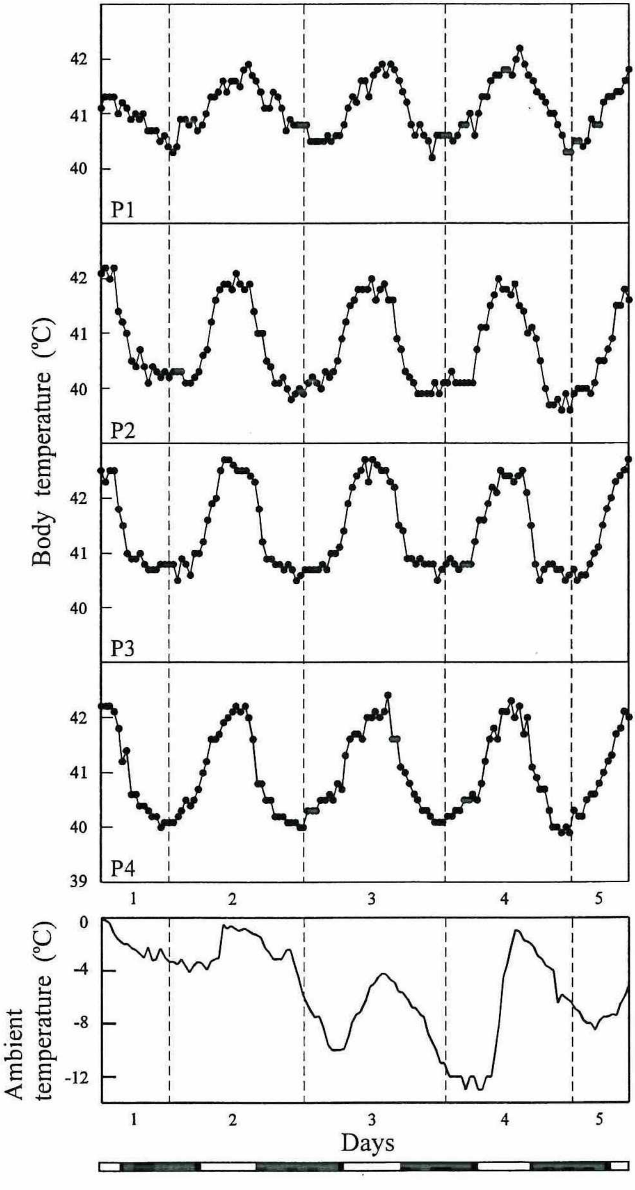

Figure 2. : Autocorrelation plots of deep body temperatures data set for each pheasant (P1, P2, P3 and P4). The heights of the bars represent the estimated correlation coefficients, the dotted lines are plotted at zero plus and minus twice the large lag period standard errors for each coefficient.

Table 1.: The estimated coefficients of correlation and standard errors for data on deep body temperatures in four pheasants (P1, P2, P3 and P4)

Nr of bird	Period (h)	Coefficient of correlation	S.E.	Period (h)	Coefficient of correlation	S.E.
P1	1	0.87	0.104	13	-0.64	0.307
	2	0.72	0.165	14	-0.55	0.321
	3	0.55	0.197	15	-0.40	0.331
	4	0.36	0.213	16	-0.25	0.336
	5	0.15	0.219	17	-0.10	0.338
	6	-0.05	0.221	18	0.07	0.339
	7	-0.25	0.221	19	0.21	0.339
	8	-0.43	0.224	20	0.33	0.340
	9	-0.56	0.233	21	0.46	0.344
	10	-0.68	0.247	22	0.56	0.350
	11	-0.74	0.267	23	0.59	0.360
	12	-0.72	0.288	24	0.59	0.370
P2	1	0.90	0.104	13	-0.65	0.295
	2	0.72	0.168	14	-0.59	0.310
	3	0.51	0.199	15	-0.46	0.322
	4	0.30	0.212	16	-0.29	0.329
	5	0.10	0.217	17	-0.10	0.332
	6	-0.08	0.217	18	0.09	0.332
	7	-0.25	0.218	19	0.27	0.332
	8	-0.41	0.221	20	0.42	0.335
	9	-0.55	0.229	21	0.55	0.340
	10	-0.62	0.243	22	0.66	0.350
	11	-0.67	0.260	23	0.71	0.363
	12	-0.67	0.278	24	0.68	0.378
P3	1	0.87	0.104	13	-0.65	0.295
	2	0.70	0.167	14	-0.59	0.310
	3	0.50	0.197	15	-0.48	0.322
	4	0.30	0.210	16	-0.31	0.330
	5	0.10	0.215	17	-0.11	0.333
	6	-0.10	0.215	18	0.09	0.333
	7	-0.30	0.216	19	0.26	0.334
	8	-0.44	0.220	20	0.43	0.336
	9	-0.56	0.229	21	0.58	0.342
	10	-0.63	0.243	22	0.67	0.352
	11	-0.66	0.260	23	0.70	0.366
	12	-0.67	0.278	24	0.65	0.380
P4	1	0.91	0.103	13	-0.70	0.308
	2	0.75	0.168	14	-0.62	0.324
	3	0.56	0.200	15	-0.51	0.337
	4	0.34	0.216	16	-0.35	0.345
	5	0.12	0.222	17	-0.15	0.349
	6	-0.08	0.223	18	0.05	0.349
	7	-0.28	0.223	19	0.24	0.349
	8	-0.45	0.227	20	0.41	0.351
	9	-0.59	0.236	21	0.54	0.356
	10	-0.68	0.251	22	0.65	0.365
	11	-0.72	0.270	23	0.72	0.377
	12	-0.72	0.289	24	0.71	0.391

Table 2.: Summary statistics of deep body temperatures data set for each pheasant (P1, P2, P3 and P4).

Variable	P1	P2	P3	P4
Sample size	127	126	125	126
Average	41.1	40.8	41.4	41.0
Standard error	0.04	0.07	0.07	0.07
Minimum	40.2	39.6	40.5	39.9
Maximum	42.2	42.2	42.7	42.4
Range	2.0	2.6	2.2	2.5

The parameters of circadian rhythm of temperature differ between species. It seems that in large and medium-size homoiothermic animals the amplitude of body temperatures is too small to provide significant saving in their energy budgets. To date, most of the regular measurements of the circadian rhythm of body temperature in birds and mammals have been done under thermoneutral conditions. In low ambient temperatures the differences between the highest and lowest body temperatures could be greater (REFINETTI and MENAKER, 1992; PIS, unpublished data).

The changes in body temperatures may result from three processes: changes in heat generation, changes in heat losses, or a combination of the two. The available data suggest that the main factor is heat loss as body temperature can display a normal circadian rhythm even when the heat production is kept at an unchanged level (BROWN and REFINETTI, 1996). The heat production seems to be correlated more closely with the circadian rhythm of activity rather than with the circadian rhythm of body temperature (REFINETTI and MENAKER, 1992). In most studies where locomotor activity and body temperature were measured simultaneously, these variables displayed fairly similar circadian patterns (REFINETTI and MENAKER, 1992; ISHII *ET AL.*, 1996). According to many researchers the fact that these both processes occur together results from their common endogenous time controlling mechanism (ASCHOFF, 1983; REFINETTI and MENAKER, 1992; SCHMIDT-NIELSEN, 1992; BROWN and REFINETTI, 1996).

Are the circadian rhythms of deep body temperature sufficient adaptation of pheasants to survive winters occurring in Poland? Lowering their body temperature during the night results in decreasing the gradient of body and ambient temperatures which results in reducing heat loss from the body (SCHMIDT-NIELSEN, 1992). GÓRECKI and NOWAK (1990) proved that there were seasonal differences between male pheasants (lower temperature in winter) which indicate a reduced energy cost of thermoregulation. However, the body temperature on that study was taken in the rectum during metabolism rate studies. The differences between the highest and lowest body temperatures in pheasants found in the the circadian rhythm in the present experiment were surprisingly great as for such large birds (**Table 2.**). Thus it cannot be excluded that in severe winters the pheasants can fall into a kind of torpor.

In conclusion it can be stated that the deep body temperature in pheasants changes in a circadian pattern (following almost ideal 12-hour long periods) with clearly higher level during the day then in the night. It is likely that this rhythm is endogenous but still liable to modifications by some environmental factors.

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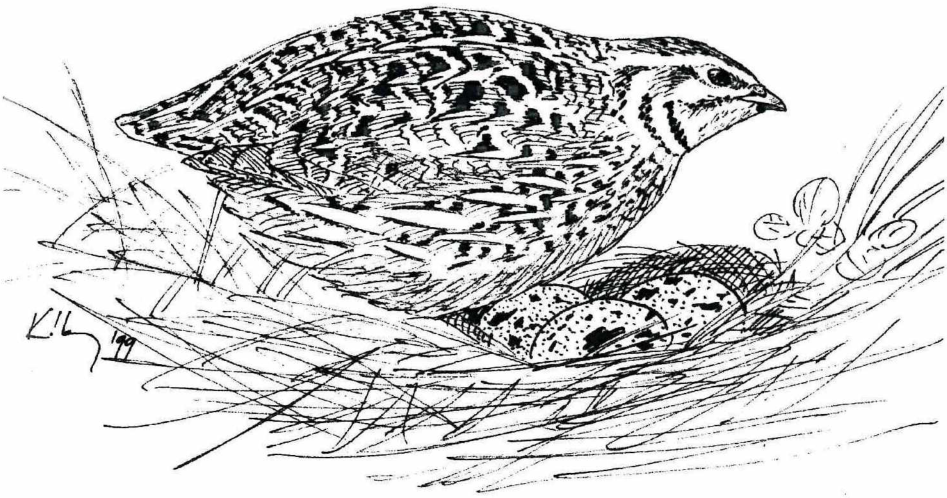

INDICATORS OF MALE QUALITY IN THE CALL OF THE COMMON QUAIL *Coturnix coturnix*

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KEY-WORDS: Common quail, *Coturnix coturnix*, indicators of male quality

ABSTRACT

PUIGCERVER, M., ROGRIGUEZ-TEIJEIRO, J.D., ZIJLSTRA, W., BONET, V. and GALLEGO, S.: INDICATORS OF MALE QUALITY THE CALL OF THE COMMON QUAIL (*COTURNIX COTURNIX*):The Common Quail (*Coturnix coturnix*) is a Galliforme species whose reproductive cycle occurs inside dense cereal crops; for this reason, most communication between individuals is vocal.

It is well known that unpaired males use a very stereotyped advertising trisyllabic call, or triplet, onomatopeically described as Awet my lips; moreover, mate switching has been observed for almost 75 % of females, which actively induce divorce by soliciting other males of higher body condition. However, we still do not know whether the body condition of males is reflected in their song.

To test this hypothesis, we captured 54 males during 1995-97 in Catalonia (Northeast Spain), analysed a total of 605 triplets with Multi-Speech 3700 software in a personal computer (syllable length and interval time between syllables) and measured body condition of these individuals by rescaling body mass to a user-defined standard (an average of wing length), taking allometry into account.

The results of a discriminant analysis show that time intervals between syllables are the two variables that allow us to distinguish between individuals best. Moreover, a significant correlation between an interval ratio (interval 1 divided by interval 2) and body condition index has been found ($r=0.38$, $n=36$, $p=0.024$) when body condition index does not reach low values.

These results indicate that this ratio may, in certain circumstances, provide a cue as to the status males; because of their stereotyped structure, male calls may be good cues that can be used by females as honest signal to distinguish males and their quality. However, other cues still not found may also be involved in the choice of males by females.

1. INTRODUCTION

The Common Quail (*Coturnix coturnix*) is a Galliforme species whose reproductive cycle occurs inside dense cereal crops (GLUTZ *ET AL*. 1973). The tall cover of these areas allows the bird to live a secretive life, and it is very difficult to see. This fact explains that most communication between individuals is vocal instead of visual and that the species posseses a wide range of calls (GUYOMARC'H and GUYOMARC'H 1996).

It is well known that unpaired males use a very stereotypic advertising trisyllabic call or triplet, onomatopeically described in English literature as "wet my lips" and preceded by a low pitched vibrato ("waw-waw") (CRAMP and SIMMONS 1980). The temporal structure of triplets is very constant and has low intra-individual variation (SCHLEIDT and SHALTER 1973, PINCZON DU SEL & GUYOMARCH 1991); moreover, since there are large interindividual differences, these triplet calls can distinguish individual males (SCHLEIDT 1983, PINCZON DU SEL and GUYOMARCH 1991).

During the breeding season in Europe, the sex-ratio is very skewed, favouring males. In Spain there are almost five males for every female (RODRÍGUEZ-TEIJEIRO *ET AL.* 1992). This would lead females to exert stringent sexual selection, especially when it is taken into account that males provide no parental care and that their mean life span is fairly low (0.8 years, PUIGCERVER *ET AL.* 1992).

Mate switching has been observed for almost 75 % of females (RODRIGO-RUEDA *ET AL.* 1997). Within one breeding period, a female may divorce her partner for a male with a higher body condition index. Also, in male-male fights that were observed in previous studies, the winner always had the better body condition index.

This divorce is thought to be induced by the female (see RODRIGO-RUEDA *ET AL.* 1997 for more details). Due to the constant inflow of new males throughout the breeding season (RODRÍGUEZ-TEIJEIRO *ET AL.* 1992), by soliciting other males and thus initiating male-male competition, the female optimizes the quality of her partner at any given moment. One way for a female to obtain information about a prospective partner might be the calls of the male. Judging by their calls, the female would invite certain males to come and strive for her.

The hypothesis of this study is, then, that the stereotypic structure of the trisyllabic advertising call of males may reflect body condition, thus providing a cue in mate choice.

In other species of birds the cues to quality males are song rate and repertoire (length and complexity) (see for example CATCHPOLE 1987, HOI-LEITNER *ET AL.* 1993, HORN *ET AL.* 1993, LAMPE and ESPMARK 1994, LAMPE and SAETRE 1995, SEARCY 1992). The song rate usually is correlated with the size, body condition or/and quality of the territory (see for example APPLEBY and REDPATH 1997, GALEOTTI *ET AL.* 1997, NYSTRÖM 1997); however, the Common Quail is not a territorial species (PUIGCERVER 1990). With regard to the repertoire, sexual song in the Common Quail is reduced to the triplet call and to the low pitched vibrato (pre-sexual call), which can be heard only at short distances. For these reasons, it is possible that females of Common Quail use other cues related to song, like the structure of the triplets.

2. MATERIAL AND METHODS

Four breeding sites of Catalonia (Northeast Spain) were used in this study: Alp (Girona Province, 421 23 N 11 53 E, altitude 1.158 m), Sant Boi de Lluçanés (Barcelona Province, 421 03 n 21 09 E, 810 m), Mas Esplugues (Tarragona Province, 411 25 N 11 23 E, 628 m) and Pla de Santa Maria (Tarragona Province, 411 22 N 11 15 E, 400 m). The main crops in these areas are wheat and barley.

During the breeding seasons 1995-97 (from April to July), we captured 54 males, which were induced to call by playing a tape-recording of a female call. This decoy was also used to lure the males into a net. Recordings of males were made using a Philips DCC 170 recorder and a Philips LB 9098/20 uni-directional microphone.

We analysed a total of 605 triplets of these 54 individuals with Multi-Speech 3700 software in a personal computer. We measured syllables length (syll1,syll2 and syll3) and interval time (or distance) between syllables of the male advertising call (Entre 1-2 and Entre 2-3) (see **Figure 1**). All these temporal variables were measured in milliseconds, with an error margin of about 0.5 ms. No frequential or energetic variables were analysed, since the conditions of recording (for instance distance between individual and microphone, wind, etc.) were too variable.

To normalize the males, and thus control for the effect of size on weight, we calculated a body condition index following SENAR *ET AL.* (1994).The method consists of rescaling body mass to a user-defined standard, taking allometry into account. Wing length was used to correct for allometry.

3. RESULTS AND DISCUSSION

To show that individuals can be distinguished on the basis of the structure of their song, we applied a step-wise discriminant analysis (**Table 1**). Four of the five variables defined in material and methods section were used in the model. As can be seen in table 1, intervals between syllabes allow us to correctly classify the 97.33 % of the cases. This results of individuals recorded in field conditions support those obtained by other researchers (SCHLEIDT 1983, SCHLEIDT and SHALTER 1973, PINCZON DU SEL and GUYOMARC'H 1991) in laboratory conditions, clearly showing that the features which allow distinctiveness are those which constitute the rhythm of this call.

For this reason, we have generated a new variable, Entre 1-2/Entre 2-3, or interval rate, because it summarizes the call rhythm in just one variable.

As BRIANT AND JONES (1995) have shown in *Delichon urbica*, body condition index may vary from one year to another depending on the severity of the African winter. In our study, body condition was similar for the years 1995 and 1996, but in 1997 it was significantly lower (t=2.07, 51 d.f., p=0.04) (**Figure 2**). For this reason, we decided to split data into two different sets for further analyses: that of 1995+1996 and that of 1997.

Table 1. Discriminant analysis carried out to distinguish individuals on the basis of the structure of their song. Variables analysed were syll1, syll2, syll3, entre 1-2 and entre 2-3. F to enter: 3.84; F to remove: 2.71.

STEP	VARIABLE ENTERED	WILKS	% OF VARIANCE	CUMULATIVE %
1	Entre 1-2	0.0285	75.88	75.88
2	Entre 2-3	0.0026	21.45	97.33
3	Syll 1	0.0006	2.31	99.64
4	Syll 2	0.0004	0.36	100.0

No significant correlations were found between body condition and the five variables describing the structure of male call, nor with the total length of the call, with one exception: there was a significant correlation between the interval ratio (Entre 1-2/Entre 2-3) and body condition index for the data set corresponding to 1995+1996 (r=0.38, n=36, p=0.024; regression line: Entre 1-2/Entre2-3=-0.756+0.0327*BCI; r^2=0.12, F=5.60, p=0.024) (**Figure 3**). Males with a high body condition have a relatively short second interval. However, no correlation was found for the set of data of 1997.

No significant correlations were found between morphometrical variables (wing length, weight) and those describing the song structure of the male, included interval ratio.

We conclude that this interval ratio reflects body condition in years in which it reaches normal values and, therefore, it may serve as an indicator of male quality. We must bear in mind that, due to their stereotypic structure, calls distinguish males and their quality.

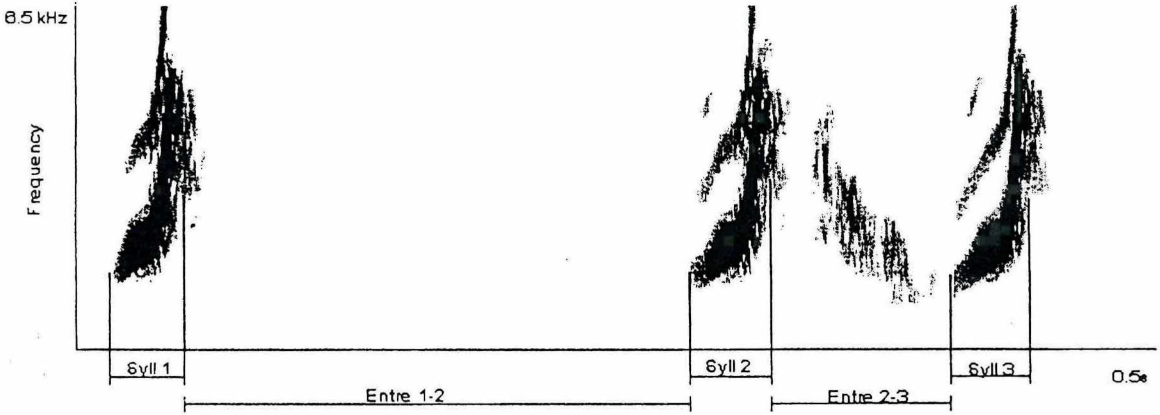

Figure 1: Sonagram of the trisyllabic advertising call of males showing the five measurements involved in this study: the length of syllables (syll 1, syll 2, syll 3) and the distance between syllable 1 and syllable 2 (Entre 1-2), and between syllable 2 and syllable 3 (Entre 2-3).

However, this cue seems to be valid only in those years in which body condition reaches normal values. Moreover, the coefficient of determination found is rather low (0.12); these facts strongly suggest that females could use multiple cues in mate choice. In the Ipswich sparrow, females use two different cues for mate choice: the size of the territory and the song rate; however, the relative importance of each cue varies from year to year (REID & WEATHERHEAD 1990). These other cues could be, in the Common Quail:

a) The rate of song: this seems to be an important cue in a nonterritorial icterid species without parental care, *Molothrus ater* (WEST *ET AL.* 1981).

b) The pre-sexual call (waw-waw) could contain complementary information for mate choice. According to GUYOMARC'H *ET AL.* (1998), unmated females are preferentially attracted by this sexual call when they are at the beginning of their sexual development.

c) At short distances, visual cues might also play an important role. The anchor pattern of males throat, which shows a high variability, could play an important role in mate choice. This should be studied in the near future.

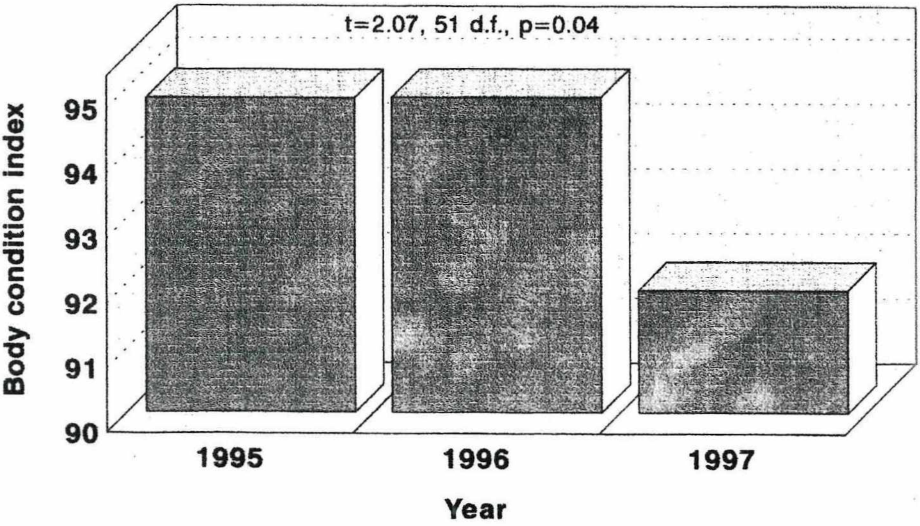

Figure 2: Body condition of males analysed in 1995 and 1997. There is a significant difference between body condition of 1995 and 1996 data when compared with that of 1997.

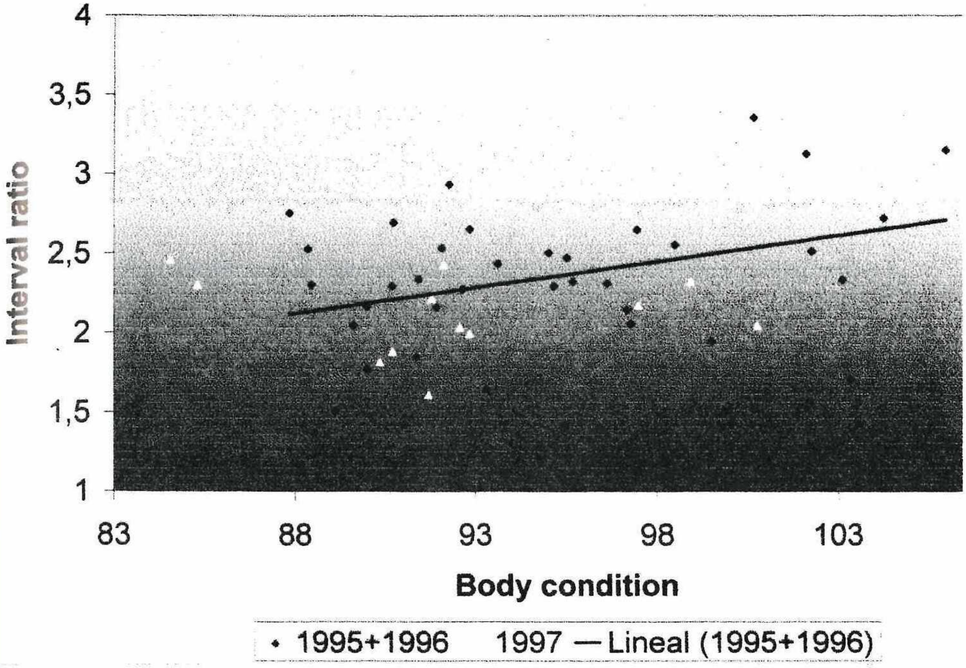

Figure 3: Interval ratio Vs body condition index for the data sets of 1995+1996 and 1997.

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HYBRIDIZATION AND INTROGRESSION OF JAPANESE QUAIL MITOCHONDRIAL DNA IN COMMON QUAIL POPULATIONS: A PRELIMINARY STUDY

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KEY-WORDS: hybridization, introgression, mitochondrial DNA, japanese quail, common quail

ABSTRACT

PUGCERVER, M., GALLEGO, S., RODRIGUEZ-TEIJEIRO, J.D., D'AMICO, S. and RANDI E.: HIBRIDIZATION AND INTRIGRESSION OF JAPANESE QUAIL MITOCHONDRIAL DNA IN COMMON QUAIL POPULATIONS: A PRELIMINARY STUDY: The Common Quail (*Coturnix coturnix*) is nowadays considered an allospecies of the Japanese Quail (*Coturnix japonica*). Despite the distribution area of both species has a small overlap region, no hybrids have been described there; however, restocking with Japanese Quail or hybrids during the hunting season is a very frequent practice in several European countries, like Spain and France. This entails a potential risk of genetic pollution over the Common Quail populations. The aim of this study is to test, by using walk-in funnel traps, the degree of attraction exerted by females of Japanese Quail towards males of Common Quail during the breeding season of the latter species, that is, before the hunting season. Moreover, a molecular study has been carried out by analysing a sequence of 425 nucleotides of the 5' part (domain I) of the mt DNA control-region (the hypervariable region of the control region) of 10 commercial Japanese Quail and 14 wild male quails captured in Northeast Spain during the breeding season. According to some characteristics of their call, 4 of these 14 males were considered hybrids and the other 10 were classified as Common Quail.

Results show that: 1) Females of Japanese Quail attract males of Common Quail in a 66.6 % of the cases. 2) The Common and the Japanese Quails differ at about 6 % of the sequenced mtDNA fragment. Therefore, it is possible to identify both species and their hybrids. As it could be expected, all the quails considered "a priori" as hybrids had a Japanese mtDNA, which was also present in one of the bird classified as Common Quail. These results suggest that the presence of Japanese Quail (or hybrids) in the study area are a real danger of genetic pollution of the wild populations, and that molecular techniques are very useful to detect hybrids and to quantify the degree of hybridization.

1. INTRODUCTION

The Common Quail (*Coturnix coturnix*) and the Japanese Quail (*Coturnix japonica*) are nowadays considered closely related, but different, allospecies (JOHNSGARD 1988). Compared with nominate *C. coturnix*, East Asiatic *japonica* has elongated chin feathers instead of short rounded ones (TAKA-TSUKASA 1935, SAINT-JALME *ET AL.* 1987), and shorter wing length (GUYOMARC'H *ET AL.* 1998). Thus, these species are phenotipically rather similar and morphological differences are frequently doubtful. The best trait allowing species identification is the call of males, which is trisyllabic in the Common Quail and completely different from that of the Japanese Quail (see GUYOMARC'H and GUYOMARC'H 1996). Unfortunately, the call of females is very similar in both species.

Common and Japanese Quails have widely allopatric distributions with only a small overlapping region, where no hybrids have been described (MOREAU and WAYRE 1968). Nevertheless, thousands *C. japonica* or hybrids are released every year in several European countries (Spain, France, Italy, etc.). Only in Catalonia (Northeast Spain), a total of 94.838 Japanese Quail and/or hybrids were released; according to a survey carried out in the Haute Garonne (France) in 1986, 75 % of the hunted quails were Japanese Quails (GUYOMARC'H 1995). These restocking practices during the hunting season (from mid-August to October) entail a potential risk of genetic pollution of the Common Quail populations. In fact, both phenotypic hybrids and Japanese Quails have been occasionaly captured in spring in Spain (RODRÍGUEZ-TEIJEIRO *ET AL.* 1993) in the breeding areas of the Common Quail.

The main risk of genetic pollution may occurs when males of the nominate *C. coturnix* are attracted by the call of females *japonica* or hybrids, because are the females of *C. coturnix* who choose their partners. It seems unlikely, therefore, that females of Common Quail could choose Japanese Quail males, due to the very different advertising call of the latter if compared with those of Common Quail males.

The aim of this study is, at first instance, to test the degree of attraction exerted by females of Japanese Quail towards males of Common Quail during the breeding season of the latter species. Moreover, a molecular genetic study has been carried out in order to test whether both allospecies and their hybrids can be identified by mitochondrial DNA sequencing.

2. MATERIAL AND METHODS

For the first aim of the study, in 1998 10 females of *Coturnix coturnix* and 9 females of *Coturnix japonica* were kept in walk-in funnel traps that were randomly placed in cereal plot borders of Mas Esplugues (Catalonia, Northeast Spain), a traditional breeding site of the allospecies *Coturnix coturnix*. Three days per week during the breeding season (May to July), walk-in funnel traps were inspected in order to check if any male had been attracted by females.

For the molecular study, total DNA of 10 commercial Japanese Quails and 14 wild male quails (10 of them "a priori" classified as Common Quail and 4 as hybrids, attending to phenotypic criteria) was extracted from 95% ethanol preserved blood or feather root samples **(see Table 1)**, using guanidinium thiocyanate and diatomaceous silica particles (GERLOFF *ET AL.* 1995).

We have used the Polymerase Chain Reaction (PCR) to amplify the 5' half of the mtDNA control-region (CR), which includes the hypervariable parts of domain I (RANDI and LUCCHINI 1998). Amplifications were performed with primers PHDL and PH1H (RANDI and LUCCHINI 1998), using a 9600 PerkinElmer thermocycler with the following program: initial denaturation at 94 C for 2 min, 30 cycles at 94 C fro 15 sec, 50 C for 15 sec, 72 C fro 1 min, and the final extension at 72 C fror 10 min. Each amplification was performed in a total volume of 10 ml with 2nM MgCl2. We have sequenced 425 nucleotides of the mtDNA CR by cycle sequencing with the ABI Prism Dye Terminator kit in an ABI 373 automatic sequencer, using primer PHDL.

3. RESULTS

As shown in **Table 2**, females of Common Quail attract males of their species in the 90 % of the cases; however, females of Japanese Quail also attract males of Common Quail, although in a lower proportion (66. 6 %). Therefore, we can affirm that released Japanese Quails may attract males of Common Quail.

With respect to the molecular analysis, the aligned nucleotide sequences are shown in **Figure 1**. There were 24 variable sites, listed in **Figure 2**, which defined 10 different CR haplotypes. Phylogenetic relationships among these haplotypes were reconstructed by the Neighbour-Joning procedure, based on Kimura 2-parameters estimates of DNA distance,

Table 1: List of the 24 studied individuals.

ID	**SCIENTIFIC NAME**	**TISSUE**
Cja. 1	Coturnix japonica	Blood
Cja. 2	Coturnix japonica	Blood
Cja. 3	Coturnix japonica	Feather
Cja. 4	Coturnix japonica	Feather
Cja. 5	Coturnix japonica	Blood
Cja. 6	Coturnix japonica	Blood
Cja. 7	Coturnix japonica	Blood
Cja. 8	Coturnix japonica	Blood
Cja. 9	Coturnix japonica	Blood
Cja.10	Coturnix japonica	Blood
Cco. 1	Coturnix coturnix	Blood
Cco. 2	Coturnix coturnix	Blood
Cco. 3	Coturnix coturnix	Blood
Cco. 4	Coturnix coturnix	Blood
Cco. 5	Coturnix coturnix	Blood
Cco. 6	Coturnix coturnix	Blood
Cco. 7	Coturnix coturnix	Blood
Cco. 8	Coturnix coturnix	Blood
Cco. 9	Coturnix coturnix	Blood
Cco. 10	Coturnix coturnix	Blood
Chyb. 1	Hybrid	Blood
Chyb. 2	Hybrid	Blood
Chyb. 3	Hybrid	Blood
Chyb. 4	Hybrid	Blood

and using the computer program MEGA (KUMAR *ET AL.* 1993). The phylogenetic tree (**Figure 3**) showed that:

1) *C. japonica* and *C. coturnix* CR haplotypes are separated in two distinct clades at an average genetic distance of about 6%.

2) All *C. japonica* shared the same CR haplotype, except sample CJA10.

3) On the contrary, there was great genetic variability among *C. coturnix*, which showed 8 different and rather divergent haplotypes.

4) All the phenotypically hybrid quails had the *C. japonica* common CR haplotype.

```
                                                                                                                  1 1111111111 1111111111 1111111111 1111111111 1111111111
                 1 1111111112 2222222223 3333333334 4444444445 5555555556 6666666667 7777777778 8888888889 9999999990 0000000001 1111111112 2222222223 3333333334 4444444445
        1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890
#CJA5   AACTCCCCTA CTTAGTGTAC CCCCCCTTTC CCCCCCAGGG GGGGTATACT ATGCATAATC GTGCATACAT TTATATTCCA CATATACTAT GGTACCGGTA ATATATATTA TATACGTACT AAACCCATTA TATGTATACG GGCATTACAT
#CJA8   .....?.... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb1  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb3  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA3   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA1   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA9   .....?.... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb2  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO4   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO3   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO9   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO7   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO1   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... ....T..... .......... .......... ..........
#CCO6   .......... .......... .......... .......... .......?.. ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO8   .......... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA6   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO2   .......... ....?..... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA4   .....?.... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA7   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb4  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO5   .......... .......... .......... .......... .......?.. ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO10  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA2   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA10  .....?.... .......... .......... .......... .......... ...T...... .......... .......... .......... .......... .......... .......... .......... .......... ..........

        1111111111 1111111111 1111111111 1111111111 1111111112 2222222222 2222222222 2222222222 2222222222 2222222222 2222222222 2222222222 2222222222 2222222222 2222222223
        5555555556 6666666667 7777777778 8888888889 9999999990 0000000001 1111111112 2222222223 3333333334 4444444445 5555555556 6666666667 7777777778 8888888889 9999999990
        1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890 1234567890
#CJA5   ATTGTCCCCA TTTCTCCCCA TGTACATTAG TGCATGCTCC AAGACATAAA CCATACGTTC ACCTAGTAAT AGACTTTCCA CTAACAGGAC ACCATAACTA TGAATGGTTG CAGGACATAA GCTTACTAAA TACTTAGCTC CCCATTTGGT
#CJA8   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb1  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb3  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA3   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA1   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA9   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb2  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO4   .......... .......... .........A .......... .G........ ......AC.. .....AC.GC T......... ......A.G. .......... .........A .......... .T.....T.. .......... .A........
#CCO3   .......... .......... .........A .......... .G........ ......AC.. .....AC.GC T......... ......A.G. .......... .........A .......... .T.....C.. .......... .A........
#CCO9   .......... .......... .........A .......... .G........ T.....AC.. ..T..AC.GC T......... ......A.G. .......... .........A ........G. .TC....T.. .......... .A........
#CCO7   .......... .......... .........A .......... .G........ T.....AC.. ..T..AC.GC T......... ......A.G. .......... .........A ........G. .TC....T.. .......... .A........
#CCO1   .......... .......... .........A .......... .G........ T.....AC.. ..T..AC.GC T......... ......A.G. .......... .........A ........G. .T.....T.. .......... .A........
#CCO6   .......... .......... .........A .......... .G........ ....G.AC.. .....AC.GC T......... ......A.G. .......... .........A .......... .T.....T.. .......... .A........
#CCO8   .......... .......... .........A .......... .G........ ......AC.. ..T..AC.GC T......... ......A.G. .......... .........A .......... .TC....C.. .......... .A........
#CJA6   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO2   .......... .......... .........A .......... .G........ ......AC.. T....AC.GC T......... ......A.G. .......... .........A .......... .T.....T.. .......... .A........
#CJA4   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA7   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#Chyb4  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CCO5   .......... .......... .........A .......... .G........ ......AC.. ..T..AC.GC T......... ......A.G. .......... .........A ........G. .T.....T.. .......... .A........
#CCO10  .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA2   .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... .......... ..........
#CJA10  ?......... .......... .......... .......... .......... .........T .......... .......... .......... .........? .......... .......... .......... .......... ..........
```

Figure 1: Aligned nucleotide sequences of the mtDNA CR corresponding to the 24 analysed individuals. CJA = *C. japonica*; CCO = *C. coturnix*; Chyb = hybrids. ? symbols mean doubtful nucleotides; dots mean nucleotide identity with the reference sequence CJA 5.

Table 2: Females of Japanese and Common Quail which attracted one or more males inside the walk-in funnel traps throughout the breeding season of 1998.

SPECIES	NUMBER OF INDIVIDUALS WHICH ATTRACTED ONE OR MORE MALES	PERCENTAGE
C. japonica	6	66.6
C. coturnix	9	90

```
         111222222 2222222222 2222
        5189000011 1111223366 7779
        4502157801 3679017909 2382
#CJA5   CCGACAGTCA CGTATAGAGA CTAC
#CJA8   .......... .......... ....
#Chyb1  .......... .......... ....
#Chyb3  .......... .......... ....
#CJA3   .......... .......... ....
#CJA1   .......... .......... ....
#CJA9   .......... .......... ....
#Chyb2  .......... .......... ....
#CCO4   T.AG..AC.. .ACGCTAGA. T.TA
#CCO3   T.AG..AC.. .ACGCTAGA. T.CA
#CCO9   T.AGT.AC.. TACGCTAGAG TCTA
#CCO7   T.AGT.AC.. TACGCTAGAG TCTA
#CCO1   TTAGT.AC.. TACGCTAGAG T.TA
#CCO6   T.AG.GAC.. .ACGCTAGA. T.TA
#CCO8   T.AG..AC.. TACGCTAGA. TCCA
#CJA6   .......... .......... ....
#CCO2   T.AG..AC.T .ACGCTAGA. T.TA
#CJA4   .......... .......... ....
#CJA7   .......... .......... ....
#Chyb4  .......... .......... ....
#CCO5   T.AG..AC.. TACGCTAGAG T.TA
#CCO10  .......... .......... ....
#CJA2   .......... .......... ....
#CJA10  T.......T. .......... ....
```

Figure 2:. CR haplotypes found in the 24 samples analysed.

4. CONCLUSIONS

The results obtained clearly show that restocking with females of Japanese Quail or hybrids constitute a real danger of genetic pollution of the wild populations of the Common Quail. Moreover, nucleotide sequencing of domain I of the mitochondrial CR is a useful tool to describe DNA differences between *C. coturnix* and *japonica*, and it is a marker of hybridization and maternal introgression. Intraspecific mtDNA variability is very low in *C. japonica*, as consequence of the bottleneck at domestication and low effective population size of the reared stocks. All the hybrid quails had the *C. japonica* CR haplotype, indicating that females *japonica* are used for interspecific crosses. Introgression of *C. japonica* mtDNA could be identifyied in natural populations of *C. coturnix* using mtDNA sequencing. Finally, as suggested by the case of the sample CCO10, formerly classified as *Coturnix coturnix* in basis of its phenotype, the real degree of introgression of Japanese DNA in Common Quail populations may be seriously underestimated if only phenotypic characteristics were used. All in all, the use of molecular techniques are, then higly recommended.

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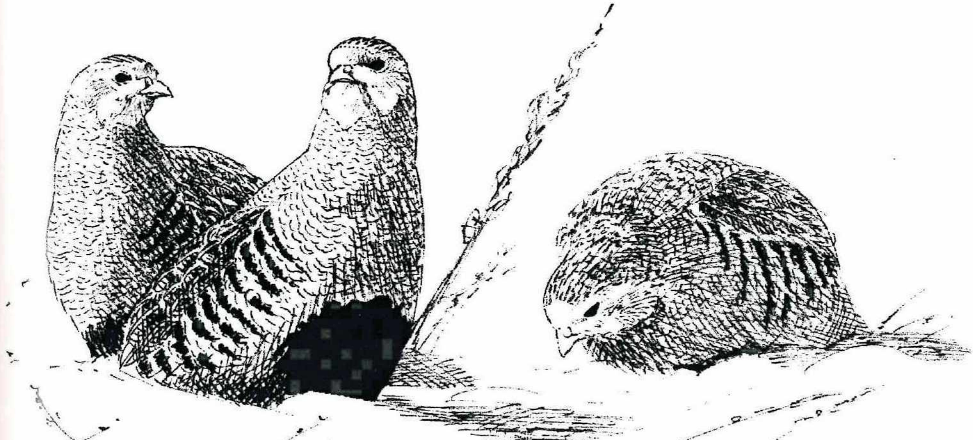

LOCAL AGE AND SEX RATIOS OF RED-LEGGED PARTRIDGE (*Alectoris rufa*) DECLINING POPULATIONS IN HUESCA (SPAIN)

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KEY WORDS: Red-legged partridge, Alectoris rufa, Local age and sex-ratio, Declining populations, Ebro valley, Spain.

ABSTRACT

NADAL, J.; NADAL, J. and RODRIGUEZ-TEIJEIRO, J.D.: LOCAL SEX RATIOS OF RED-LEGGED PARTRIDGE (ALECTORIS RUFA) DECLINING POPULATIONS IN HUESCA: Age and sex ratios of red-legged partridge populations are different among near localities (hunting grounds of 2.000 to 3.000 ha) from low Cinca study area (60.000 ha) -Ebro valley (Spain)-. In declining red-legged partridge populations of low Cinca, juvenil sex ratio frecuently is greater than 1, but it shows differences among distinc localities according to seasons. The same happens, but more marked with adult sex ratios. On the other hand, age ratios are frecuently lower than 1. Neverthеrless, age ratio, also shows differences among localities. In spite of pronounced decline of red-legged partridge populations in low Cinca during the study period, not all localities showed this situation. Age and sex ratios from distinct localities, shows that in the study area there are local populations in better and worse situation. Red-legged partridge populations structure not only are dynamic in time, but also among near and different localities, as response to factors such as weather summmer storms, hunting management, agrosystem cycles and predation. This requires that necessaryly red-legged partridge populations management are at global and locality level.

I. INTRODUCTION

The hunting management absence and habitat spoil are responsible of low Cinca (60,000 ha) red-legged partridge populations decline (NADAL *ET AL*, 1996 a). Both factors determine that population loss is greater than population gain (BIRKAN 1979 and POTTS, 1986). In order to hunting pressure and by other hand to predation impact extract more partridges that a sustainable tax of extract will do (BIRKAN, 1979; POTTS, 1986, and BERNARD-LAURENT *ET AL*, 1991), this implies that during autumn age-ratio frequently is lower than one (NADAL *ET AL*, 1996a, 1996b and 1997).

Rains and temperatures fluctuate seasonally controlling habitat quality and mortality, by this climate direct and indirectly influence up the balance of gains minus loss in population (COLES, 1977; PEPIN *ET AL*, 1985; HUDSON and RANDS 1988; LUCIO, 1990 and BERNARD-

LAURENT *ET AL*, 1991). In decline red-legged populations, with the pass of the time gains minus loss are frequently negative (NADAL *ET AL.*, 1996).

In Herault stable populations, at local scale (3.000 ha) are known that during autumn exist age and sex structures differences among localities, besides that these differences do no are constant with the pass of hunting seasons (PEPIN *ET AL*, 1985; RICCI *ET AL.*, 1987 and 1988). Does it happen the same in decline low Cinca population?. Which are such differences with regard to stable populations?. If abundance and structure fluctuations of local red-legged partridge populations are due to mediterranean climate local effect (due to rains and temperature distribution, overcoat to summer storms) (PEPIN *ET AL*, 1985) how do the local subpopulations contribution affect to low Cinca population decline?. Which is the roll in this process of partridge migrations among different localities?. Which implications are deduced by local population dynamics for populations management?

2. STUDY AREAS, MATERIALS AND METHODS

Low Cinca area was selected for study demography and population dynamics of red-legged partridge populations in previous studies (NADAL, 1994 and NADAL *ET AL.* 1996a, 1996b and 1997). This area of 60,000 ha is composed by agrosystems that include slopes and hills inhabit for the transition evergreen oak grove (Quercetum rotundifoliae) to Kermes oak bush (Rhamnetum cocciferae -coscojar-) in a semiarid and subhumid climate.

In low Cinca there are about one hunting ground each 3,000 ha. Hunting parties, pressure, hunter numbers and bag results are very different in each hunting ground. Partridges were hunted by walking up. To inspect samples we contacted hunters directly. All samples included in this study were wild partridges. Birds were classified in to age and sex group following cuantitative and qualitative criteria demostrated useful for previous authors (NADAL *ET AL.*, 1996).

The difficulties encountered in obtaining samples let us work with little data, between 1.1% and 2.7% of the spring population. Since the sample was very small we used FISHERs' exact test. To demonstrate the significance with respect to 1:1 proportion the binomial test was used (SIEGEL, 1976). Results with critical level P^2 0.10 are considered significant (RATTI and ROTELLA, 1989) whenever they can be supported by results with P^2 0.05 for other similar contrasts. Such strategies have been used to avoid increasing the type II error probability (STILL, 1982; LUNA and MARTIN, 1984).

3. RESULTS

3.1. LOCAL JUVENILE SEX RATIO

During the 1984-5 season juvenile sex ratio (JSR) in Torm locality is greater than 1 ($P \leq 0.10$ binomial) while does not in the other localities (fig. 1). This season JSR is greater in Torm locality than in Puey ($P \leq 0.024$ Fisher exact test). In 1985-6 season the JSR is greater than 1 in Torm locality ($P \leq 0.037$ binomial) and Mcor ($P \leq 0.019$ binomial), but no in Last and Berb (**Figure 1**). The JSR of Mcor locality is greater than in Monz ($P \leq 0.07$ Fisher exact test).

During the 1986-7 season the JSR do not differ from 1 in neither of studied localities (fig. 1). Nevertheless JSR from Last and Mcor localities are lower than from Monz ($P \leq 0.024$ and $P \leq 0.07$ respectively, Fisher exact test), by other hand the JSR of Last locality is greater than in Torm ($P \leq 0.098$ Fisher exact test). In 1987-8 season JSR is lower than 1 in Last ($P \leq 0.073$ binomial) while no in the other localities (**Figure 1**).

3.2. LOCAL ADULT SEX RATIO

In the 1984-5 season adult sex ratio (ASR) of Mcor locality is greater than 1 ($P \leq 0.046$ binomial), while of Berb is lower than 1 ($P \leq 0.031$ binomial) (**Figure 2**). The ASR from Berb is lower than in Last, Mcor and Puey localities ($P \leq 0.036$, $P \leq 0.007$ and $P \leq 0.016$ respectively, Fisher exact test). During the 1985-6 season ASR does not differ significantly from 1 in neither locality (**Figure 2**).

In the 1986-7 season ASR in Mcor and Last is greater than 1 ($P \leq 0.019$, $Z= 1.39$ $P \leq 0.082$ respectively binomial), while no in the other localities (**Figure 2**). The ASR from Monz is lower than from Last and Mcor localities ($P \leq 0.076$ and $P \leq 0.035$ respectively, Fisher exact test). During the 1987-8 season the ASR does not differ from 1 in neither locality (**Figure 2**). Nevertheless, the ASR from Last locality is greater than from Mcor ($P \leq 0.058$ Fisher exact test).

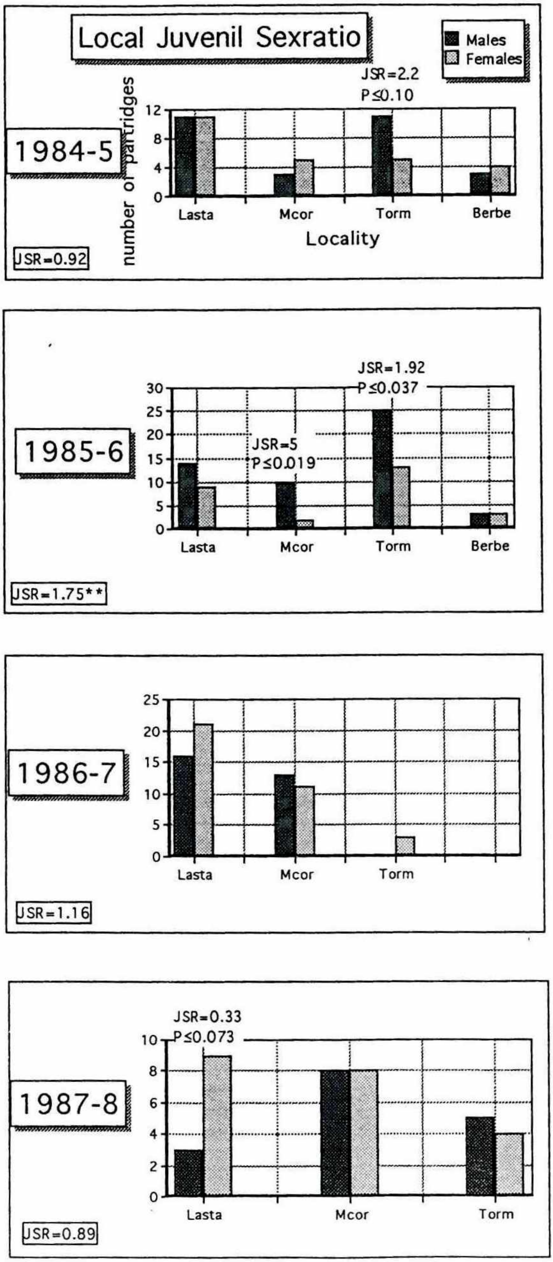

Figure 1: Local juvenil sex ratio in low Cinca, dark bars males and pale bars females. JSR: juvenil sex ratio in all the season, *$P \leq 0{,}10$, **$P \leq 0{,}05$ to be different from 1:1 proportion

3.3. LOCAL AGE RATIO

During the 1984-5 season the age ratio (AR) does not differ from 1 in neither locality (fig. 3). In the 1985-6 season AR from Lasta and Mcor localities is lower than 1 ($Z = 2.02$, $P \leq 0.022$ and $Z = 1.54$, $P \leq 0.062$ respectively, binomial), but no in the other localities (**Figure 3**).

During the 1986-7 season AR is significantly lower than 1 in Torm locality ($P \leq 0.046$ binomial), nevertheless no in the other (**Figure 3**). The AR from Puey locality is significantly lower than from Last and Mcor ($P \leq 0.029$ and $P \leq 0.031$ respectively, Fisher exact test), and the AR from Torm locality is significantly lower than from Last and Mcor ($P \leq 0.030$ and $P \leq 0.035$ respectively, Fisher exact test). In the 1987-8 season the AR of Berb is significantly greater than 1 ($P \leq 0.065$ binomial), but no in the other localities (**Figure 3**). The AR from Berb locality is greater than from Torm ($P \leq 0.048$ Fisher exact test).

4. DISCUSSION

During autumn, in decline low Cinca red-legged partridge populations, at local level (hunting ground) differences of age and sex ratios among localities are found (**Figure 1, 2** and **3**). Age and sex ratios differences among localities change with the pass of seasons (**Figure 1, 2** and **3**). This agree with Herault stable populations fact (PEPIN *ET AL*, 1985; RICCI *ET AL*., 1987 and 1988). Nevertheless, in contrast with the notice in stable populations of Herault, in decline low Cinca populations, the age ratios frequently are lower than one, and sex ratios greater than one (NADAL *ET AL*, 1996a, 1996b and 1997) (**Figure 1, 2** and **3**).

Red-legged partridge populations abundance and structure fluctuations must be to local effects of mediterranean climate (due to rains and temperature distribution, overcoat to summer storms) (PEPIN *ET AL*, 1985 and LUCIO 1990). This makes that local contribution to low Cinca population decline, is no constant during different seasons, however it is necessary to manage this population at local scale (PEPIN *ET AL*, 1985; RICCI *ET AL*., 1987 and 1988) considering their contribution to global low Cinca population. It is necessary to create stimulus for low Cinca inhabitants realise management activities with the aims to stop wildlife and red-legged partridge habitat quality spoil (BIRKAN, 1979; POTTS, 1986 and BERNARD-LAURENT *ET AL*, 1991).

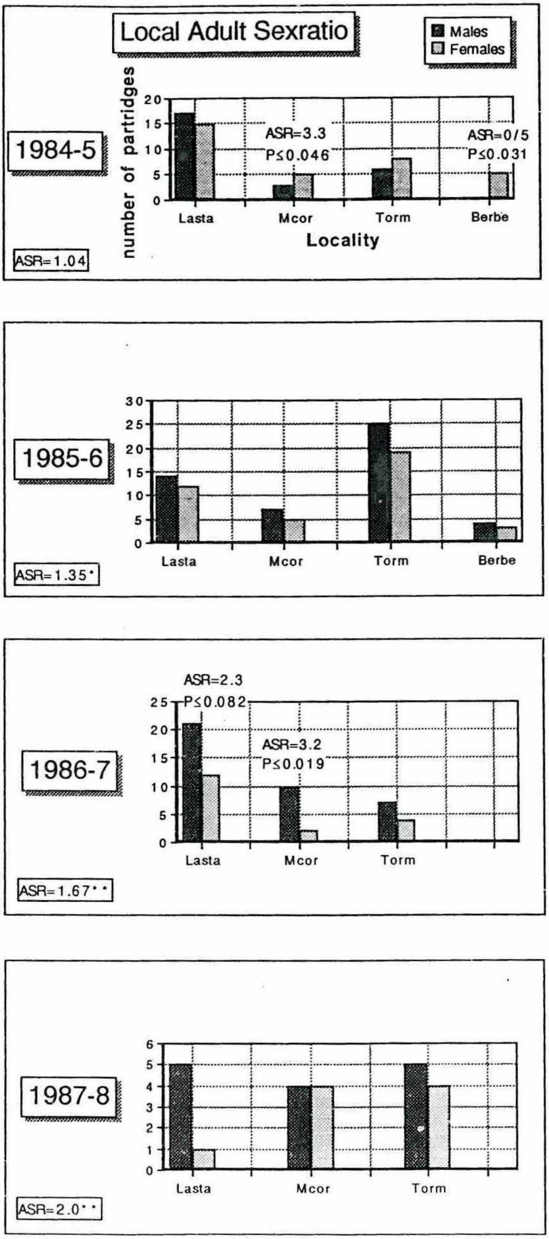

Figure 2: Local adult sex ratio in low Cinca, dark bars males and pale bars females. ASR: adult sex ratio in all the season, *P≤0,10, **P≤0,05 to be different from 1:1 proportion

Each spring from localities which have habitats with more quality and exercise adequate hunting pressure, partridge dispersion to localities with excess of extracts are produced (GREEN, 1983). With this strategy, low Cinca red-legged population reduce the predation impact and mortality (GREEN, 1983; HUDSON and RANDS 1988), but penalise to better manage localities and favour to more careless (BIRKAN, 1979; POTTS, 1986, and BERNARD-LAURENT *ET AL*, 1991). The age and sex ratios are useful to identify which localities export and import partridges (NADAL, 1994), this information must be use to design so much the management plan for low Cinca population as for localities (subpopulations).

Trough spring dispersion, decline red-legged partridge populations reduce the species disappear at local scale (GREEN, 1983; RICCI, 1985 and NADAL, 1994). This distribution strategy of partridges maximising spatial occupancy, also happens in stable populations (PEPIN *ET AL*, 1985; RICCI *ET AL.*, 1987 and 1988) and is general to living beings. Nevertheless, while in decline populations are developed to avoid local isolation (NADAL, 1994), in stable or increase populations, have the mission of controlling population size (GREEN, 1983 and RICCI, 1985). In both situations the population respond with the same strategy for maximise the space occupancy for increase biological efficiency and to guarantee their existence.

The low Cinca red-legged population management demand to work at global and local scale. We must consider that maximising space occupancy rebound negatively in better manage localities, because it rests partridges to recolonize depopulated localities. However, it is suitable to design management plans locally in order to get greater effort of habitat restoration and hunting pressure control over careless localities (BIRKAN, 1979; POTTS 1986, BERNARD-LAURENT *ET AL*, 1991).

In areas with decline populations exists stable localities, decrease localities and disappear localities (or discontinuous in time) (NADAL 1994). Precisely, species disappear process begins to consolidate when the number of localities where population is disappear or it shows discontinuous, is greater than of decline or stable localities. If low Cinca population remains isolated to neighbouring populations we can consider this as metapopulation.

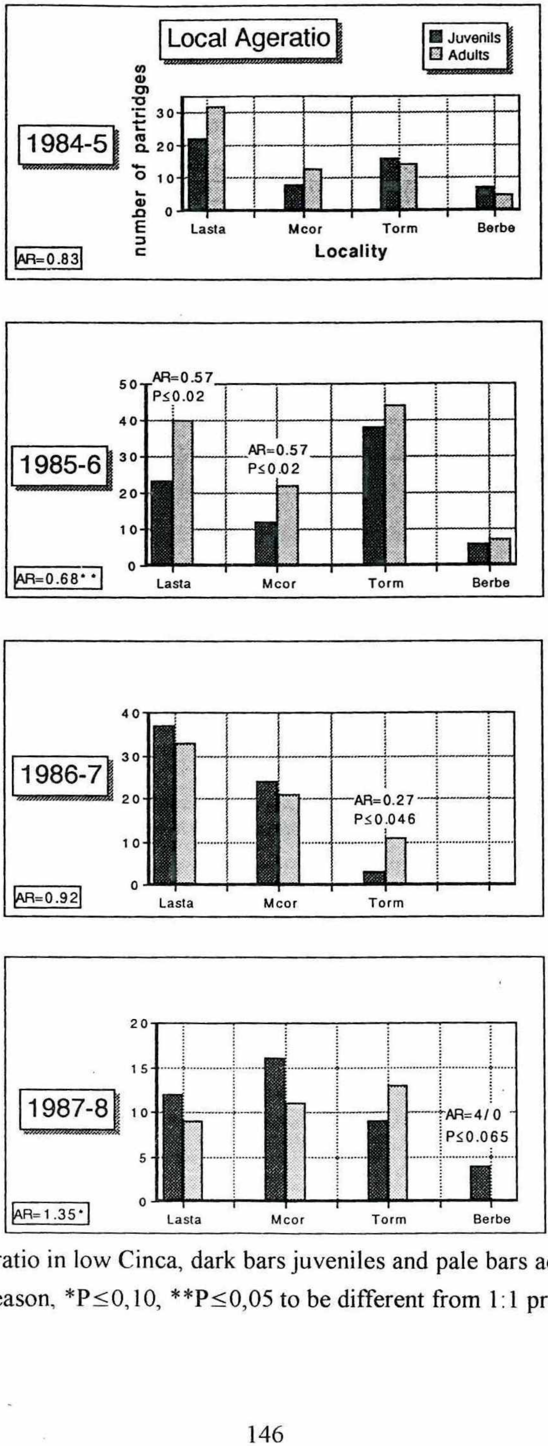

Figure 3: Local age ratio in low Cinca, dark bars juveniles and pale bars adults. AR: age ratio in all the season, $^{*}P \leq 0{,}10$, $^{**}P \leq 0{,}05$ to be different from 1:1 proportion

Local age and sex ratios are a useful tool for red-legged partridge population management (PEPIN *ET AL*, 1985; RICCI *ET AL*., 1987 and 1988). It is known that the number of samples that we can get from different localities is proportional to partridge abundance, however it shows which are the localities with more low partridge density (NADAL, 1994). Localities where it is possible to obtain more than 20 samples allows to calculate autumn age and sex ratios to determine so much population condition and trend as to predict immigration or emigration (dispersion) of partridges from this locality during spring (NADAL, 1994).

All these work hypothesis must be verified with radiotracking studies in the future, nevertheless, it must be applied with urgency to global and local low Cinca population management, before it arrive to metapopulation condition. Global and local management plan absence is one of principal cause of low Cinca partridge regression. Management plans for this species must be develop profuse habitat restoration and predator control programs, and social dimension aspects to get hunter and people participation.

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THE STATUS OF PARTRIDGES IN NORTH-CENTRAL FRANCE

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KEY-WORDS: Grey partridge, *Perdix perdix* L., Red-legged partridge, *Alectoris rufa* L., France, reproductive success, survival rate, status

ABSTRACT

REITZ, F. : THE STATUS OF PARTRIDGES IN NORTH-CENTRAL FRANCE. The partridge populations in North-Central France (Grey partridge, *Perdix perdix*, and Red-legged partridge, *Alectoris rufa*) have been continuously monitored since the beginning of the eighties. Therefore we can determine the evolution and the most recent values of:

i. spring abundance indices of Grey partridges,
ii. the actual spring densities in well-managed areas (i.e. with bag limits and sometimes habitat improvement),
iii. reproductive success,
iv. survival rate of adult Grey partridges.

Although high densities are still observed in some regions, nowadays tendencies mainly show a decline in Grey partridge densities essentially due to a decrease in the survival rate of adults.

1. INTRODUCTION

The management of entirely wild partridge populations is well-developped in North-Central France. It firstly consists in adapting the hunting pressure to game bird demography. In this way, spring counts of breeding pairs and brood sampling are performed each year to calculate hunting plans. Most of these data and several hunting bag data have been collected by ONC since the end of the seventies. It is therefore possible to get a rather good idea of the status of the partridge populations in the areas concerned and to estimate the recent trends in the variations of the determining demographic parameters, i.e. the annual adult survival rate and reproductive success. Most of these data concern the Grey partridge (*Perdix perdix* L.). However, since wild Red-legged partridge (*Alectoris rufa* L.) populations are also present in the southernmost monitored areas, some data on reproductive success are available concerning this species.

2. MATERIAL AND METHODS

The landscape of most of the monitored areas is flat farmland intensively cultivated to cereals and industrial crops (oilseed rape, sugar beets, potatoes, peas, sunflowers, maïze, etc) with large fields, very few hedges and woods. However, where both partridge species are present, the landscape often is more diversified. The areas have a very variable surface ranging from 2 km² for private estates to more than 150 km² for areas managed by groupings of hunter associations. The partridge populations in all these areas are managed with bag limits. The habitat sometimes is also improved by predator control, management of set-aside fields for wildlife or artificial feeding of adults (cereal grains in troughs).

Pair counts

Partridges are flushed by beating the whole areas (small ones) or samples of areas (biggest ones) in late winter or in the beginning of spring. The partridges are counted by observers posted all around the surface to be censused. When both species are present, the distinction is not systematically made nor possible, so the given results represent all partridges.

The abundance index was calculated as follows: for each year *n*, was calculated the mean pair density in the only areas (reference areas) for which all demographic parameters were known from spring *n* to spring *n+1* (sample size in **Table 1**.). The index for each year was calculated by setting the value for 1990 at 100and then by applying the ratios of mean pair densities for successive couples of years.

Brood sampling

Broods are observed in many reference areas a few weeks after the cereal harvest. Observers are driving slowly a car along the paths and across the cropped fields to detect the broods. They determine for each brood, using binoculars and sometimes a telescope, the number of young and adults and the sex of Grey partridge adults. The number of observed broods (or birds for red-legged), sampled areas and concerned departements are given in **Table 1**.

Reproductive success is calculated as a young per hen ratio. This calculation assumes for the Red-legged partridge that males and females be in equal quantity (young per hen ratio = 2 x young per adult ratio).

Table 1: Sample sizes concerning brood sampling and the numbers of reference areas for the Grey partridge (areas for which all the demographic data are available from one spring to the next).

Year	Grey partridge brood sampling			Red-legged partridge brood sampling			Reference areas for Grey partridge[i]
	departements	areas	broods	departements	areas	observed birds	
1979	12	36	662				7
1980	14	58	914				24
1981	17	86	1603				37
1982	15	76	1840				25
1983	17	87	2541				28
1984	18	100	2774	from 4 to 9 according to the year	13	938	0
1985	13	70	1885		18	1587	0
1986	16	106	2799		13	1413	0
1987	18	133	2690		15	2140	0
1988	18	151	3724		15	1814	18
1989	21	196	5845		33	3833	28
1990	21	224	8669		29	5489	25
1991	21	254	8469		21	3349	41
1992	21	280	8440		28	4174	62
1993	21	325	9339		20	4541	71
1994	20	297	7445		24	3093	81
1995	20	274	7430		44	3273	71
1996	23	319	8840		42	4778	56
1997	23	376	8261		42	3098	41
1998[ii]	17	330	8790		31	2527	44

[i] year n-1 to year n

[ii] data collection for 1998 is not yet finished

Adult survival rate estimates

The method has been explained elsewhere (REITZ, 1992). It is based on a demographic balance between two spring counts which takes into account the reproductive success and the hunting bag. The major assumptions are: i. an identical survival rate of young and adults after the brood sampling, ii. hunting mortality is additive since the calculation considers that 60% of the birds killed by hunting should have survived till the next spring.

These estimates could only be made for the Grey partridge since we have no valuable data for Red-legged partridge spring densities. They are not corrected for bird movements (emigration, immigration) so that they are only *apparent* survival rates.

Two successive annual estimates of the adult survival rate for one reference area are not totally independent because of the use of one spring count for both. Therefore, the trend in the mean survival rate was computed using each area's data only for one year out of two.

Relationship between Grey partridge reproductive success and climatic conditions

A regressive model had been developped to explain and predict the variations of the Grey partridge reproductive success by climatic variables (see REITZ, 1988). This model was updated with the most recent data using a stepwise regression model. The climatic data that were used (bought from METEOFRANCE) concerned the months of May, June and July and were the monthly mean or total of six parameters (lowest daily temperature, mean daily temperature, amount of precipitations, duration of precipitations, intensity of precipitations, i.e. the ratio of the quantity to the duration, number of days with more than 0.1mm of precipitations)

All statistics were performed with SPSS 7.5 for Windows software.

3. RESULTS

Spring density

The index of Grey partridge spring abundance shows high variations from 80 in the first years of monitoring to 150 in 1991 and back to 80 in 1998 (**Figure 1.**). So the present day status of the Grey partridge is not very favourable in spite of population management. However, the mean densities of breeding pairs are still rather high (**Figure 2.**): from 5 pairs per km² for both species together in the worst cases to 25 pairs per km² in the northernmost departements.

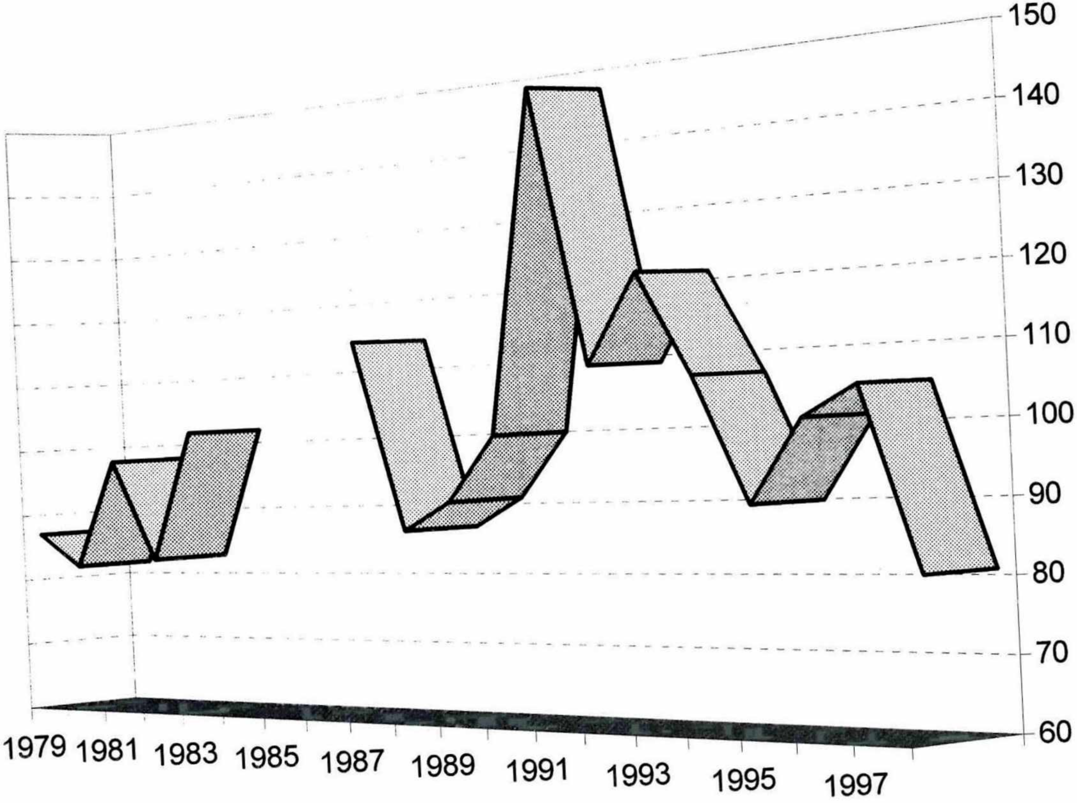

Figure 1: Spring abundance index of Grey partridges)set to 100 in 1990).

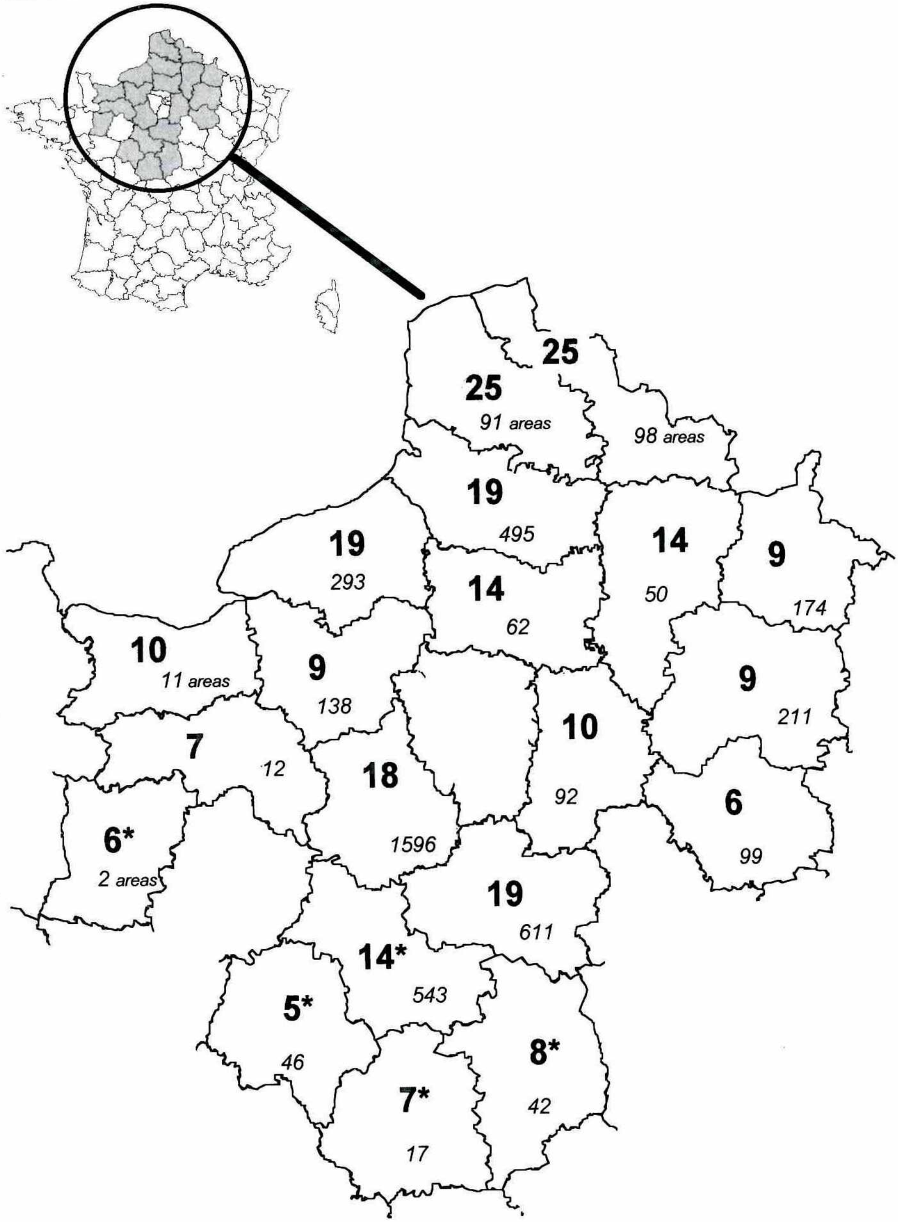

Figure 2: Mean 1998 spring density of managed populations in the departements of northern France: number on green background=number of breeding pairs of only grey or *Grey and Red-legged partridges per km², *number in italics=censused surface (in km²) or number of censused areas when specified*

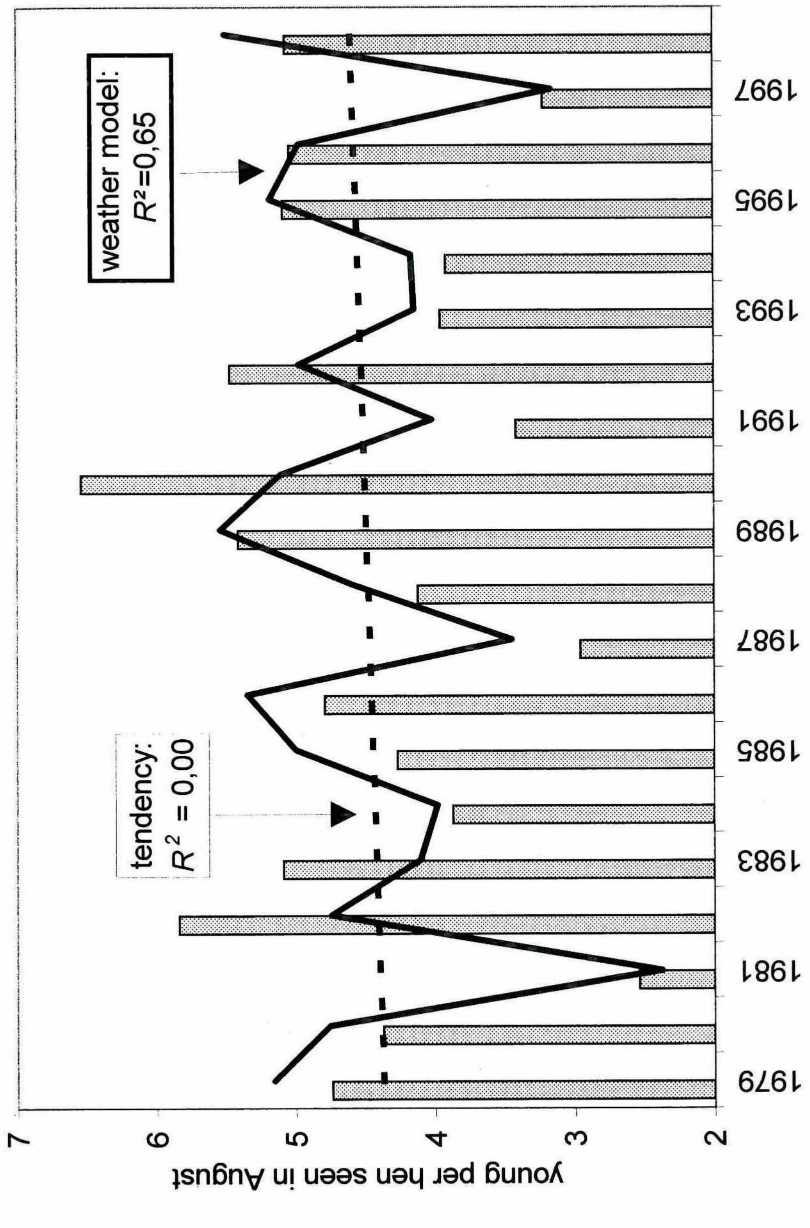

Figure 3: Reproductive succcess of Grey partridges.

Reproductive success

Grey partridge

The mean reproductive success of the Grey partridge over the last twenty years is 4.5 young/hen (min: 2.5 in 1981, max: 6.5 in 1990, **Figure 3.**). There is no tendency toward a decrease during this period ($P=1.0$). The major part of the variations can be explained by the conjunction of two climatic parameters: the duration of precipitations in June and the number of days with precipitations of more than 0.1mm in May ($P<0.001$).

Red-legged partridge

Data have been collected only since 1984. The reproductive success of this species has always been much lower than that of the Grey partridge except in 1987 (however, for this year, the limitation of the Grey partridge data set to the region where the Red-legged partridge is present, would have restored a difference in favour of the Grey partridge). The average value is 2.6 young per hen with a minimum of 1.2 in 1994 and a maximum of 4.4 in 1990 (**Figure 4**.). There is a slight but not significant tendency to decline ($P=0.11$).

Game bag

The mean Grey partridge bag in the reference areas varied from 1 partridge/km² in 1987 to 20 partridges/km² in 1982 and 1990 with an average value of 10 partridges/km² (**Figure 5**.). Since 1992, it has in average never exceeded 15% of the estimated autumn population (by reference to the next spring count and considering a natural mortality rate of 40% during winter).

Annual survival rate of adult Grey partridges

This is the most worrying demographic parameter since it is subject to a highly significant tendency to decrease (**Figure 6**., $P<0.001$). At the end of the seventies, about one bird out of two did survive from one spring to the next. Nowadays this is only the case for one bird out of three.

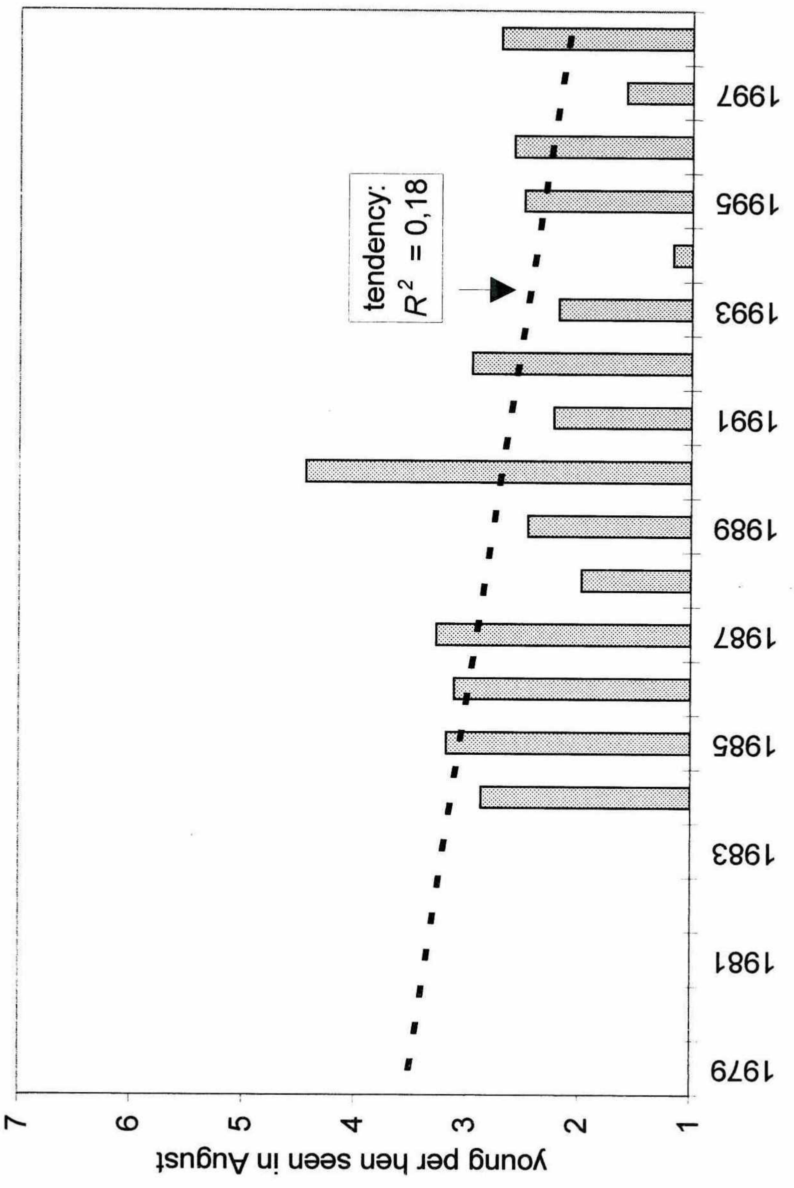

Figure 4: Reproductive success of Red – legged partridges.

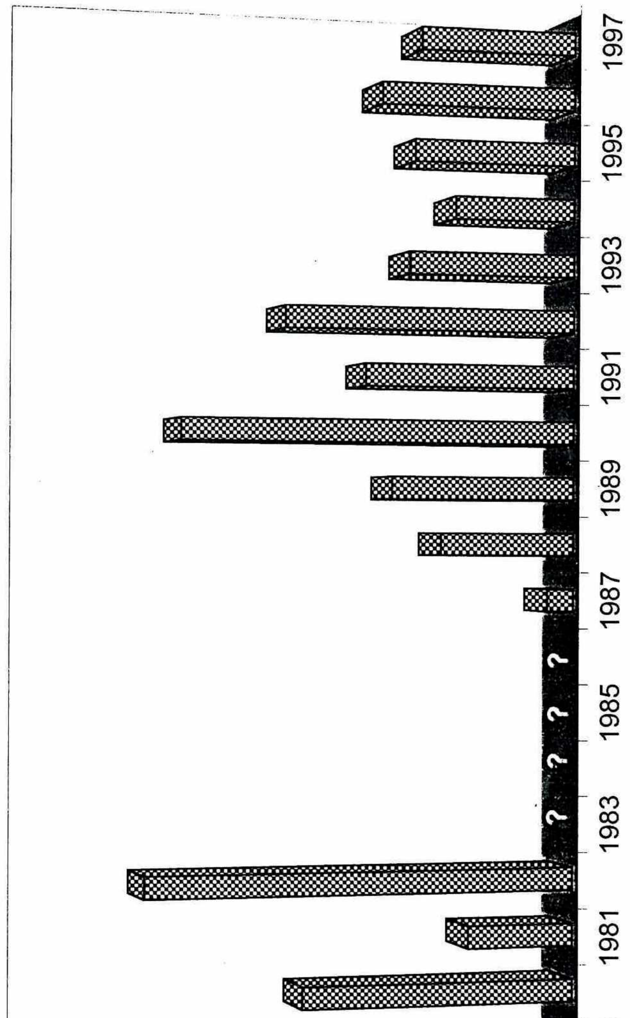

Figure 5: Mean hunting bag of wild Grey partridges collected in reference areas.

4. DISCUSSION AND CONCLUSION

In spite of a good management of the partridge populations, Grey partridge densities have been regularly declining since 1991. The game bags have been greatly reduced to preserve the spring stocks but this apparently is no more sufficient. The highest densities are now recorded in the northernmost areas and not in the Beauce region which for a long time has been considered the « bastion » of the Grey partridge in France. If the reproductive success fluctuates with climatic conditions but does not show a trend to decrease, this is not the case of the adults survival rate. Explanations for this can be the regression of landscape diversity with lesser and lesser cover for brood protection in autumn and winter and/or a highly probable increase in the abundance of adult partridge predators (foxes, mustelids, feral cats and harriers).

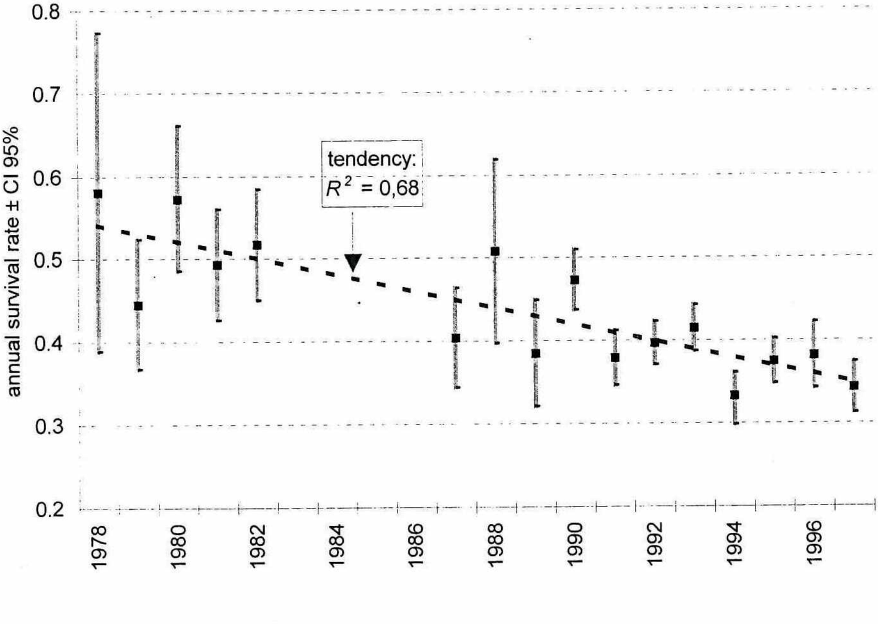

Figure 6: annual survival rate of adult Grey partridges from spring n to spring n+1(hunting mortality excluded) with confidence interval at P=0.05.

A very large study was carried outt from 1995 to 1997 to improve our understanding of the Grey partridge situation in France (see BRO *ET AL*, 1998).

The population trends of the Red-legged partridges are still very imprecise. However, the persistence of this species in the centre of France, in spite of a very low reproductive success, supposes that the adult survival rate is much higher than in Grey partridges. If we might conclude by a rapid international comparison, we should say that the situation of the Red-legged partridge in the Centre of France seems to be quite similar to that of the Grey partridge in England (lack of good nesting habitat and low survival rate of the chicks, POTTS, 1986) while the situation of the Grey partridge in the intensive farming regions of the Centre-North of France evokes, although in a very different habitat, the problem of grouse management in Scotland (heavy mortality in adults due to predation, REDPACH AND THIRGOOD, 1997).

ACKNOWLEDGEMENTS

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CONSERVATION STATUS OF THE FINNISH GREY PARTRIDGE (*Perdix perdix lucida*)

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KEY-WORDS: Grey Partridge, conservation status

ABSTRACT

UIMANIEMI, L., LUMME, J., PUTAALA, A. and HISSA, R.: CONSERVATION STATUS OF THE FINNISH GREY PARTRIDGE ***(Perdix perdix lucida).*** The conservation status of Finnish Grey partridge population was studied by sequencing 377 nucleotides of mitochondrial (mt) control region I. European Grey partridge has distinct maternal lineages in Finland and France. Individuals from Finnish natural populations represent subspecies *Perdix perdix lucida* and French population subspecies *Perdix perdix perdix*. High divergence between these subspecies indicates separation already during Middle pleistocene. Within Finnish populations no genetic variation was found. The genetic structure of captive partridges from Finland and Sweden was compared to that of natural populations in Finland. Finnish captive stock contains "French" lineage among individuals used for restocking. The "French" mtDNA has not been detected among "wild" birds in Finland. The genetic constitution may have been deteriorated because of mixing with the Swedish and even the French stocks. As an implication for conservation we conclude that the farm stocks of grey partridge used for restocking and supplementary breeding should always be founded from local populations. Then possible released individuals represent population typical to each region.

1. INTRODUCTION

The European Grey partridge (*Perdix perdix*) is a bird of open arable lands. It reaches its northernmost limit at Tyrnävä, Finland. Originally the Grey partridge has arrived to Finland from Carelian Isthmus, Southeast Finland, in the beginning of 1800 century (MERIKALLIO, 1958). At the same time there has been also introductions of the Grey partridge to Finland. As introduction sources literature mentions Sweden and also some Middle European countries. The species has decreased in numbers in its whole distribution area during last decades. In Finland the number of the Grey partridge has decreased from 15000 pairs to 3000-5000 breeding pairs. Once continuous distribution area of the species is more fragmented nowadays.

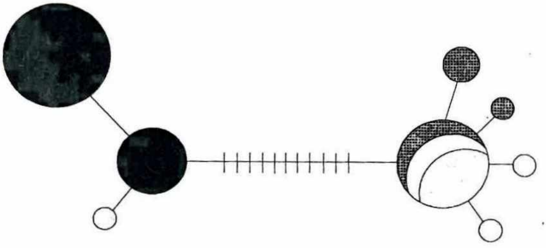
The main reason for the declining of the species is changes in agriculture. Due to modern type of harvesting and the use of herbicides there are not enough suitable habitats and food for the species. Despite declining of the species the Grey partridge is still a hunted species in most of its distribution area.

The aim of this study was to evaluate the conservation status of the Finnish grey partridge population by sequencing 377 nucleotides of mitochondrial (mt) control region I. High mutation rate on mtDNA lineages and haploid mode of inheritance make mtDNA an excellent tool for constructing phylogenies and time scales relating molecular lineages even below species level. Because of its mode of inheritance, mtDNA is sensitive to bottlenecks in population size and to population subdivision (WILSON *ET AL.*, 1985).

2. MATERIAL AND METHODS

We studied three wild populations from Finland: Tyrnävä, Kauhava and Jokioinen. There were five samples from each population. Also five samples from Finnish captive stock were studied. From Sweden we got egg samples from captive stock. From France we got 11 liver samples from shot wild birds (**Figure 1.**).

For analyses we used blood, liver and egg samples. From tissue samples we extracted total DNA and from eggs mtDNA. No sign of nuclear copies were found. We amplified 377 nucleotides of mitochondrial control region I with PCR. Sequencing was done with both radioactive and automated sequencing method. Sequences were aligned and analysed.



- ● Tyrnävä, Finland, wild birds
- ● Jokioinen, Kauhava, Southern Finland, wild birds
- ○ Oulu, Finland, captive birds
- ● France, wild birds
- ○ Tranås, Sweden, captive birds

Figure 1: The sampling locations of the European Grey Partridge (*Perdix perdix*)

3. RESULTS AND CONCLUSIONS

Sequencing 377 nucleotides of mitochondrial control region I of the European grey partridge from Finland and France reveals distinct maternal lineages in the species. Individuals from Finnish natural populations represent subspecies *Perdix perdix lucida* and French population subspecies *Perdix perdix perdix*. These two subspecies diverge from each other by 12 point mutations, mainly transitions. This divergence is high within a species ($d = 0.031$) indicating separation during Middle Pleistocene. Already in Finland the northern and southern populations have drifted. Within Finnish populations no genetic variation was found. The genetic structure of captive partridges from Finland and Sweden was compared to that of natural populations. Sequencing of captive farm individuals reveals that both lineages exist among individuals used for restocking, both in Sweden and in Finland. Even if the supplementary stocking has continued quite long, the "French" mtDNA has not been detected among "wild" birds in Finland.

SIIVONEN (1957) suspected that introductions with wrong material may have been deteriorated genetic constitution of original Finnish Grey partridge population already in 1957. This study provides excellent conservation genetic lessons from supportive introductions.

Based on these preliminary results we present following conservation genetic conclusions (**Figure 2.**):

1. Finnish partridge population represents the *Perdix perdix lucida*, which differs by 12 point mutations from the western European *Perdix perdix perdix*.
2. Supportive breeding has been made by wrong material, i.e., by Swedish stocks representing the western subspecies *Perdix perdix perdix*.
3. The genetic constitution of Finnish grey partridges may have been deteriorated because of mixing with the Swedish and even French *Perdix perdix perdix* stocks.
4. Restocking programs should be stopped immediately. Restocking could be continued only by proper bird material, but it has been demonstrated that birds do it better themselves.

Figure 2.: The minimum spanning network of the Grey Partridge. Each tick mark represents one point mutation. Each population has been marked with the particular shading and the size of the circle describes number of the individuals included to the circle. There are two distinct main lineages in this network.

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EFFECTS OF A CHANGE IN DIET ON THE NUTRITIONAL STATUS OF HAND-REARED GREY PARTRIDGE (*Perdix perdix*)

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KEY-WORDS: change in diet, nutritional status, hand-reared Grey Partridge, Finland

ABSTRACT

LIUKKONEN-ANTTILA, T., PUTAALA, A. and HISSA, R.: EFFECTS OF A CHANGE IN DIET ON THE NUTRITIONAL STATUS OF HAND-REARED GREY PARTRIDGE (*Perdix perdix*). The effect of an abrupt change in diet on the grey partridge was studied. The determined parameters were BM, food consumption, GE, produced excreta, EE, ME, MEC, Hb, Hct, glucose, total protein, triglyserides, uric acid, T_3, T_4, and the masses of gizzards and livers and the lengths of small intestines and caeca. The groups differed significantly from each other according to BM, consumed food, GE, excreta production, EE, ME, MEC and masses of gizzards. On the other hand, no differences were seen in analysed blood metabolites or other morphological measurements. However, on the basis of this study we can conclude that this period of six weeks may not be sufficient to precondition the birds to a life in the wild.

1. INTRODUCTION

Previous studies on galliform species show that hand-reared birds fed with commercial diets differ in their physiology and anatomy from the wild birds (MOSS, 1972, 1983; HANSSEN, 1979; PUTAALA AND HISSA, 1995). The first few weeks after the release into the wild seems to be most critical for the survival of hand-reared grey partridge (PANEK, 1988; DOWELL, 1990; PUTAALA *ET AL.*, 1998). The limited ability of the digestive system to use fibrous natural food may contribute to the birds' poor survival. It is even possible that birds starve to death before their digestive system is adapted to the natural diet (PUTAALA AND HISSA, 1993). The adaptation from commercial to fibrous natural food is assumed to take several weeks, if not months (MOSS AND TRENHOLM, 1987; MOSS, 1989).

The aim of this study was to determine if the poor performance of hand-reared partridges after their release into the wild could be explained by digestive constraints associated with the changing diet. We supposed that the change in diet may be expressed in lowered body mass, higher mass of consumed food, lowered metabolised energy coefficient and changes in gut morphology and in some blood metabolites.

2. MATERIAL AND METHODS

We performed two feeding trials from January to April in 1996 and 1997 on hand-reared grey partridges. We simulated the abrupt change in diet, which takes place when hand-reared birds are released into the wild. In 1996 we used 30 grey partridge females and in 1997 12 females and 12 males. For morphological measures we used 5 males from both diet groups. We examined how a change in diet from commercial to natural affected the grey partridges'

a) 1996/1997	body mass (BM)
b) 1996	food consumption (fresh/dry mass), gross energy (GE) intake excreta production, excretory energy (EE) metabolised energy (ME) metabolised energy coefficient (MEC)
c) 1997	haemoglobin (Hb), haematocrit (Hct) glucose, total protein, triglyserides, uric acid triiodothyronine (T_3), thyroxine (T_4)
d) 1997	gizzard and liver mass length of small intestine and caeca

Before the feeding trial birds were acclimated to indoor conditions (+ 15 °C, photoperiod 7L:17D) and fed with pelleted commercial poultry food (Täsmä-Herkku, Raisio, Finland). After the acclimation period birds in the control group continued to receive only commercial food and birds in the test group were fed only with natural food (oat grains, barley sprouts and weed seeds; *Galeopsis sp., Fallopia convolvulus, Polygonum lapathifolium*), commonly encountered in the winter diet of grey partridge in Finland (PULLIAINEN, 1965, 1984). The energy content of every foodstuff was determined with a Gallencamp bomb calorimeter (CAMBRIDGE INSTRUMENT Co Ltd, England).

BM, food consumption, GE, excreta production, EE, ME and MEC

The birds were weighed every third day both during the acclimation period and during the feeding trial. The food consumption of each foodstuff separately was closely examined on a daily basis. Each bird's diet and its energy content was exactly recorded. Excreta were collected once a week and the energy content of three excreta pellets (ca. 1.0 g each) per bird was determined as mentioned before.

Metabolised energy (ME) content per day was calculated as the difference between gross energy (GE) intake and excretory energy (EE). The metabolised energy coefficient (MEC) was calculated as ME/GE (for terminology and formulae: NIKIFOROV, 1992).

Blood metabolites

Blood samples of 1.5 ml were collected three, five, seven and nine weeks after the birds had been taken inside to ensure they were acclimated. During the feeding trial samples were collected one, two, four and six weeks after the change in diet. Blood was collected from the *vena brachialis* with 23 G needles and syringes handled with 20.8 % EDTA as an anticoagulant. Plasma was separated in a centrifuge.

Hb and Hct were analysed from whole blood from samples drained directly into capillary tubes. Hb analysis was made with an Ames Hb Mini-Pak in an Ames Minilab PC and Hct with a Micro-Haematocrit Reader. Glucose, uric acid, triglycerides and total protein were analysed with Boehringer commercial kits and T_3 and T_4 from plasma with Orion diagnostica radioimmunoassay.

Morphological features

After the feeding trial was completed, five males of both diet groups were killed. Before weighing, the gizzards were emptied and the inner cuticle was removed. Livers were weighed separately. Both caeca and small intestine were straightened but not stretched before measuring, and the mesenteries were removed.

Statistical analysis

All statistical analyses were performed using the statistical software package SPSS 6.3.1. As sexes did not differ from each other in their responses to the change in diet (*Repeated*

Measures Analysis of Variance, $F_{11} = 1.08$, $P = 0.378$), the data from females and males were pooled in 1997.

Mass changes during the acclimation period and feeding trial were tested by Repeated Measures Analysis of Variance. We compared food intake, excreta production, GE, EE, ME and MEC in test and control birds at the end of the acclimation period with by t-test and during the feeding trial by the Repeated Measures Analysis of Variance.

We compared all the blood parameters as mentioned above. The weights of the gizzards and livers and the lengths of the small intestines and caeca in the test and control birds were compared with the *Mann-Whitney U-test*.

3. RESULTS

There was no difference between the groups in 1996 or in 1997 in the BM during the acclimation period. In both years birds in the test group lost BM dramatically after the change in diet, which then stabilised at a lower level than in the control group (1996 $F_{12} = 9.42$, $P < 0,001$; 1997 $F_{12} = 5.54$, $P < 0.001$, **Figure 1.**).

During the acclimation birds in the control and test group did not differ from each other according to food consumption, GE intake, excreta production, EE, ME or MEC. During the feeding trial the test group birds consumed somewhat more food ($F_6 = 18.67$, $P < 0.001$, **Table 1.**) and had lower GE intake ($F_6 = 7.98$, $P < 0.001$, **Table 1.**) than control birds. There was a significant difference between the groups in the amount of produced excreta and excretory energy ($F_6 = 36.25$, $P < 0.001$; $F_6 = 42.44$, $P < 0.001$, **Table 1.**). Test birds metabolised less energy ($F_6 = 10.58$, $P < 0.001$, **Table 1.**) and had a lower metabolised energy coefficient ($F_6 = 15.23$, $P < 0.001$, **Table 1.**) than control birds.

In analysed blood metabolites there was no difference between the groups either before of after the change in the diet. Test group birds had heavier gizzards than birds in the control group (6.0 +- 0.2 g and 4.7 +- 0.3 g respectively, $z = -2.4023$, $P = 0.0163$).

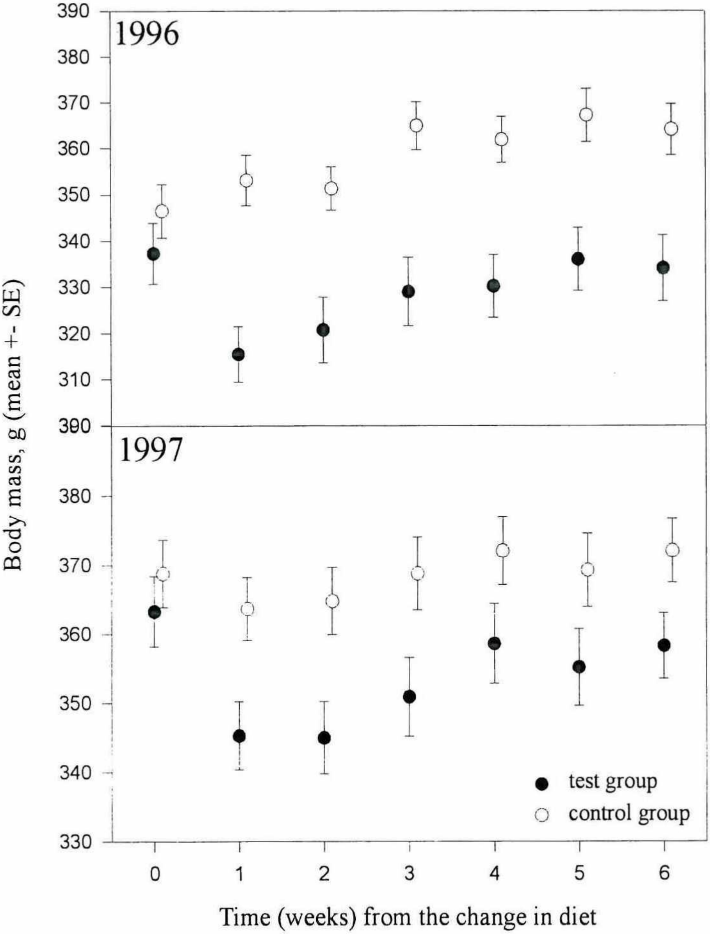

Figure 1: Body masses of the birds in both diet groups. In 1996n=15 and in 1997n=12 in both groups

Table 1.: Consumed food and its energy content (GE), excreta and excretory energy content (EE), metabolised energy (ME) and metabolised energy coefficient (MEC) (mean ± SE) before the change in diet (week 0) and during the feeding trial (weeks 1-6). n = 15 in each group.

Weeks after the change in diet	Group	Consumed food, g fresh weight/day	GE, kJ/day	Excreta, g dry weight/day	EE, kJ/day	ME, kJ/day	MEC
0	test	24.4 ± 1.9	383.7 ± 13.7	9.1 ± 0.3	105.5 ± 3.7	278.2 ± 11.7	0.72 ± 0.01
	control	22.9 ± 1.5	360.3 ± 16.7	8.8 ± 0.5	103.6 ± 6.7	256.7 ± 13.0	0.71 ± 0.01
1	test	17.1 ± 1.1	219.1 ± 18.9	6.0 ± 0.4	75.3 ± 6.1	143.9 ± 16.9	0.62 ± 0.04
	control	22.3 ± 0.4	350.9 ± 5.5	10.4 ± 0.3	121.3 ± 4.2	229.7 ± 5.9	0.65 ± 0.01
2	test	32.8 ± 2.6	371.2 ± 30.1	13.2 ± 1.0	157.4 ± 11.2	213.9 ± 25.1	0.56 ± 0.03
	control	24.8 ± 0.9	389.9 ± 14.0	4.1 ± 0.1	45.6 ± 1.4	344.4 ± 14.0	0.88 ± 0.01
3	test	21.2 ± 1.5	264.9 ± 16.6	9.1 ± 0.6	99.8 ± 7.4	165.1 ± 14.9	0.61 ± 0.03
	control	18.6 ± 0.6	291.9 ± 9.3	10.7 ± 0.3	97.3 ± 4.4	194.6 ± 9.2	0.66 ± 0.02
4	test	25.7 ± 1.7	332.7 ± 10.9	11.6 ± 0.7	123.5 ± 7.9	209.2 ± 13.1	0.62 ± 0.03
	control	22.6 ± 0.6	354.2 ± 10.1	8.0 ± 0.3	74.2 ± 3.0	280.0 ± 9.3	0.79 ± 0.01
5	test	26.2 ± 1.5	306.6 ± 11.2	11.9 ± 0.6	154.1 ± 7.9	152.5 ± 11.8	0.49 ± 0.03
	control	23.4 ± 0.7	367.7 ± 11.7	7.2 ± 0.2	86.6 ± 4.5	281.1 ± 9.2	0.77 ± 0.01
6	test	37.2 ± 1.2	294.7 ± 15.7	9.0 ± 0.9	95.3 ± 5.7	199.4 ± 16.4	0.67 ± 0.03
	control	18.7 ± 0.7	294.1 ± 11.1	8.2 ± 0.3	76.4 ± 3.1	217.7 ± 8.9	0.74 ± 0.01

4. CONCLUSIONS

The abrupt change in diet affected the birds' ability to utilise energy from the fibrous natural food. The change decreased the birds' BM and although the birds were able to gain mass after a week from the change in diet, this may indicate a higher water content of the alimentary canal, due to the higher water content of eaten sprouts. For the same reason the amount of consumed natural food is somewhat higher on fresh weight basis than the amount of commercial food. Heavier gizzards may indicate a greater need for effective grinding ability. Results of the plasma analysis did not express significant nutritional stress or analysed parameters were not sufficiently sensitive to nutritional changes in birds.

After an acute change in diet from commercial to natural food, the released birds have to find proper food items and require more time for feeding. Further, they have to increase food intake to compensate for the poor quality of the food compared with the commercial food. A six week period of natural feeding in captivity before release may not be sufficient to make birds preconditioned to feeding in the wild.

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POPULATION GENETICS OF GREY PARTRIDGE (*Perdix perdix*) IN AUSTRIA - PRELIMINARY RESULTS

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KEY-WORDS: population genetics, horizontal starch electrophoresis, biochemical-genetic staining, Grey Partridge, Austria

ABSTRACT

EFFENBERGER. S. and SUCHENTRUNK. F.: POPULATION GENETICS OF GREY PARTRIDGE. *Perdix perdix,* FROM AUSTRIA - PRELIMINARY RESULTS. Over the last twenty years numbers of grey partridges decreased steadily in Austria. Loss of suitable habitat and increasing numbers of predators play a considerable part in the decline. Although habitat improvement for game birds was carried out. there are still no signs of an increase in partridge numbers even without hunting pressure. Therefore we suggest that another reason for this might be the loss of genetic variation due to inbreeding. To asses the amount of genetic variation in natural populations of grey partridges in Austria we apply starch geleelectrophoresis of allozymes and multilocus DNA-fingerprinting in more than 200 birds. In order to compare genetic variation and parameters of fertillity we started a breeding program with controlled inbreeding and out breeding pairs.

1. INTRODUCTION

As in many other European countries, densities of partridge declined dramatically in the recent past in Austria. Although there have always been fluctuations in the numbers of partridges recorded in the annual hunting bags, populations have never experienced such a drastic decrease as in the past 20 years. Considerable reduction in numbers within a population can cause a loss of genetic variability and hence reduce the adaptive potential of populations (AVISE, 1994).

The aims of our study were to estimate genetic variability in different populations of free ranging grey partridges (*Perdix perdix*) in Austria, to reveal genetic divergence among local populations, and to check for patterns of possible genetic depletion in certain regions. A good estimate of overall genetic variability of nuclear DNA can be achieved by studying allozymic variability at structural gene loci.

If a reduction of genetic variability can be found in regional populations, various conservation measures such as establishing suitable habitat connections to ensure enough gene flow between seperated populations or restocking programs with genetically suitable birds could be taken into account.

2. MATERIAL AND METHODS

236 liver samples of wild living grey partridges were collected during the hunting season in autmn 1997 in three parts of Austria (Upper Austria, Lower Austria, Burgenland). We sampled high density populations as well as low density populations, in terms of numbers of breeding pairs per hunting estate. Horizontal starch gel electrophoresis was used to screen 26 structural gene loci for allelic variability. Tissue preparation, electrophoresis, and biochemical-genetic staining were performed according to HARTL AND HÖGER (1986) and GRILLITSCH *ET AL.* (1992).

3. RESULTS AND CONCLUSIONS

The analysis of allozymic variability of *Perdix perdix* in Austria revealed a low level of genetic variability in comparison to diverse bird species from different orders (EVANS, 1987). In the present analysis only samples from Austria were included. Therefore all populations have already experienced a decrease in numbers mainly due to loss of suitable habitat. To evaluate the degree of genetic variability found in this analysis, a comparison to other still thriving populations of the same species should be considered. To date, however, no such studies on the genetic variability in grey partridge are available.

A detailed analysis of different subpopulations revealed no substantial genetic differentiation of the austrian partridge population into regional gene pools. This suggests that the degree of migration among diverse regions is high enough to maintain gene flow. Although the monogamous breeding system and overlapping generations together with probably low effective populations sizes in Austria, are known to increase the risk for inbreeding, the present genetic analysis did not support this hypothesis. Even regions with very low densities showed no signs for any depletion of genetic variability or increased inbreeding. Furthermore we did not find any density dependant variations in any of the studied population genetic parameters.

This study provides only a first estimation of genetic variability in grey partridge in one European country. More population genetic data of this species using different molecular marker systems are needed to assess actual levels of genetic variability in grey partridge and to estimate the influence of declining populations on the ability of retaining genetic diversity.

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IMPACT OF RADIOTRANSMITTERS AND TRAPPING ON MORTALITY OF ADULT GREY PARTRIDGES (Peridx perdix)

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KEY-WORDS: Grey partridge, *Perdix perdix*, trapping, tagging, postrelease, radio tracking, mortality, Feuchtwangen, North Bavaria, Germany.

ABSTRACT

KAISER, W.: IMPACT OF RADIOTRANSMITTERS AND TRAPPING ON MORTALITY OF ADULT GREY PARTRIDGES (*Peridx perdix*). An increased mortality of grey partridges can be observed after trapping and tagging. During the first week postrelease mortality was 12 % (n = 240) compared to a mean of 3 % in the following 12 weeks (range 1 - 5 %). The difference found was significant (chi^2 = 9,80, 1 df, $p < 0,05$). Most losses occured during the first two days after capture (59 %, n = 29). The increased mortality of tagged birds (27 %, n = 86) after the first week versus untagged birds (17 %, n = 169) in 27 coveys also was significant (chi^2 = 3,69, 1 df, $p < 0,05$, one-tailed). Predation was the main source of mortality found in the first week and later. During the first week postrelease mammalian predators were responsible for most of the losses (47 %, n = 29). Raptors only contributed 33 %, but were the main reason for losses after the first week (45 %, n = 96). To avoid bias of results on survival, birds lost during the first week after trapping should be excluded from analysis as has been recommended in other studies. Suitable technics of trapping and further reduction of weight of radiotags in combination with the preference for necklace radios can further improve the number of birds surviving the critical period after capture. The overestimate of the real mortality by using only tagged birds for analysis should be kept in mind when discussing survival.

1. INTRODUCTION

In many studies radiotelemetry has been used to give estimates on survival of wild populations. Typical radio packages used weighed up to 12.5 % of a bird´s body weight and were believed to increase mortality (Brander & Cochran 1969). Later studies indicated a high mortality of birds with packages of 4 % body weight (Schulz 1975; McCrow 1982) and among some phasianids even less than 4 % were suspected to increase mortality (Warner & Etter 1983). Beside the package weight the performance of studied birds also can be influenced by the way the transmitter is mounted and by the act of trapping and handling the birds.The objective of this paper is to show that radio-necklaces weighing less than the 2 % which were suggested by Warner and Etter (1983) also can have a severe impact on survival and that during the first week trapping itself is likely to be responsible for most of the losses.

Funding was provided by the Bavarian State Ministry of Agriculture. I wish to thank all farmers and hunters for giving me access to their land and supporting me in my struggle for knowledge.

2. STUDY AREA AND METHODS

The study area is located east of Feuchtwangen (District Ansbach) in north-west Bavaria, near Nürnberg, Germany. It is situated between 427 m and 514 m above sea level. Of the total area 29% is covered by small woodlands and 60% is private farmland. The main crops are winter cereals (40%), maize, rape and root crops (21%). 39% of farmland consists of permanent grassland (RIEDER, 1984).

From 1991 until 1994 a total of 240 birds was trapped using Japanese nets (5 x 18 m) with a mesh width of 3 x 3 cm. Most Birds were caught in February, March and September, October. The main methods used for trapping was driving them into the nets by helpers or by slowly driving up to coveys or pairs with a jeep. Also other methods like night-trapping with a strong light were tested. Only one bird was injured seriously during trapping and had to be killed. During ringing, radio tagging an weighing the eyes of the birds were covered with a hood. Time of handling was tried to be kept at a minimum. The birds were equipped with necklace radio tags (TW-3, BIOTRACK Co., England) with a life expectancy of 7-8 months and a range of 800 m to 1000 m. The weight of the tags (7 g) comprised about 1.8 % of body weight. During the tagging-procedure birds were kept in a dark box. All were released at the same time to avoid further disturbance of covey and pair integrity. I used a portable telemetry system (TELEVILT RX-81 receiver, Sweden, and a two-element Yagi aerial) to monitor survival of radio tagged birds. Partridges were located every day during the first week after capture and every second day on average in the following weeks. It was possible to discover deaths within 24 hours during the first week and withing 48 hours in following weeks. The number of birds in the covey was counted at least once a week. A bird was considered alive until the first day its loss was noticed; because all radio tagged birds that were lost from a covey had died, missing birds without radio-tag also were assumed to have died. There was no visible difference in behaviour right after releasing for most birds. But juveniles weighing less than 350 g showed obvious stress symptoms and therefore were not radio tagged during later actions.

For analysis of survival of radiotagged birds I used PEARSON chi-square statistic.

3. RESULTS

Losses related to trapping and tagging

Increased mortality of adult, wild partridges was noted during the first week after release. The mortality rate found was as high as 12 % (n = 240) and decreased to a mean of 3 % (range 1 - 5 %) in the following weeks (**Figure 1.**). The difference was significant ($chi^2 = 9{,}80$, 1 df, $p < 0{,}05$). By subtracting the mean mortality rate of week 2 - 12 from the one observed in week 1 an estimate for the suspected researcher-induced mortality of 9 % is obtained.

Analysing the time of loss within the first week reveals that most birds died within the first 24 hours and were found on the day of capture or the first day after. Both days together hold 59 % (n = 29) of the losses in the first week. After these two days mortality dropped quickly to a "normal" level and remained low until day 7 (**Figure 2.**).

Losses related to tags only

To assess if radiotags can also cause increased mortality after the birds got used to them radiotagged partridges in 27 coveys were compared to those without in the same coveys. The assumption was that birds without tags lost from the covey were dead. Results show a significant ($chi^2 = 3{,}69$, 1 df, $p < 0{,}05$, one-tailed) difference: 27 % (n = 86) of partridges with necklaces were lost from coveys whereas only 17 % (n = 169) of birds without tags disappeared (**Figure 3.**).

Cause of losses

Predation was the main source of mortality both in the first week and later. In the first week postrelease most losses were due to mammalian predators (45 %, n = 29). The following weeks were dominated by losses to avian predators (45 %, n = 96) (**Figure 4.**). Mortality during the first 24 hours after trapping (day 0 and day 1, **Figure 4.**) also was mainly caused by mammals.

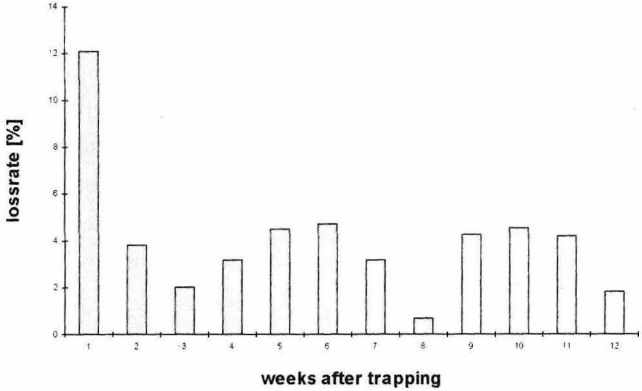

Figure 1: Lossrate of adult grey partridges during the first 12 weeks after trapping. The number of birds "at risk" each week was reduced by the number of losses the week before and the number of birds with signal loss.

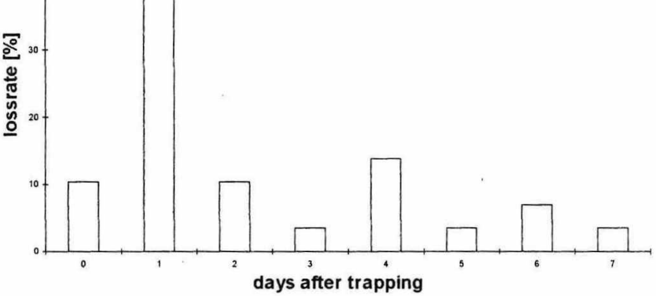

Figure 2: Adult grey partridges lost during the first week after trapping (n = 29). Most losses occured on the first day after capture.

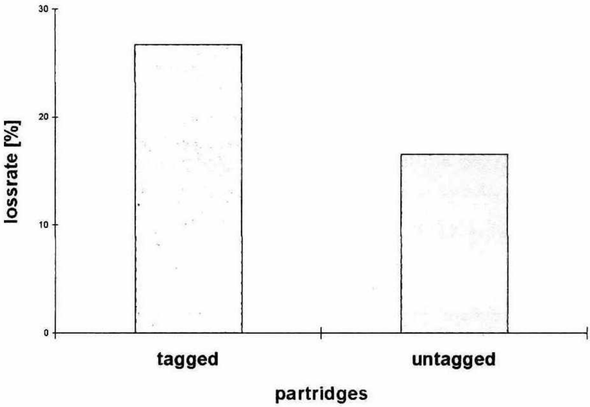

Figure 3: Lossrate of 86 radiotagged partridges versus 169 wild partridges in 27 coveys during autumn and winter 1991 to 1994. Birds without radiotag missing from the covey were assumed to be dead.

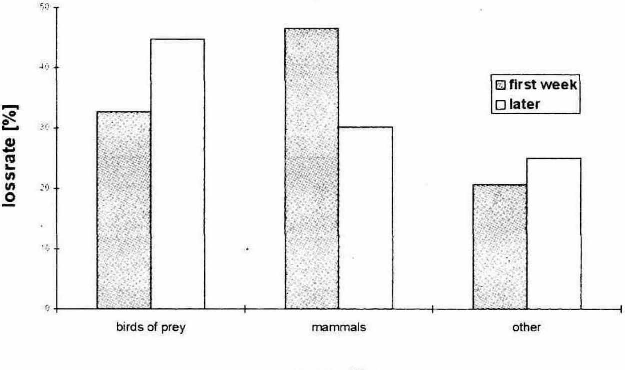

Figure 4: Cause of loss of adult, radiotagged grey partridges during the first week (n = 29) and later (n = 96)

4. DISCUSSION

Researcher-induced mortality has been reported from several studies (DUMKE AND PILS, 1973; WARNER AND ETTER, 1983; MARKS AND MARKS, 1987; CARROLL, 1990; PUTAALA *ET AL.*, 1997). But the actual proportion of losses due to trapping and tagging may vary greatly in different telemetry studies (CARROLL, 1990). CARROLL (1990) estimated a researcher-induced mortality of 34 % during the first week after capture. Other work shows similar results to this study. In ring-necked pheasants 11 % of the birds died within the first 5 days of radiotagging (DUMKE AND PILS, 1973). Losses of grey partridges in Finland also were as high as 12 % (PUTAALA *ET AL.*, 1997).

The reasons for losses during the first week are often attributed mainly to radiotransmitters. In Illinois results of a study on hen pheasants suggest a decrease of predicted survival with increasing weight of radio package from 2.3 to 3.3 % of body weight (WARNER AND ETTER, 1983). Results from Finland show a reduced take-off capability of partridges with back-mounted transmitter of 4 % of body weight (PUTAALA *ET AL.*, 1997), but first week mortality was similar to this study with 7 g (1.8 % of body weight) necklaces. The weight of tags also was found to have no effect on pheasant recovery rate, but recovery of birds with backpacks was lower than for birds with necklace (MARCSTRÖM *ET AL.*, 1989). Partridges were caught in about the same time periods in different studies. Therefore neither weight of radiotag, way of mounting or time of year can explain all differences found in first week mortality in various studies although weather at time of capture may effect survival. The fact that most birds die within the first 24 hours after capture strongly suggests that trapping and handling itsself has the most important impact on first week mortality. The use of necklaces being easier to mount can further reduce the time of handling and therefore is preferable to backpacks as has been recommended by MARCSTRÖM *ET AL.* (1989). In the first week mammals were found to be responsible for most of the losses suggesting that scent might play an important role, too.

Significantly increased loss rates of tagged birds versus untagged birds in coveys nevertheless emphasize a still negative effect of transmitters in later periods. Increased vulnerability to predation may be due to diminished acceleration and manoevering capabilities as described by PUTAALA *ET AL.* (1997).

To avoid bias of results on survival, birds lost during the first week after trapping should be excluded from analysis as has been recommended in other studies. Suitable technics of trapping and further reduction of weight of radiotags in combination with the preference for necklace radios can further improve the number of birds surviving the critical period after capture. The overestimate of the real mortality by using only tagged birds for analysis should be kept in mind when discussing survival.

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ESTIMATING BROOD PRODUCTION AND CHICK SURVIVAL RATES OF GREY PARTRIDGES: AN EVALUATION

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ABSTRACT

AEBISCHER. N. J. and REITZ. F.: ESTIMATING BROOD PRODUCTION AND CHICK SURVIVAL RATES OF GREY PARTRIDGES: AN EVALUATION. Potts (1986. The Partridge: Pesticides. Predation and Conservation. Collins. London) described a method of estimating the parameters quantifying breeding success for the grey partridge *Perdix perdix* on the basis of autumn counts. We review his method and evaluate its accuracy against situations where the true values are known: an intensive study at Damerham. U.K. (1947-1959). two small radio-tracking studies in the U.K. (early 1980s). and a large-scale radio-tracking study in France (1995-1997). The method performed well when compared with the British data. which had been obtained from sites with low predator pressure. In France. estimated chick survival rates were also accurate after correcting for differences in brood size at hatching. even with sample sizes as low as two. The method proved not suitable to estimate hen survival rates in areas with a high density of harriers *Circus*. Elsewhere. the accuracy of the estimation of hen survival rates was generally good (making allowance for additional mortality caused by wearing radio transmitters). although it deteriorated for chick survival rates below 0.3.

1. INTRODUCTION

Any study of animal demography relies crucially on an accurate estimation of demographic parameters such as survival rates or breeding success. Over the last thirty years, sophisticated statistical methods have been developed to estimate such parameters from intensive studies, such as capture-mark-recapture for survival estimation (SEBER, 1982; BURNHAM *ET AL.*, 1987; POLLOCK *ET AL.*, 1990; LEBRETON *ET AL.*, 1992), or detailed nest monitoring for breeding success (HENSLER and NICHOLS, 1981; AEBISCHER, 1999). These methods require considerable time and effort to implement, and belong primarily to the domain of purpose-designed scientific research programmes.

Another source of demographic data, particularly in the field of wild game management, is the annual or biannual survey carried out for monitoring purposes and for determining harvest levels. Numbers of wintering geese, for example, are counted annually in several European countries to monitor population size (ROSE and SCOTT, 1994). In addition, the separate identification of adult and young geese during the counts gives an annual index of productivity, and a method of estimating annual survival rates (OWEN, 1982; EBBINGE, 1985; FOX *ET AL.*, 1989). This approach is much simpler than the previous one in terms of time and effort. Although potentially less rigorous and hence less accurate; it may nevertheless provide adequate estimates of some of the demographic parameters that are important for managers and, indeed, for population biologists (FOX *ET AL.*, 1989; EBBINGE, 1991).

For the grey partridge *Perdix perdix*, such surveys have been carried out routinely on European shooting estates after the cereal harvest (MIDDLETON, 1937; POTTS, 1986; BIRKAN and JACOB, 1988). As for geese, the separate identification of adult and young birds provides an annual index of productivity and an estimate of annual survival rates (MIDDLETON, 1935; BLANK and ASH, 1962; REITZ, 1992). Unlike geese, though, it is also possible to differentiate male and female adult grey partridges during the surveys (differences described in BIRKAN and JACOB, 1988), and to record individual brood sizes. POTTS (1980, 1986) used this further information to obtain a detailed breakdown of demographic parameters during the breeding period rather than simply an index of productivity, and proposed a series of formulae to do so. This paper uses data from intensive studies in the U.K. and in France for an evaluation of the accuracy of breeding parameters estimated using the Potts method.

2. METHODS

2.1.DEFINITIONS AND POTTS ESTIMATION OF DEMOGRAPHIC PARAMETERS

Originally a species of temperate grassy steppes, the grey partridge adapted readily to temperate agricultural landscapes and was once widespread across much of Europe. Since the 1950s, agricultural intensification has been the underlying cause of a decline of over 80% in most countries where the grey partridge occurs (POTTS, 1986; AEBISCHER and POTTS, 1994). A brief account of the life cycle of the grey partridge is as follows (POTTS, 1986; BIRKAN and JACOB, 1988). The species is monogamous. Birds pair in early spring, and nesting starts in May. The female alone incubates the eggs, while the male stands on guard. During the laying and incubation period, the hen is particularly vulnerable to ground predators such as the red fox *Vulpes vulpes*, while the eggs are attractive to corvids, mustelids, rats and other ground predators. The peak hatching period is the second half of June. Partridge chicks leave the nest only a few hours after hatching. They feed themselves, but initially require brooding by the parents to keep warm. During the first two weeks of life, the chick diet is predominantly invertebrate, then changes towards the mainly vegetable adult diet of seeds and green matter. Most chick mortality occurs within the first six weeks after hatching. In August, grey partridges form into coveys usually comprising a family group, often accompanied by one or more unsuccessful breeders. Shooting, if it occurs, takes place in autumn and early winter. Coveys persist through the winter, then break up in early spring as pairs form and the cycle starts again.

Aware of the above, POTTS (1980) identified six major demographic parameters that described the life cycle, and for which he proposed estimation formulae based on autumn count data. These parameters are defined below:

Hen survival rate: the proportion of spring females that survive the breeding season.

Clutch survival rate: the proportion of clutches that hatch at least one chick, after excluding clutches where the female died.

Brood production rate: the proportion of spring pairs that successfully hatch young. The brood production rate is the product of hen survival rate and clutch survival rate.

Chick survival rate: the proportion of chicks surviving for six weeks after hatching.

Shooting survival rate: the proportion of August partridges that survive the shooting season.

Overwinter change rate: the proportional change in number of females between the end of the shooting season and the following spring. This rate may include immigration, emigration, or both. It can also be calculated from August, in which case it includes shooting losses.

The estimation formulae proposed by POTTS used counts carried out after harvest, usually in late August. They required that in each observed covey, numbers of males, females and young be counted separately. The estimation of the breeding parameters revolved around the estimation of chick survival rate. POTTS recognized that the better the chick survival rate, the more young birds would be present on average in a covey. The relationship was complicated by the fact that the number of broods counted did not represent all broods that hatched, but only those where at least one chick survived. To take total brood losses into account, POTTS derived an empirical relationship between geometric mean brood size at count time and actual chick survival rate, using data from studies by JENKINS (1956) and BLANK and ASH (1962) (**Figure 1**). The corresponding formula for the estimation of chick survival rate,

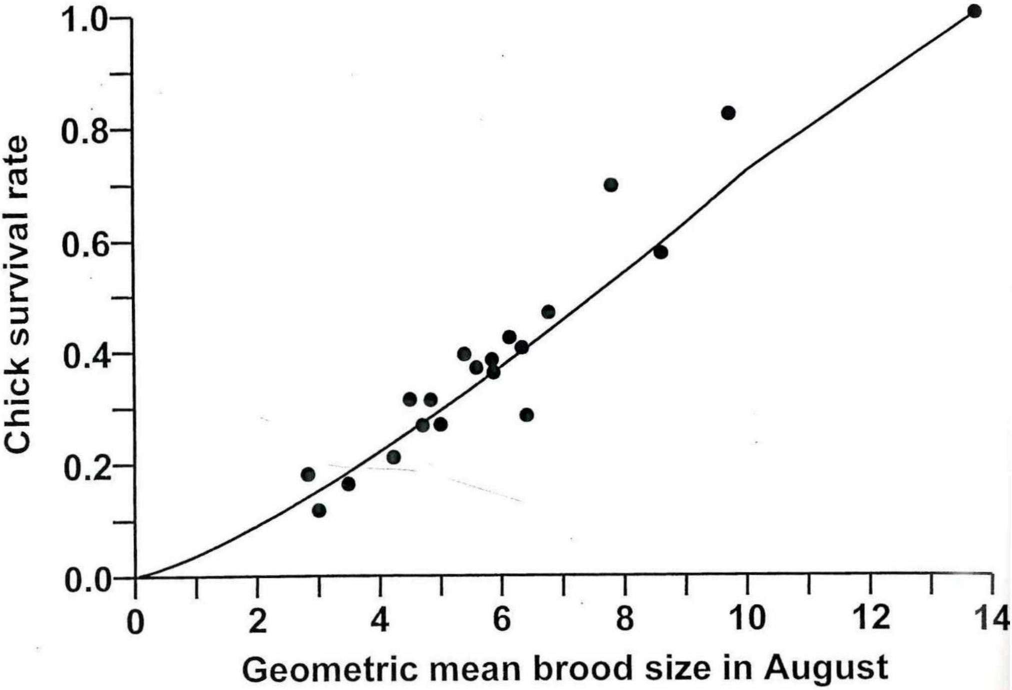

Figure 1: Empirical relationship between survival rates of grey partridge chicks and corresponding geometric mean brood sizes, based on U.K. data from JENKINS (1956) and the Damerham study; each point corresponds to a year. Source: POTTS (1986).

and the formulae that provide estimates of other demographic parameters, are presented in **Table 1.**

One major assumption underlying the validity of the formulae is that the number of August males represents the number of spring pairs (and hence the number of spring females). The argument for accepting this assumption is that the spring sex ratio is biased towards males, so that male losses during the breeding season reduce the number of spring males to the number of pairs. POTTS (1986, p. 42) showed that the assumption held for an intensive study area in the U.K.

Table 1: Formulae proposed by POTTS (1980, 1986) for the estimation of demographic parameters of the grey partridge, based on August covey counts.

Demographic parameter	Formula
Chick survival rate[1]	If geometric mean brood size $x \leq 10$: $0.03665\, x^{1.293}$
	If geometric mean brood size $x > 10$: $x / 13.84$
Number of broods hatching:	(August young) / (chick survival rate) / 13.84
Brood production rate[1]:	(Broods hatching) / (August males)
Hen survival rate[1]:	(August females) / (August males)
Clutch survival rate[1]:	(Broods hatching) / (August females)
Overwinter change rate:	$(\text{Males in August})_{t+1} / (\text{August females} + \tfrac{1}{2}\,\text{August young})_t$

[1] Estimates are truncated if necessary to keep them between 0 and 1

Another assumption underlying the estimation of chick survival rate is that the average brood size at hatching is 13.84 (calculated from the averages of 27 U.K. studies: POTTS, 1986, p. 42). If this is not the case, then, as POTTS (1980) showed, the geometric mean brood size needs to be adjusted before the formula is applied, by multiplying by 13.84 and dividing by the correct brood size at hatching.

2.2. DAMERHAM AND OTHER U.K. STUDIES

The I.C.I Game Research Station carried out an intensive study of grey partridges from 1947 to 1959 on West Park estate at Damerham, in Hampshire, U.K. (BLANK and ASH, 1962; BLANK *ET AL.*, 1967). Out of a total area of 14.5 km^2, 5% was woodland, the rest was farmland that followed a mixed rotation of arable and grass such that about 50% was in cereals (POTTS, 1986). The estate employed five gamekeepers to manage the estate for partridges, including controlling the abundance of predators. The study involved complete censuses carried out in March, September and December, with a sample count of one-third to one-half of the March population in August. During these counts, birds in each covey were sexed and, if young birds were present and distinguishable (adult plumage is acquired after 12 weeks), aged as well. Large numbers of birds were individually marked, and more than half of the partridge nests were found each year; their outcome was closely monitored. These intensive data provided values for actual annual brood production rates and chick survival rates, while the raw data from the August counts were used to obtain matching estimates from the formulae in **Table 1.**

Two other intensive U.K. studies of grey partridges exist. GREEN (1984) monitored the fate of partridge broods with radio-tagged parents in two 10-km^2 areas of arable farmland in north-west Norfolk in 1980 and 1981. The adult females were tagged on the nest, and the survival of eight broods was assessed for 20 days from hatching. RANDS (1986) did likewise on a 11-km^2 arable farm in north-east Hampshire in 1984; he tracked 9 broods for 21 days from hatching. In both studies, gamekeepers were active on the areas concerned. The average survival rate of chicks up to three weeks of age was known exactly in both cases, and was given by (total number of chicks at three weeks) / (total number of chicks that hatched). It was compared with that calculated using POTTS' formula applied to the geometric mean of the brood sizes at three weeks.

2.3. FRENCH NATIONAL GREY PARTRIDGE STUDY

The Office National de la Chasse, the Union Nationale des Fédérations Départementales des Chasseurs and eight separate Fédérations Départementales des Chasseurs conducted a major study of grey partridge demography in northern and central France in 1995, 1996 and 1997 (REITZ, 1996). The study involved ten study sites, each between 20 and 150 km^2 in size, and at least 50 km apart. On average, about 30 females were radio-tagged on each site in each year in early spring, and monitored daily throughout the breeding season. The survival of the tagged females from 1 May to 31 August was calculated using the Kaplan-Meier method (POLLOCK *ET AL.*, 1989). If a tagged bird attempted to nest, the success or otherwise of incubation was recorded, as were the number of chicks at hatching and at six weeks. On the same sites, sample counts of the grey partridge stock were undertaken in August of each year; for each covey, the numbers of males, females and young were recorded. The radio-tagged birds provided exact data for each site and year on hen survival, clutch survival and chick survival rates. Using the formula in **Table 1**, matching chick survival rates were estimated from the geometric mean brood size at six weeks of all radiotagged females with broods. The August count data were used to estimate hen survival and clutch survival using the POTTS method for each site and year, for comparison with the values obtained from radiotagged birds.

At each site in each year, ancillary data were collected on harrier abundance in the summer (*Circus aeruginosus*, *C. cyaneus* and *C. pygargus* combined), by means of evening counts from a grid of fixed locations at the end of May and beginning of June. The counts were expressed as numbers of harriers per 10 km^2. For the present study, sites were classified into two categories according to whether the mean number over the three years was above 1 (harriers present) or below 1 (harriers absent). In 1996 and 1997, an index of mustelid abundance was obtained on each site by walking twice (two weeks apart) along 30 transects in May/June, and scoring each one as positive or negative for the presence of mustelid faeces. The index was the proportion of positives out of the 60 scores. Here, sites were classified into two categories according to whether the mean index value over the two years was above 0.3 (high mustelid density) or below 0.3 (low mustelid density).

3. RESULTS

3.1. EVALUATION OF POTTS' ESTIMATION: U.K. STUDIES

Using the data from Damerham, Figure 2 illustrates the excellent level of agreement between the chick survival rates observed by intensive monitoring of broods after hatching, and those estimated from August counts. That the points straddle the 1:1 line is not surprising, given that the formula for estimating chick survival rate was based partly on the Damerham data. What is noteworthy is that the average error in the estimates (vertical distance between each point and the 1:1 line) is small, even though the observed chick survival rates range from 0.11 to 0.77. Thus the mean difference between 11 estimated and observed rates was 0.012 (s.d. 0.052), indicating that approximately two-thirds of estimates were within 0.05 of the true chick survival rate. Sample sizes for the estimated rates lay between 49 and 148 depending on the year. The two points from the studies by GREEN and RANDS both appear below the 1:1 line, with departures of -0.04 and -0.06 respectively from the chick survival rates observed through radio-tracking.

The Damerham data also allow a comparison between 11 observed and estimated brood production rates (**Figure 3**). The average difference (bias) was -0.06, with a spread (s.d.) of 0.12, twice as high as that for chick-survival rate. The bias did not differ significantly from zero (t_9=1.83, P=0.100). For six of the years, the observed chick survival rates were below 0.3. All of the corresponding estimates of brood production rate were below the 1:1 line, two of them by over 0.2.

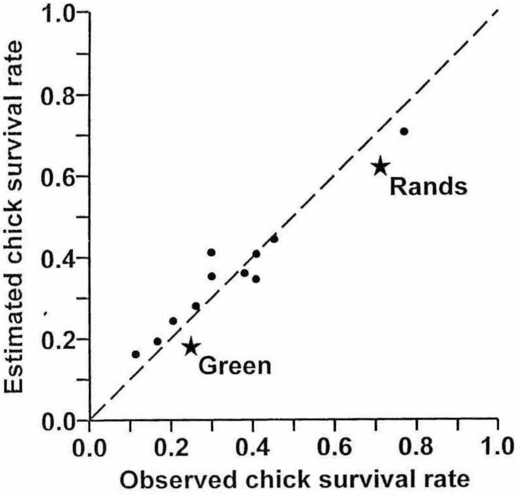

Figure 2: Comparison between estimated and observed chick survival rates of the grey partridge in the U.K.: data from the intensive study at Damerham (circles), and from two radio-tracking studies (stars) by GREEN (1984) and RANDS (1986). The dashed line represents 1:1 correspondence.

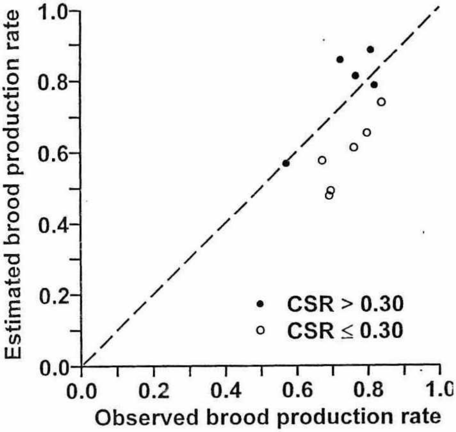

Figure 3: Comparison between estimated and observed brood production rates of the grey partridge in the U.K.: annual data from the intensive study at Damerham. The dashed line represents 1:1 correspondence. CSR = chick survival rate.

3.2. EVALUATION OF POTTS' ESTIMATION: FRENCH STUDY

Using data from broods with radio-tagged parents from the French study, observed annual chick survival rates were compared with estimated ones (**Figure 4**). The scatter from the 26 points was much greater than for the Damerham data (s.d. 0.18), but eight of the points were based on only one brood, and a further eight on two. When points based on only one brood were omitted, the scatter was reduced to 0.11. The mean difference between estimated and observed chick survival rates was -0.076, indicating significant bias (t_{16}=2.81, P=0.013).

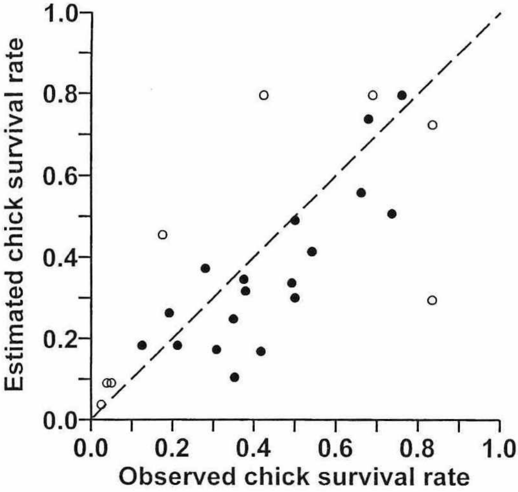

Figure 4: Comparison between estimated and observed chick survival rates of broods with radio-tagged parents in France: annual site data from the French National Grey Partridge Project. The dashed line represents 1:1 correspondence. Points based on only one six-week-old brood are open, those based on two or more are filled.

The POTTS method of estimating chick survival rate assumes an average brood size at hatching of 13.84. This assumption was not verified for the French radio-tracked broods, which averaged 11.79 chicks at hatching over the three years, with no significant effects of year or site (**Table 2**). In fact, the three annual averages in France were all lower than the 27

U.K. ones that contributed to the 13.84 ($t_{28}=6.86$, $P<0.001$). The estimated chick survival rates were therefore recalculated using the geometric mean brood sizes adjusted by multiplying them by 13.84/11.79 (**Figure 5**). This adjustment virtually eliminated the bias (mean difference between estimated and observed chick survival rates was 0.002, s.d. 0.13), and produced a good fit throughout the length of the 1:1 line. For comparison, the s.d. was 0.20 when adjusted values based on only one point were considered as well.

Table 2: Average brood sizes at hatching for grey partridges in the U.K. (POTTS, 1986) and for broods with radio-tagged parents in the French National Grey Partridge Project 1995-1997.

U.K. (POTTS, 1986, p. 46):

Average (± s.e.) of 27 studies	13.84±0.10

France (this study):

Year	Broods	Chicks hatched ± s.e.
1995	30	12.27±0.64
1996	38	11.84±0.62
1997	33	11.30±0.55
Overall	101	11.79±0.35

Two-way analysis of variance:

testing for an effect of year: $F_{2,89}=2.07$, $P=0.132$;

testing for an effect of site: $F_{9,89}=1.50$, $P=0.160$.

Estimated hen survival rates were almost without exception higher than observed ones obtained from radio-tagged females (**Figure 6**). The mean difference was 0.30 (n=29) with a s.d. of 0.19; the bias was significant ($t_{27}=8.19$, $P<0.001$). The points fell into two clusters, according to whether harriers were present or absent. In the presence of harriers, the mean difference between estimated and observed hen survival rates was 0.41 (s.d. 0.15), significantly greater than that in the absence of harriers (mean 0.14, s.d. 0.12, $t_{27}=5.06$, $P<0.001$). Taking into account the clustering associated with harrier presence, there was no evidence of a further effect of mustelid abundance ($F_{1,26}=2.00$, $P=0.169$).

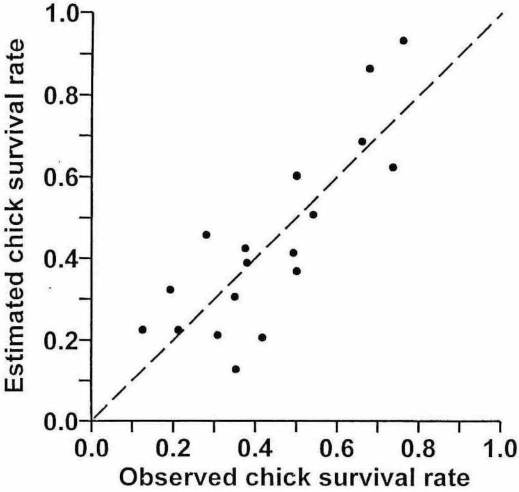

Figure 5: Comparison between estimated and observed chick survival rates of broods with radio-tagged parents in France: annual site data from the French National Grey Partridge Project, excluding points based on only one six-week-old brood. Estimates have been adjusted for a brood size at hatching of 11.79 instead of 13.84. The dashed line represents 1:1 correspondence.

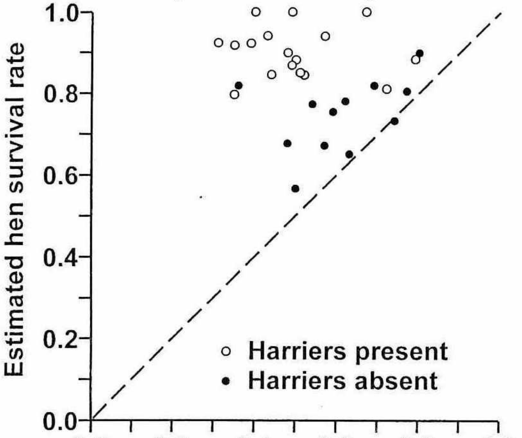

Figure 6: Comparison between estimated and observed hen survival rates in France: annual site data from the French National Grey Partridge Project. Observed rates were obtained from radio-tagged females, estimated ones from August counts. The dashed line represents 1:1 correspondence.

Estimated clutch survival rates were nearly all higher than those observed from radio-tagged females (**Figure** 7), and the bias was significant (mean difference 0.33, s.d. 0.24, $t_{27}=7.24$, $P<0.001$). The separation according to presence or absence of harriers was less marked than for hen survival, and not sufficient to show a significant difference ($t_{27}=0.89$, $P=0.379$). Nevertheless, in the absence of harriers there was a significant relationship between the estimated and the observed clutch survival rate ($F_{1,10}=12.00$, $P=0.006$), such that the slope differed significantly from one ($t_{10}=5.53$, $P<001$). No such relationship existed in the presence of harriers ($F_{1,15}=0.07$, $P=0.790$). There was no evidence of any clustering with regard to the abundance of mustelids ($F_{1,27}=0.05$, $P=0.819$).

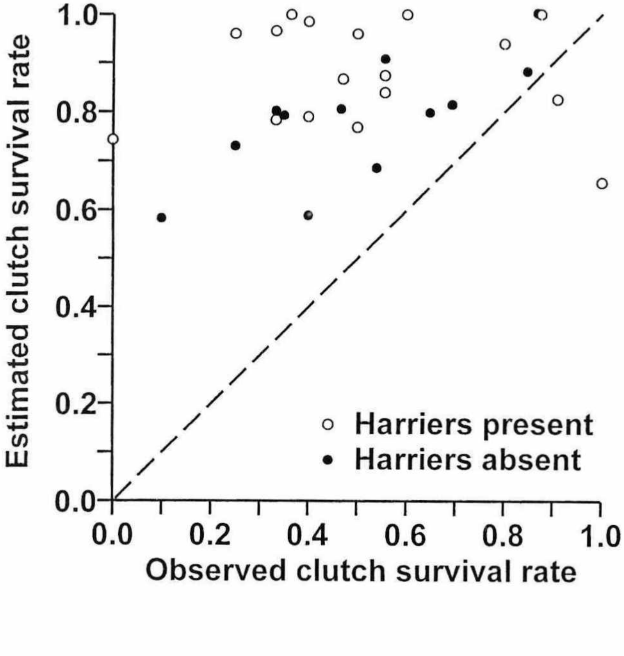

Figure 7: Comparison between estimated and observed clutch survival rates in France: annual site data from French National Grey Partridge Project. Observed rates were obtained from radio-tagged females, estimated ones from August counts. The dashed line represents 1:1 correspondence.

4. DISCUSSION

The empirical method of estimating chick survival rates from geometric mean brood sizes (**Figure 1, Table 1**) was found to perform remarkably well for all datasets, once the following factors had been taken into consideration:

(a) Brood size at hatching. Although there was high consistency in mean brood size at hatching across years and studies in the U.K. (POTTS, 1986), the value calculated for radio-tagged females in the French study was significantly lower than the U.K. average of 13.84, in line with the latitudinal trend noted by LACK (1947). As POTTS (1980) intimated, ignoring such differences can lead to positive or negative bias in the estimated chick survival rates, depending on whether the actual value is higher or lower than 13.84. Thus in the French study, actual brood size at hatching was 15% lower than the U.K. one, and resulted in a negative bias of –0.08. This bias disappeared when geometric mean brood size was adjusted upwards to compensate. As in the U.K., the French data indicated a high consistency in mean brood size at hatching across years and sites, implying that detailed knowledge of local variations in brood size at hatching is not necessary to apply the Potts method, so long as sufficient information on a broad regional scale is available to decide whether or not an adjustment is required.

(b) Survival period. The chick survival rates estimated for the two small U.K. radio-tracking studies were both lower (by 0.05 on average) than the observed ones. This was probably because they were estimated from broods aged three weeks instead of six weeks. Although most chick mortality occurs within the first 3-4 weeks after hatching (JENKINS, 1961; CARROLL *ET AL.*, 1990; REITZ and MAYOT, 1997), some additional losses would be expected during the next three weeks (e.g. PULLIAINEN, 1968). When applied to a mean brood size at three weeks, the formula in **Table 1** would return an estimated chick survival rate at six weeks, which should therefore be increased slightly to give one at three weeks. The observed difference is in line with what would be expected.

(c) Sample size. Not surprisingly, the accuracy of the estimation depends on the sample size used to calculate geometric mean brood size. POTTS (1986) recommended a minimum of ten broods for estimation purposes. Unexpectedly, even with sample sizes as low as two, the accuracy was good (**Figure 4**). The spread of the mean difference between estimated and observed fell from 0.20 when sample sizes of one were included, to 0.13 when they were excluded, while it was 0.05 when sample sizes were 49 or more with the Damerham data. Obviously, the higher the sample size the better, but the results imply that even in a situation where the stock is declining and it is increasingly difficult to find broods during the autumn counts, reasonable estimates of chick survival rate may still be obtained.

The Damerham study provided a direct comparison between estimated and observed brood production rates (**Figure 2**). The spread was similar to that recorded for the comparison of chick survival rates from the French study (excluding sample sizes of one), so can be considered good. Because the Damerham estate was well-keepered, observed brood production rates were all quite high (0.57-0.84), so that the adequacy of the method at low rates could not be assessed. The estimated values had a tendency to be more variable at low chick survival rates (below 0.3). This is because the calculation of estimated brood production rate involves division by the estimated chick survival rate (see **Table 1**); the lower the latter, the more even small differences between estimated and true chick survival rates become amplified in the process.. Given the fall in U.K. chick survival rates caused by the widespread use of herbicides (POTTS, 1977, 1980, 1986), and the more recently observed reduction associated with the use of summer insecticides (POTTS, 1990; AEBISCHER and POTTS, 1998), chick survival rates are now often lower than 0.3 (POTTS and AEBISCHER, 1995). The consequential effect on the accuracy of estimated brood production rates must therefore not be ignored, and such estimates should be treated cautiously.

The French study enabled separate comparisons between estimated and observed hen survival and clutch survival rates. Because the radio-tagging was directed at female partridges, it was not possible to apply the formulae in **Table 1** to the same birds that provided the observed rates (there was no equivalent of the number of August males). In consequence, the comparisons were not direct ones, but made use of August counts to evaluate estimated rates. This assumed that the observed rates from radio-tagged birds were representative of the population as a whole, and introduced an additional source of variation.

Nevertheless, the difference observed between sites with and without harriers was strikingly large. On sites without harriers, the spread was relatively low (similar to that recorded for the comparison of chick survival rates, excluding sample sizes of one). Although bias was present, it could be explained by increased mortality incurred because of the presence of the radio transmitters. With this interpretation, the bias of 0.14 represented the reduction in survival rate caused by wearing a transmitter. Such levels are compatible with what is known about radio effects on the wearer (e.g. WARNER and ETTER, 1983; MARKS and MARKS, 1987; CALVO and FURNESS, 1992). In the absence of harriers, therefore, it is likely that estimates of hen survival rates are good approximations to the actual ones.

In the presence of harriers, the use of the female:male ratio to estimate hen survival rates considerably overestimated the true rates. The reason was the relative shortage of males in the autumn counts. Indeed, in three cases there were more females than males, whereas the normal situation is for a surplus of males over females (BIRKAN and JACOB, 1988; REITZ, 1992). It seems likely that, as the male stands guard, he is more conspicuous than the female to foraging harriers, and hence more vulnerable. The additional male losses required to produce the observed difference in sex ratio may be evaluated from the ratio of the average estimated female survival rate in the absence of harriers to that in their presence. With a mean observed female survival rate of 0.46, and average biases of 0.14 for the estimated female survival rate in the absence of harriers and of 0.41 in their presence, this ratio was (0.46 + 0.14) / (0.46 + 0.41) = 0.69, i.e. the survival rate of males on sites with harriers needed to be 69% lower than on sites without them. Harrier diet is known to include adult gamebirds (SCHIPPER, 1973; UNDERHILL-DAY, 1985), but neither of these authors separated summer gamebirds into males and females. BRÜLL (1953) found, however, that 65% of grey partridges killed by goshawks were males: this may simply reflect the surplus of males over females in the population, or it may indicate greater vulnerability of males than females to raptors.

The distinction between sites with and without harriers is less clear in the comparison of estimated and observed clutch survival rates. On average there was a large positive bias, meaning that clutch survival rates obtained from radio-tagged females were consistently lower than those estimated from autumn counts. This is in line with BRO *ET AL.* (1999), who observed that, in general, overall chick production was lower for radio-tagged females than for control birds (BRO *ET AL.* were, however, not able to identify the reproductive stage when the difference occurred). In the absence of harriers, a significant relationship existed between estimated and observed clutch survival rates, albeit with a slope that was significantly less than one (**Figure** 7). This relationship could be the expression of a radio effect on clutch survival. In the presence of harriers, no such relationship was detected, possibly because harriers are recognized egg predators (CRAMP and SIMMONS, 1980).

In conclusion, chick survival rates can be reliably estimated from geometric mean brood sizes, provided that brood size at hatching is taken into account and sample sizes are at minimum two. The same holds for brood production rates, as long as chick survival rates are above 0.3. The evaluation of estimated hen and clutch survival rates is complicated by comparing observed values from radio-tagged females with estimated ones from August counts. No clear conclusion can be drawn for clutch survival rates, but hen survival rates seem well estimated in the absence of harriers.

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HOME RANGE AND HABITAT USE BY THE ENDANGERED GREY PARTRIDGE (*Perdix perdix*) IN THE IRISH MIDLANDS

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KEY-WORDS: home range, habitat use, endangered, Grey Partridge, Irish midlands

ABSTRACT

O'GORMAN. E.C., KAVANAGH, B. and ROCHFORD,J.: HOME RANGE AND HABITAT USE BY THE ENDANGERED GREY PARTRIDGE (*Perdix perdix*) IN THE IRISH MIDLANDS: The last potentially viable population of native Irish Grey Partridge (*Perdix perdix*) is located over a 25 km^2 area at Boora bog, Co. Offaly, in the Irish midlands. The habitat is a mosaic of cutaway bogland, coniferous forestry, newly created farmland and wetlands. Since 1996 a combination of predation control and the provision of habitat strips has been the focus of conservation efforts in Boora in an attempt to increase partridge numbers in the short-term. The aim of this study is to provide baseline information on partridge movements and habitat use in the conservation site. The result of two years fieldwork is presented. An area of 18 km^2 was mapped during the course of fielwork. Nine male birds were radio-tracked. The biological time periods (B.T.P.) calculated for breeding pairs were Exploration, Prelay, Lay, Incubation, Brood rearing, Primary and Secondqary covey movements. The home range varied in size and location from one B.T.P. to the next. This was linked to habitat availability. Breeding attempts occurred in young forestry plantations and newly created habitat strips within the cutaway bog area. The coveys left the cutaway bog area in late summer to feed on nerby pasture. A second movement in late Autumn was made to utilise winter stubbles on adjacent farmland. Birds returned to breeding sites in the cutaway bog area the following spring. The practical applications of the findings to the conservation effort are discussed.

1. INTRODUCTION

The Grey Partridge (*Perdix perdix*) is currently listed as an „endangered" species in Ireland (WHILDE, 1993). The partridge is now limited to two populations in the Irish Midlands (KAVANAGH, 1997). Both populations, one in Lullymore, co. Kildare, the other in Boora, Co. Offaly are associated with areas of citaway bogland.

A radio-tracking study was conducted from 1992-94 in Lullymore to give a greater understanding of the role played by cutaway bogland in partridge ecology (HEARSHAW, 1996). During this study the local partridge population did not increase despite management measures and the national population continued to decline (KAVANAGH, 1995). It became clear that the species was at risk of extinction. A project was initiated in 1996 in an attempt to preserve the species from further decline (KAVANAGH, 1998). The conservation effort focused on the larger population in Boora with a combination of predation control and habitat management.

The present radio-tracking study began in March 1997. The objective was to monitor the movement patterns and habitat use of birds within the conservation site. Most partridge radio-tracking studies have used time periods based on pre-determined calender dates. These dates are chosen by the researcher rather than being influenced by changes in the requirements of individual partridge. Examples include 1-2 month intervals (MCCROW, 1977; SMITH *ET AL*, 1982), seasonal, ie. winter and spring (CHURCH, K.E., 1990) and spring & summer (BIRKAN et al, 1992; CHURCH, 1995) time periods. Other radio-tracking studies have focused only on particular times of the year such as the breeding season (CARROLL *ET AL*, 1990; CHURCH, 1994; ENCK, 1990; RANDS, 1986a) or other specific time periods (CHURCH *ET AL*, 1980; KAISER, 1995; REITZ and MAYOT, 1998; THOMAIDES *ET AL*, 1995). In this study an attempt was made to follow birds through an entire year.

2. STUDY AREA, MATERIALS AND METHODS

Much of the study area (**Figure 1**) was once covered in raised bog (BELLAMY, 1986). Peat harvesting of the raised bog was carried out on a large scale by the semistate body „Bord na Mona" since the 1940's. Once the layers of peat have been removed the resulting area is termed cutaway bog. Some of this cutaway bog has been left idle for up to 25 years, and natural recolonisation by a widw variety of flora and fauna has taken place (KAVANAGH, 1990).

Farmland is found on „mineral islands", areas of calcium rich moraine deposits, such as eskers, at an elevation slightly above that of the surrounding bog. In recent years there has been significant reclaimation of cutaway bog in Boora. Wetlands, conifer plantations and commercial grassland have been created depending on local conditions (MACNALLY, 1998). Trapping of partridge began in March 1997. A farm-reared partridge was used as a decoy to trap wild birds in a funnel entranced cage trap. Several birds were caught at night with a net and lamp as they roosted on the ground. Using a tape recording of a jeep on approach resulted in a 100% attempt/catch ratio (W. KAISER pers. comm.). Only male birds were fitted with radio-transmitters. Leg rings were attached to female birds caught. Birds were weighed and in several cases feather and blood samples taken for future DNA analysis.

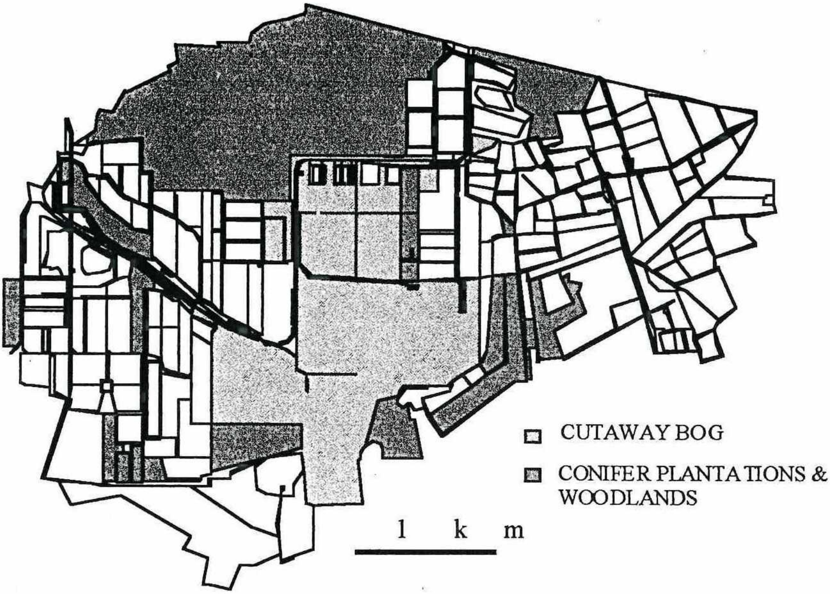

Figure 1: Map of the Grey Partridge study area in Boora, Co. Offaly, 1997-1998.

The transmitter was attached to the bird around the neck with a cord. A knot was tied in the cord at the required fit and super-glue applied to this knot. The transmitter sits snugly against the feathers of the upper chest and the whip antennae extwnds behind the bird's head. This necklace desing has been used in previous partridge studies (BIRKAN *ET AL*, 1992; BRO *ET AL*, 1998; HEARSHAW, 1996; KAISER, 1995) and on other ganebirds (MARCSTROM *ET AL*, 1989; WILLEBRAND *ET AL*, 1990). Biotrack Ltd., U.K supplied the 10g TW-3 radio-transmitter. It has a ground-ground range of 1-3 km and a transmitting life of 7-9 months. The signal was recived on a mariner 57 receiver and hand-held Yagi 3-element aerial

Radio-tagged birds were located 1-2 times daily with radio-fixes at least 5 hours apart. At each radio-fix the date, time, weather, habitat type, location and other relevant details were recorded. In many cases visual observation of birds was possible. When the accuracy of a fix was undetermined between two habitat types, triangulation was used or the area was searched for droppings after the bird had left. During the breeding season care was taken to minimize disturbance due to the risk of observerinitiated corvid predation (HAMMOND and FORWARD, 1956; KAVANAGH, 1995; MACINNES and MISRA, 1972). All radofixes were calculated by triangulation during this time.

3. DATA ANALYSIS

The concept of a home range has been defined and refined by several authors (BURT, 1943; MOHR, 1947; JEWEL, 1966; BAKER, 1978). A home-range consists of a restricted area within which an animal moves when performing its normal activities. Stating the time period over wich a home-range is measured should be fundamental to the definition of a home-range (MORRIS, 1980).

Home range and habitat use for each time priod were calculated using Ranges V (KENWARD, 1996). Habitat preferences were analysed using Compositional Analysis (AEBISCHER and ROBERTSON, 1992; AEBISCHER *ET AL*, 1993).

In this study an attempt was made to monitor the movements of birds through a complete year. During the course of fieldwork a number of distinct time periods became evident. These have been coined „Biological Time Periods' (B.T.P.) as they are based on breeding behaviour and movement patterns of the birds being followed as opposed to simple calender periods.

The biological time periods calculated for breeding pairs in this study were exploration, habituation, lay, incubation, brood-rearing, primary and secondary covey movements.

Exploration: first described by CHURCH *ET AL.* 1980, when radio-tracking pre-nesting pairs in Wisconsin, U.S.A. A similar movement pattern was discovered in the previous Irish study (HEARSHAW, 1996) and in this study. This involved large movements across the study area by the newly formed pair with no obvious center of activity.

Prelay: began when movements of the pair became more restricted to an area in which the eventual nest site was initiated. Similar movements were described by CHURCH et al. 1980, as habituation and was termed prelay in the HEARSHAW study.

Lay: this was the time period during which the hen was laying eggs in the nest. At this time the hen is only present at the nest for 2% of the time all visits being during the day (FANT, 1953). An average of one egg is laid every 1.4 days (POTTS, 1986).

Incubation: this time period referred to the duration the hen was incubating the clutch of eggs. At this time the hen is present at the nest for 90% of the time, all absences being during the day (FANT, 1953).

Brood-rearing: begins when the chicks hatch. The movements of the parents and brood were restricted in this study until the chicks reached 5-7 weeks. A number of sudies have investigated movements during brood-rearing (CARROLL *ET AL*, 1990; CHURCH, 1980; GREEN, 1984; RANDS, 1986a).

Primary covey movements: this time period began with a sudden movement by the covey out of the brood rearing area in the late summer. This time period was first described in this study and may be unique to Irish partridge behaviour.

Secondary covey movements: a sudden movement out of the previous home range in autumn to an new area in which the civey remained through the winter.

Within each B.T.P. home ranges were calculated using Multiple Convex Polgon (MCP), Harmonic mean analysis (HM) and cluster analysis (CL). A full review of these and other techniques is given in HARRIS *ET AL* 1990 and KENWARD 1996. The habitat type at each radio-fix was recorded during fieldwork. The percentage habitat use was indicated by the proportion of radio-fixes occuring in each habitat type in a given B.T.P.

Habitat preferences were calculated by comparing habitat use with habitat availability. There have been many publications on analysis techniques (BYERS *ET AL*, 1984; FREIDMAN, 1937; JOHNSON, 1980; NEU *ET AL*, 1974). The advantages and limitations of these are discussed in ALDRIDGE and RATTI 1986, 1992. This study used the technique of Compositional Analysis (AEBISCHER and ROBERTSON, 1992; AEBISCHER *ET AL*, 1993). The habitat proportions are transformed into log ratios, thus rendering each proportion independent from the rest. The analysis of data produces a ranking system from most preferred to last preferred habitats.

Two levels of analysis were used to define habitat preferences within a biological time period

1. **MCP Vs STUDY.** The proportion of habitat types contained within the home range (MCP) are compared with the availability of each habitat type in the study area.

2. **USE Vs MCP.** The proportion of radio-fixes in each habitat type compared with the proportion of habitat types available within the home range (MCP).

4. RESULTS

Fieldwork was conducted continously from March 1997-October 1998. Nine male birds were captured and fitted with radio-transmitters, five in 1997 and four in 1998. Sufficient data for detailed analysis was obtained of movements and habitat use of three birds. The three birds, two paired (one pair in each year) and one unpaired male, were tracked for a period of between 8-10 months each.

An area of 18 km^2 was mapped during the tracking period with thirteen main habitat types identified. The size of these habitats varied greatly with grassland, tall forestry and cutaway bog being the three largest (**Table 1, Figure 1**).

The majority of the grassland consists of cattle and sheep pasture, with many fields taking silage or hay in the summer. Forestry refers to conifer plantations and naturally regenerated mixed willow (*Salix* spp.) and birch (*Betula* spp.) woods on cutaway bog. Tall forestry in classified when the average height is over 2m and the canopy has become closed with no ground vegetation except rushes (*Juncus effusus*). In contrast young forestry (<2m) areas contain an open canopy with a diversity of herbaceous plants and grasses. Edge refers to roads, railways (for transporting peat) and the ungrazed/unploughed portions of agricultural land. Tillage contains spring sown oats and barley with stubbles left over the winter and various root crops. The habitat strips were planted in the central cutaway bog area in the study area (**Figure 1**) adjacent to railway lines. Nesting and brood rearing cover were provided with seed mixes recommended by the Game Conservancy.

Table 1: Habitat availability (decreasing order) in the Grey Partridge study area in Boora, Co. Offay, 1997-1998.

	Boora in 1997		**Boora in 1998**	
Habitat	**Hectares**	**%**	**Hectares**	**%**
Grassland	492	27,0	489	26,8
Tall Forestry	371	20,3	371	20,3
Cutaway Bog	364	20,2	364	20,0
Edge	112	6,1	112,44	6,2
Handcut Bog	97,4	5,3	97,4	5,3
Tillage	91,6	5,0	94,1	5,2
Drains	83,01	4,6	83,01	4,6
Heather Top	66,2	3,6	66,2	3,6
Young Forestry	60	3,3	60	3,3
Hedgerows	36,5	2,0	36,5	2,0
Lakes	21,99	1,2	21,99	1,2
Habitat strips	19,7	1,1	19,7	1,1
Buildings	7,87	0,4	7,87	0,4
Total	**1823,27**	**100**	**1823,27**	**100**

Home range calculation

A summary of the biological time periods (B.T.P.) with various details and home range calculations is given in **Table 2** for a breeding pair in 1997 and 1998. No home ranges could be calculated for exploration as both birds were captured at the end of this B.T.P. The early stage of the „secondary covey movements" time period in 1998 was similar to 1997 but was not completed due to predation. A visual representation using 90% Harmonic Mean Analysis is given (**Figure 2**.) to illustate the successive locations of home ranges in each B.T.P. in 1997. A similar pattern was evident for pair m6 in 1998.

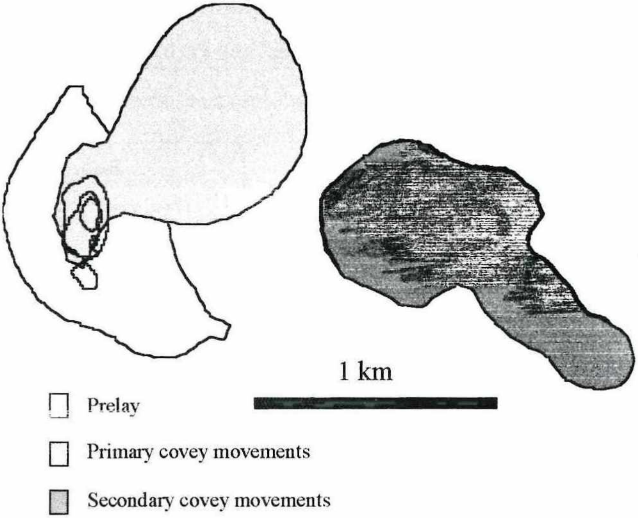

Figure 2: Home range calculated during each Biological Time Period using 90% Harmonic Mean Analysis for a pair of Grey Partridge in Boora, Co. Offaly in 1997.

Habitat use

The precentage habitat use was indicated by the proportion of radio-fixes occuring in each habitat type in a given B.T.P. (**Table 3**.). Changes in the size and location of home ranges from one B.T.P. to the next are linked to changes in habitat use. Birds used a high proportion of cutaway bog and young forestry during prelay. Young forestry predominated during lay, incubation and brood rearing in 1997. In 1998 a combination of young forestry, cutaway bog and habitat strips were used. Once the covey moves away from the brood rearing area (primary covey movements) a switch to open pasture is evident with less time spent in young forestry, cutaway and handcut bog than in the prelay. The covey moves again to exploit winter stubbles (tillage) as they become available. This is during the secondary covey movements B.T.P. in late autumn and winter. A similar proportion of pasture is used as before. Individual birds return to the cutaway areas during covey break-up the following Spring.

Table 2: Summary of radio-tracking data collected for a pair of Grey Partridge in Boora, Co. Offaly in 1997-1998.

	Start date	**Finish date**	**No. days**	**Fixes**	**MCP**	**HM 85*, 90**	**CL 90*, 95**
Prelay							
1997	16-Apr-97	15-May-97	30	27	80,7	57,8	6,9*
1998	24-Mar-98	3-May-98	41	35	19,5	10,9	9,8
Lay							
1997	16-May-97	5-Jun-97	21	21	8,2	2,5	1,4
1998	4-May-98	25-May-98	21	17	20,4	14,2	5
Incubation							
1997	6-Jun-97	30-Jun-97	25	26	5,5	3,1	0,8
1998	26-May-98	19-Jun-98	25	25	6,7	3,2	3,4
Brood rearing							
1997	1-Jul-97	19-Aug-97	50	41	5,1	5,6	3*
1998	20-Jun-98	26-Jul-98	37	31	13	5,8	1,1
Primary covey movements							
1997	20-Aug-97	6-Nov-97	79	50	77,4	68	16,8*
1998	27-Jul-98	27-Sept-98	63	67	68,1	41,9	32,3*
Secondary covey movements							
1997	7-Nov-97	22-Jan-98	77	28	91,9	63,8	14,4*

KEY: Fixes = number of radio-fixes recorded during B.T.P.

MCP = Home range size calculated using Multiple Convex Polygon

HM = Home range size calculated using 85 or 90% Harmonic Mean Analysis

CL = Home range size calculated using 90 or 95% Cluster Analysis.

Table 3: Percentage of radio-fixes recorded in each habitat type for all B.T.P.s for a Grey Partridge pair in Boora, Co. Offaly in 1997-1998.

	Prelay		**Lay**		**Incub.**		**Br. Rear.**		**Pr. Cov.**		**Sec. Cov.**	
YEAR	**97**	**98**	**97**	**98**	**97**	**98**	**97**	**98**	**97**	**98**	**97**	**98**
Cutaway bog	29,6	32,6		29,4		88		25,8	10	22,4	3,6	
Handcut Bog	3,7	4,7							18		3,6	
Heather Top	3,7											
Tall Forestry												
Young Forestry	63	41,9	95,2	64,7	92,3		100	67,7	16	16,4		
Grassland		9,3			7,7				48	44,8	46,4	
Tillage											42,9	
Habitat strips		4,7		5,9		12		6,5		6		
Edge		7	4,8						8	10,4	3,6	

Table 4: Ranking of habitat preferences in all B.T.P.s for a Grey Partridge pair in Boora, Co. Offaly 1997-1998.

	MCP Vs TOTAL	USE Vs MCP	MCP Vs TOTAL	USE Vs MCP
	1997	1998	1997	1998
Prelay	YF, C, Hab	YF, HB, HT	YF, C, D	Hab, YF, C
Lay	YF, G, D	E, YF	YF, C, Hab	YF, Hab, C
Incubation	YF, G, D	YF, G	Hab,C, YF	Hab, C
Brood rearing	YF	YF	YF, Hab, C	YF, Hab, C
Pr. Cov. Mov.	YF, G, HB	E, HB, YF	YF, G, C	Hab, E, YF
Sec. Cov. Mov.	T, HB, G	C, T, E		

KEY:		
YF = Young Forestry	C = Cutaway Bog	Hab = Habitat strips
G = Grassland	D = Drain	HB = Handcut Bog
T = Tillage	E = Edge	

Habitat preferences

Habitat preferences were calculated by comparing habitat use with habitat availability as described in the Data Analysis section. The most preferred habitats are presented in ranking system in **Table 4** fot both MCP Vs. STUDY AREA and USE Vs. MCP. Where greater than there habitat types were involved only the top three ranks are shown. Young forestry, habitat strips and road edge were the most frquently preferred habitats during B.T.P.s up to primary covey movements. A preference was shown for winter stubble fields in the secondary covey movements B.T.P. in 1997.

5. DISCUSION

A pattern of home range and habitat use by partridge became evident during this study. Following a period of exploration and habituation (CHURCH *ET AL*, 1980) the pair selected a nest site within the cutaway bog one in young forestry, the other in habitat strips. Once a nest site was chosen there was a contraction in home range size corresponding to laying, incubation and brood rearing.

After several weeks of brood rearing the covey suddenly expanded the home range to explore new areas containing open pasture. A second movement then occured incorporating areas of winter stubbles away from the cutaway bog. In late winter coveýs returned to the cutaway area where pair formation occured.

The biological time periods used in this study to examine the changes in home range and habitat use over the year for each individual have been more informative than if calender dates were chosen instead. Calender dates can mask stuble changes in habitat use. It is recommended that future radio-travking studies should investigate the possibility of also applying this technique to their radio-tracking data.

It is the reduction of suitable nesting and brood rearing cover on modern farmland that has contributed to the decline of the partridge population in England (POTTS, 1980; 1986). Residual cover within the cutaway bog area has provided breeding habitat in this and the previous Irish study (HEARSHAW, 1996). The remaining two populations of wild partridge in Ireland occur in areas containing large areas of cutaway bog (KAVANAGH and AEBISCHER, 1997). In the Lullymore study (HEARSHAW, 1996) recolonised areas within the cutaway bog were selected as nesting sites while the birds followed in this study preferred the cover provided by young forestry and habitat strips planted on cutaway areas. In Hungary partridge have also chosen forestry belts as nest sites (FARAGÓ, 1995). However, young forestry only provides a good breeding habitat in the first few years of growht after which it is avoided when the canopy closes.

CHURCH 1984a and KUGELSCHAFER et al. 1995 provided data indicating that birds prefer to breed in locations used the previous year. Our data also indicated That birds returned to breeding areas. These occured in cutaway bog areas. It is vital Therefore onsure suitable breeding habitat is available in these traditional nesting areas. It is disturbing that large areas of cutaway bog in the conservation site are being reclaimed as commercial grassland, forestry and wetlands. The traditional breeding areas identified during the radio-tracking study should be protected from reclaimation to allow the partridge population to recover. Additional habitat strips should also be provided in these areas.

The movement away from the cutaway bog in late autumn (secondary covey movements) appeared to be linked to the availability of winter stubbles which has been identified as a preferred winter habitat for partridge in other studies (CHURCH and PORTER, 1990; KAISER, 1995; MCCROW, 1977; SCHULZ, 1980). In this study birds moved over 1.5 km from the cutaway to suitable stubbles. The provision of winter stubbles on the cutaway bog may prevent this autumn movement off the conservation site.

Thus, the examination of radio-tracking data based on biological time periods can provide important information for the conservation of the remaining Irish partridge population.

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THE GREY PARTRIDGE (*Perdix perdix*) IN THE REGION FRIULI-VENEZIA GIULIA, NE ITALY ITS RECENT HISTORY AND CURRENT CONSERVATION EFFORTS.

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KEY-WORDS: Grey Partridge, recent history, current conservation efforts, Italy

ABSTRACT

TOUT, P. and PERCO, F.: THE GREY PARTRIDGE (*Perdix perdix*) IN THE REGION FRIULI-VENEZIA GIULIA. NE ITALY ITS RECENT HISTORY AND CURRENT CONSERVATION EFFORTS: As in much of the rest of Europe the grey partridge (*Perdix perdix*) in the region Friuli-Venezia Giulia, has suffered large declines, almost to the point of extinction as elsewhere in Italy. The author identifies some of the factors involved in the decline, such as agricultural improvements and the rise in the population of predators but pins the blame on the species' virtual disappearance from excellent habitat on excessive and irrational hnting pressure. Steps being undertaken to halt the decline in some of the areas most favoured by the species are outlined, including a temporary cessation of hunting of the species over large areas, habitat improvements, the systematic control of generalist predators such as crows and foxes and controlled reintroduction of gamefarm stock where needed. Cautious optimism for the immediate future of the species is expressed with the increasing willingness to pay on the part of dog-triallers for quality wild grey partridge stocks, low agricultural commodity prices bringing habitat creation within financial reach of hunting reserves at the expense of monoculture maize plus demographic and social changes which will greatly reduce hunting pressures in the immediate future.

1. INTRODUCTION

In common with the rest of Italy, the grey partridge in Friuli- Venezia Giulia has suffered a dramatic decline in population this century (C.M CALO' IN PERCO, F. 1994) and particularly in the years since the Second World War. Vallon (1905) considered the bird to be "a very common resident" in the region at the beginning of the century. The declines in the provinces of Udine and Pordenone, however, did not become apparent until later than in most other areas in Italy and as recently as the late 1970s two to three thousand wild grey partridges were still being shot annually in the former (unpublished data of the *Comitato Caccia* (Udine)), while in 1956 the European pointing dog trials on grey partridge were held just east of the city. Perhaps one hundred pairs now survive, spread thinly over a wide area from the border with Slovenia to the city of Pordenone in an area of c. 2000km^2. Most are located within or close to large military bases, which formed part of NATO's defences on its Central European flank. In these areas hunting and cultivation is banned and the areas are covered with permanent grassland mown annually and often covering many square kilometres. The fate of the land associated with these bases, many of which are now in disuse, is vital to the future of the species in the area.

The climate (average annual temperature 13°C, rainfall of c.1700mm yr^{-1} concentrated largely in spring and autumn, snow cover rare, warm and sunny from mid-June to the end of August) and soils (largely gravels) of the area (Poldini, 1991) are ideal for the species and chick production of successful broods appears to be excellent with large coveys composed mostly of juveniles present in autumn.

The alarming decline in spring densities, combined with increasing dissatisfaction with the "instant hunting" on the part of the hunters led to research on the species being sponsored, culminating in the visit of Ian Lindsay of the Game Conservancy Advisory Service in June 1997. He identified several potentially excellent areas for partridge, that, however tended to lack nesting cover and good predator control. Since his visit, and with the hard work and intense efforts of the some of the hunters of two hunting reserves east of Udine, Campoformido and especially Pasian di Prato, "*Progetto Starna*" - "Project Grey Partridge" has been born. Unlike some other restocking projects in Italy (e.g Montagna *et al*, 1990) we have been able to make inroads into all the limiting factors thus far identified as having an effect on partridge populations. Hunting of partridges has been banned on many of the most important reserves. $30,000 has been earmarked for the next three years, which will be used to purchase birds of the original Italian subspecies P. p. italica, (300 in 1998), build acclimatisation cages (15 thus far), Larsen Traps for corvid control and to educate and inform hunters, the public and local farmers on the problems facing the species. So far 7 hectares, spread over 20 fields in an area of 10 km2 have either been entered into 5-year set-aside and planted with brood-rearing cover, grassy banks being established along the field boundaries as nesting cover or planted up with game crops (millet, sorghum and sunflower) in early June after the barley harvest. Winter feeding is being provided and offers of land for incorporation in the project from municipalities; the church and interested parties are coming in thick and fast. If successful it is hoped to extend the project to the rest of the traditional range of the species in the region.

2. REASONS FOR THE DECLINE

Several factors can be firmly identified as having contributed to the decline in the species, among these the intensification of agriculture with increased use of irrigation and a resulting switch from wheat and barley to maize and (more recently) soya and sunflower; a huge increase in hunting pressure with the release of c.10, 000 partridges per year, mostly for "instant hunting" - so called "top-up" releases (Game Conservancy, 1992) keeping hunters in the field throughout the season when the supply of wild game in the area is all but exhausted. Finally, the gravelly nature of the soil has led to much extraction of aggregates for building, the resulting holes being used as landfills for much of the domestic waste of N.E Italy. This has allowed a veritable explosion in the populations of two potential egg predators: the magpie (*Pica pica*) and the hooded crow (*Corvus corone cornix*) (C.M CALO' in PERCO, F. 1994).

Changes in agriculture:

The period since 1970 and especially the decade 1976 - 1986 saw a rapid development in the region's agriculture, with radical land rationalization over wide areas (the so-called *riordino fondiario*) where the current tiny field structure, averaging little more than 5000m^2 per field in many areas and made up largely of autumn-sown wheat and barley, often undersown with clover in spring if the crop looked patchy and interspersed with permanent hay meadows, was largely swept away and replaced with large fields of irrigated maize. Even in areas where land rationalization has not occurred, the introduction of milk quotas rendered many small producers unprofitable and reduced the market for fodder crops, many lucerne (*Medicago sativa*) fields and hay-meadows being given over to crops for which higher subsidies were available (C.M CALO' in PERCO F. 1994).

Hunting Pressure:

Hunting pressure is extremely high. Unlike other most areas of Italy the region has autonomy in terms of hunting law and since 1969 all hunters have been attached to a reserve (based on the municipality) with their numbers in theory linked to the ability of the environment to produce game. In practice numbers are too high (a **Figure 1** hunter per 40 hectares is usual, making c. 16 outings per year) (*Comitato Caccia* (Udine), unpublished data), census data are a fiction and bag data are often "economical with the truth". The style of hunting operating in the plains - 3 or 4 hunters, each with a pointing dog "walking up" game is particularly effective in locating, holding and killing partridges. The refuge system is ineffective, as these are often cynically located on poor-quality land next to built-up areas. (personal comments from various hunters and reserve managers who wish to remain anonymous). While a few hares (*Lepus europaeus*) find sanctuary on these pitiful scraps of land they do little or nothing to assist partridges.

Top-up Releases

With the natural capital of game reduced to a fraction of its potential by excessive hunting pressures over wide areas (although hunters are often quick to blame changes in agriculture for the declines), hunters have resorted to mass releases of reared game to supplement the bag. In the province of Udine for the season 1996/97 (the latest year for which data are available) 121 450 pheasants (*Phasianus colchius*), 8 095 grey partridges, 841 European hares and 270 red-legged partridges (*Alectoris rufa*) were released on hunting reserves.

All these numbers, with the exception of hares exceed the numbers shot by a large margin. While some of these releases could be classified as "restocking", occurring outside the hunting period, most occurred during the hunting season and can be classified as "top-up releases". These keep the hunters in the field throughout the four month hunting season when, if supply were to dictate their behaviour, most would have hung up their guns by the end of November were natural stocks of resident small game and passage game species (such as woodcock (*Scolopax rusticola*) or song thrush (*Turdus philomelos*)) the only quarry available. The end result is a "draw-down" of wild stocks towards extinction with all pheasants and partridges being treated as released birds and no attempt made to conserve stocks whatsoever on most reserves.

Table 1: The number of Grey Partridges shot and released in the province of Udine (1979-1995) and the ratio between birds shot and birds released.

Season	Shot	Released	Shot : Released Ratio
1979/80	2717	202	13.45
1980/81	1570	325	4.83
1981/82	1425	937	1.52
1982/83	1533	1085	1.41
1983/84	1533	1573	0.97
1984/85	1536	1677	0.91
1985/86	2843	4269	0.67
1986/87	3095	4575	0.68
1987/88	4264	7152	0.60
1988/89	5230	8378	0.62
1989/90	5360	8666	0.62
1990/91	4024	7012	0.57
1991/92	3928	6956	0.56
1992/93	5092	8112	0.62
1993/94	4301	7281	0.59
1994/95	3688	7268	0.51
1995/96	3567	7031	0.51
1996/97	3453	8095	0.43
1997/98	2910	6818	0.43

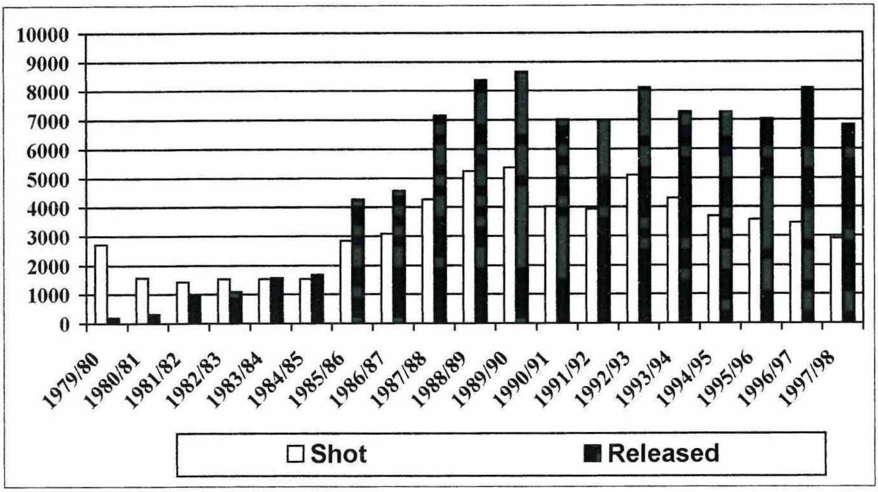

Figure 1: Changes in the relative numbers of grey partridge (*Perdix perdix*) shot and released in the province of Udine (NE Italy), 1979/80-1997-98

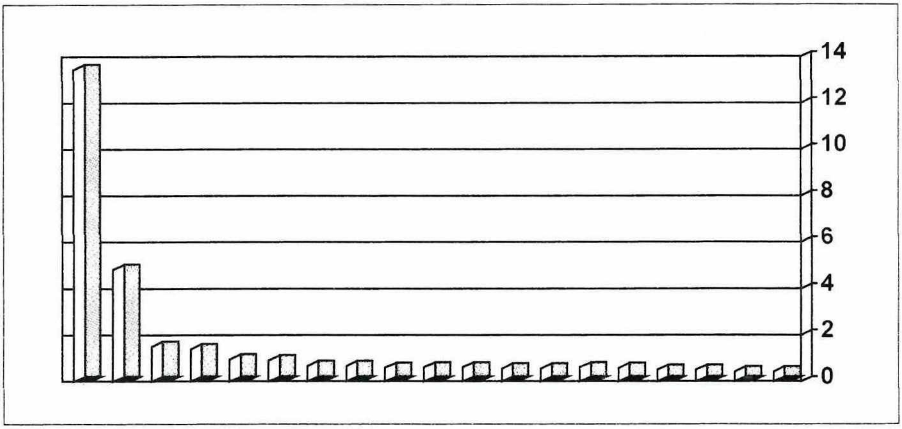

Figure 2: The collapse in the shot : released ratio for grey partridge (*Perdix perdix*) in the province of Udine (NE Italy), 1979/80-1997-98.

3. INCREASES IN PREDATOR POPULATIONS

As elsewhere in Europe the populations of potential predators upon grey partridges and their eggs have increased greatly in the last fifty years. Populations of wintering common buzzards (*Buteo buteo*) are extremely high, often exceeding one bird per square kilometre from November to March. Breeding populations are lower but rising. Personal observation suggests buzzards are not responsible for taking full-grown partridges in any number although the release of large numbers of inexperienced reared partridges could in theory assist in the development of a "search image" indifferent to reared or wild birds, leading to more frequent attacks on the latter.

Probably more significant are the increases in corvid and fox populations. Bag data for the province suggests that hooded crow numbers have risen by 231% since 1990 while magpies have gone up by a more modest 5% with peaks in the population of both species in 1994 (PERCO F., 1998). Anecdotal evidence suggests that the rise in hooded crow numbers is real and at the expense of the magpie in drier areas which are now irrigated for maize (ZULIANI M. *pers. comm.*) with the former species occupying many new areas in the high plain from where it was formerly absent.

Red fox (*Vulpes vulpes*) numbers have also sharply, with bags up by 45% since 1990. This is during a period of mass vaccination of foxes against rabies and has seen the species spread out from its stronghold in the mountains out into the plain. Its survival here is undoubtedly assisted by top-up releases of pheasants and the large numbers of small-scale landfills, which have sprung up across the area, using old dry gravel pits. The prevalence of sarcoptic mange in foxes using these landfills, which in some areas reaches almost 100% may act as a break on population increases (PERCO F., 1998)..

4. STEMMING THE DECLINE - CURRENT CONSERVATION EFFORTS

Voluntary Shooting Bans

Many hunting reserves within the current range of the partridge have introduced voluntary shooting bans on the species. On these reserves partridges are neither shot nor are ill-considered releases made. On most of these reserves a small relict partridge population (c.0.2 pairs km^{-2} or less in spring 1998) survives without interference and it is hoped that the mild winter and good breeding season in 1997/98 will prove decisive in saving the species. Hunters on these reserves report seeing more partridges than they have for many years this autumn (BORSETTA G. *pers. comm.)* with some reserves (MORTEGLIANO, CAMPOFORMIDO and PREMARIACCO) reporting that this new-found protection is following on from an excellent breeding season in 1998.

Programmed Reintroductions

"Project Grey Partridge" - "*Progetto Starna*", funded to the tune of $30,000 by the province of Udine's hunting and fishing service, foresees the release into suitable habitat of numbers of partridges from a game farm in Tuscany where a game-farm strain of the original *Perdix perdix italica* has been maintained. Two hundred of these birds, many complete with the near-blackish inverted horseshoe and reddish hue of original *italica* have been released from acclimatisation cages on the hunting reserve of Pasian di Prato. Initial results are very promising. In spite of very wet autumn weather survival has been good with 50% to 80% of birds surviving the first three months. Some coveys appear nearly complete (the birds were released coveyed-up in batches of 20) while others have split or declined to c.10 birds. Two birds (all are wing-tagged) were killed by hunters on a neighbouring reserve, one six kilometres away, one was killed by a car and another flew into the release pen netting and died. Apart from these no corpses or pluckings have been noted whatsoever. (ANTONUTTI R. *pers. comm*). Further releases (c. 60 birds) will be made in mid-December and c.15 pairs will be kept as breeding stock. We await the spring to see how many surviving birds will breed successfully.

Habitat Creation

E.U 2078/92 - an agro-environmental initiative funded by the EU has met with little success in the region, the administrative and bureaucratic structures to encourage its use were not put in place. One hunting reserve - Pasian di Prato did enter some fields into a five year agreement and followed up this initiative by renting fields from farmers after the barley harvest at the end of May. Approximately 20 fields covering 7 hectares have been sown with millet, dwarf sorghum and sunflowers and these fields have been greatly used by the partridges this autumn and winter. At a cost of c. $60 per field of 3000m^2, in 1998 approximately 40 fields covering 14 hectares of tall barley stubbles will be sown in late May and early June. Experiments will be carried out using mustard, buckwheat and pure millet stands to see which fields are favoured by the partridges.

Predator control

Funds have been made available for the manufacture of Larsen traps. These traps were met with cynicism at first, but a brief trial with a single trap at Pasian di Prato yielded 96 magpies in six weeks, while a pair of traps at Torviscosa employing hooded crows as decoys produced 83 birds in the same period. These numbers indicate the very high density of corvids on the reserves. It is hoped that several dozen Larsen Traps will be employed in spring and summer 1999, making a serious dent in corvid numbers. Fox control will continue as previously, using organised beats but it is hoped to institute experiments using "middens" while shooting from blinds to see if this raises the effectiveness of the control achieved, which is currently very labour-intensive.

5. POINTING DOG TRIALS - THE PARTRIDGES' SALVATION?

The dire state of hunting across Italy has resulted in a decline of approximately 50% in the number of hunters in the past 15 years. Increased dissatisfaction with the "sport" based almost entirely on reared birds, increased costs and a severely curtailed right-to-roam under the most recent revision of the national hunting law (157/1992) together with demographic pressures and few young males taking up the sport have all played a part. (*Cani & Caccia*, October 1998). One sport on the other hand, which seems to be flourishing is that of dog-trialling with Italy now the world centre for top quality English Setters and Pointers.

In Italy the quarry of choice is the grey partridge, with many dog-breeders and trainers traveling great distances (as far as Poland, France and Croatia) to find suitable birds for training their dogs and prepared to part with large sums of money (up to $US35 per dog per day) for the possibility to take the dogs into the field. At most of these sites no birds are ever shot (BORSETTA G. *pers. comm.*).

As the populations of wild partridges decline, the monetary value of those remaining rises. The maintenance of a small number (<5) of dense and viable populations in limited areas

(<5000ha) even at great economic cost may now be possible given the great "willingness to pay" (WTP) of dog-triallers which is now well within range of the "willingness to accept compensation" (WTAC) of hunters prepared to forego their traditional rights to hunt partridge in some of the best areas remaining in Italy, and of small-scale farmers willingness to accept compensation for the setting aside of land for nesting , brood-rearing and wintering cover, especially in the light of very low prices for cereals and falling hectarage payments (PROSPERI A.. *pers. comm.)*.

6. CONCLUSIONS- SOME REASONS FOR CAUTIOUS OPTIMISM?

After a truly terrible 50 years which has seen the population of wild partridges in Friuli-Venezia Giulia fall by something over 98% I am now more optimistic about the species prospects in the short and medium term for a number of reasons:

1) Decline in hunting pressure: the rapid aging of the hunter population, together with other factors such as the demography of Italy, lack of game, a failure to attract young people into the "sport", rising costs of permits and insurance and restrictions on the mobility of hunters and shortening of open seasons are having their effect. Demographic models indicate that hunters will become extinct in Italy by the year 2050.

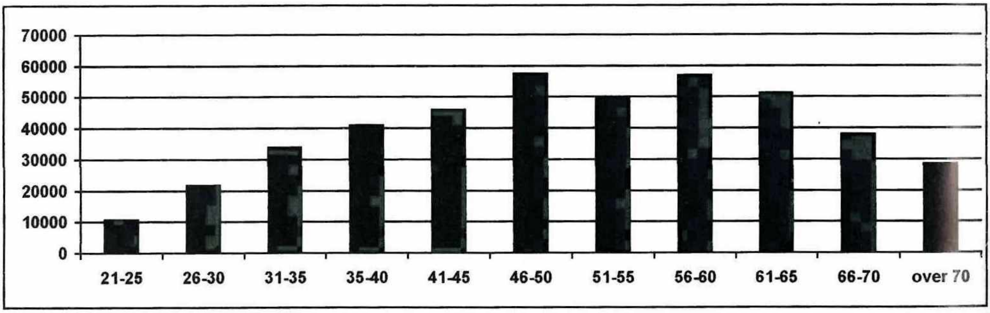

Figure 3: Membership of the Federation of Italian Hunters (FIDC) in 1996, subdivided by age classes (Source: *Cani & Caccia* magazine - October 1998)

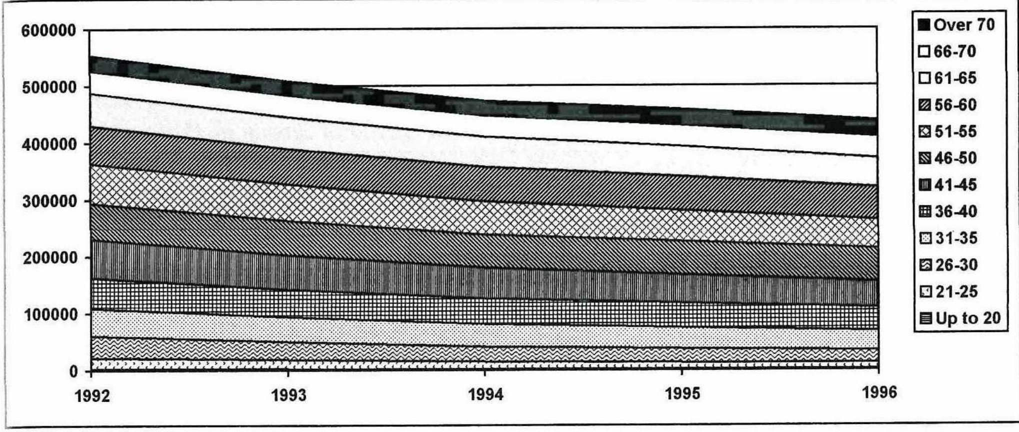

Figure 4: Illustrating the decline in the membership of the various age categories of the Italian Hunting Federation (FIDC) in the 5-year period 1992-1996 (Source: *Cane & Caccia* magazine October 1998)

2) Low prices of agricultural products and declining hectarage payments, together with the unification of hectarage payments for all crops from 1999 onwards should see a switch away from maize and soya and back towards autumn-sown wheat and barley, the prevalent crops during the heyday of partridges between the wars. Small-scale farmers should also prove more willing for this reason to enter their land into schemes such as 2078/92(ANTONUTTI R. *pers. comm.)*.
3) Increased value of the relict populations of grey partridge in the light of their non-lethal exploitation in dog-trialling, an increasingly popular sport which is increasingly viewed as the acceptable face of and adequate replacement for small game hunting (BORSETTA G. *pers. comm.)*.

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ENVIRONMENTAL CORRELATES OF THE DEMOGRAPHIC PATTERN OF DECLINING POPULATIONS OF GREY PARTRIDGE (*Perdix perdix*) IN FRANCE

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KEY-WORDS: France, habitat, harrier, hatching rate, hen mortality rate, mustelids, *Perdix perdix*, predation, radiotracking.

ABSTRACT

BRO, E., REITZ, F., MAYOT, P. and MIGOT, P.: ENVIRONMENTAL CORRELATES OF THE DEMOGRAPHIC PATTERN OF DECLINING POPULATIONS OF GREY PARTRIDGE (*PERDIX PERDIX*) IN FRANCE: We studied the ecology and the demography of grey partridge (*Perdix perdix*) on 10 study sites in North-Central France in 1995-97 using radiotracking. We analyzed the demographic patterns of populations in relation to their demographic status, and we correlated the variations in key demographic parameters to variations in environmental factors.

1- Mortality rate of hens between early April and mid-September varied from 35 to 75% across study sites. Predation accounted for 73% of mortality of hens during breeding. Predation rate on hens was positively correlated to the abundance of hen and marsh harriers, suggesting an additive mortality attributable to raptors where they are abundant.

2- Predation and farming practices were equally responsible for hatching failure. Predation rate on first clutches was positively correlated to the abundance of mustelids.

3- Chick mortality mainly occurred during the first two weeks after hatching, it was positively correlated to the abundance of hen, marsh and Montagu's harriers, and negatively correlated to cereal availability in the arable land.

Our data failed to demonstrate clearly a direct effect of habitat in the decline of grey partridge but suggested an indirect role of habitat through the abundance of predators.

1. INTRODUCTION

Grey partridge (*Perdix perdix* L.) populations declined recently in some regions in North-Central France. Some evidence attributed this decline to a decrease in survival rate of hens during breeding (REITZ, 1996). To test this hypothesis, we carried out a comparative study (GREEN, 1995): the demography of the grey partridge was recorded during spring and summer 1995-97 on 10 study sites using radiotracking (REITZ and MAYOT *in press*).

Simultaneously, data about predator abundance and habitat structure were collected. Following Caughley and Gunn 's (1996) recommendations, we first identified the demographic mechanism of the decline. The comparison of the demographic patterns of growing and declining populations showed that declining populations suffered from a combination of three poor parameters: hen survival rate during breeding, hatching rate of first clutches and offspring survival rate. Then, the next step of the analysis was to identify which environmental factors were responsible for this situation (GREEN, 1995).

This paper reports *1*- some aspects of the partridge biology during breeding, *2*- the demographic patterns of grey partridge populations in relation to their demographic status and *3*- the correlations between the variations in demographic parameters of grey partridge and the variations in environmental factors.

2. METHODS

2.1. Field procedures

2.1.1. Radiotracking.

We radiotagged 1,009 hens in late March in 1995, 1996 and 1997 on 10 study sites in North-Central France (**Figure 1**). The status (alive, dead or missing) of all radiotagged hens was monitored daily until late September. When a bird was determined as dead, its carcass was found < 24^h after death, the body and surroundings were inspected to find the cause of death according to field signs. Nests (407 first clutches, 141 second clutches) could be located when incubation had started because hens did not leave their nest any longer (POTTS, 1980). Clutch fate (hatching, desertion, destruction by farming practices or predators) was determined according to shell appearance and field signs (BIRKAN AND JACOB, 1988). The number of offspring surviving at the age of 6 weeks was counted for each brood with a tracked hen.

2. 2.Recording of land cover and landscape structure.

Each study area was visited in May to map land cover and to record landscape structure. General cover types included "cereals" (wheat, barley, oats, rye), "other crops" (maize, sunflowers, rapeseed, beet, pea, potato, hemp, flax), "forages" (ray-grass, alfalfa, clover), "pastures", "set-asides", "groves" and "row items" (hedgerow, bank, roadside, ditch).

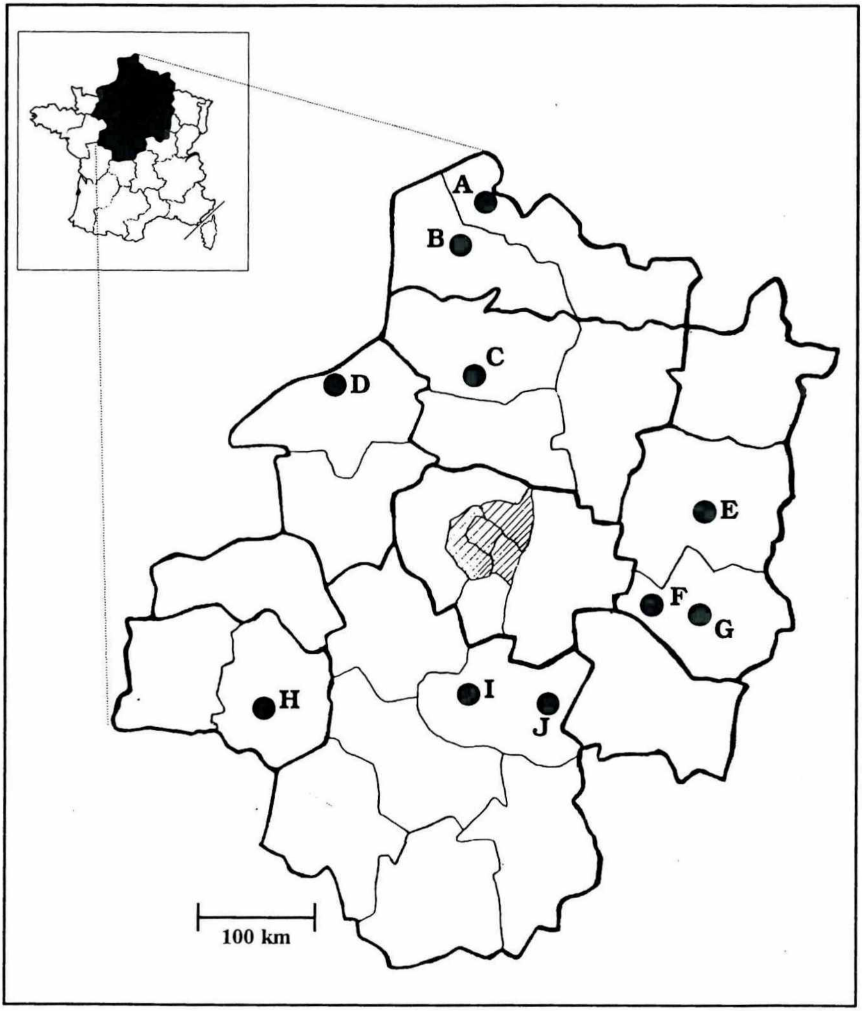


Figure 1: Map of North-Central France showing the location of the 10 study sites where grey partridges were monitored during spring and summer 1995-1997. Hatchings refer to Paris and its suburbs.

We calculated $p_i = \frac{S_i}{S}$ where S_i was the cover area of crop i and S the total area mapped for land cover.

P_i was taken as a measure of availability of cover i in arable land. The availability of row items (*i.e.* hedges, ditches, roadsides...) was calculated as an abundance index (km of row items / 100 ha of arable land). Mean field size was calculated using maps of crops.

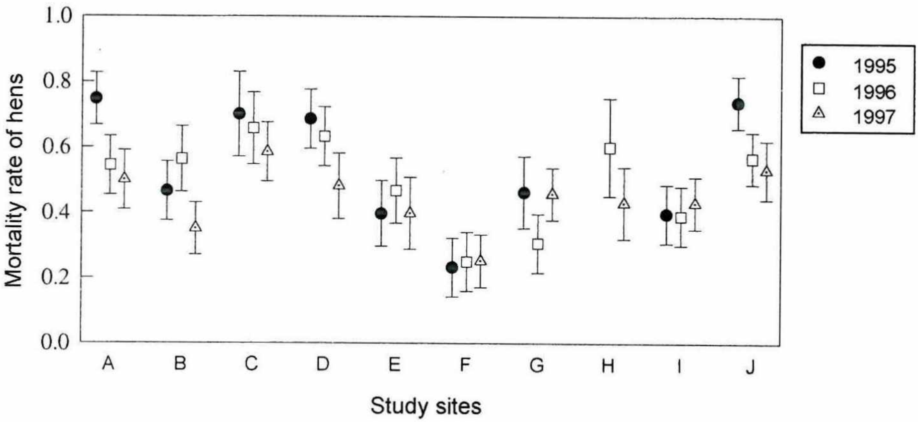


Figure 2: Hen mortality rate during spring and summer (from early April to mid-September) in each study site in 1995, 1996 and 1997; mean ± se.

2.3. Predator abundance.

The abundance of hen (*Circus cyaneus*), marsh (*C. aeruginosus*) and Montagu's (*C. pygargus*) harriers was estimated in May through fixed plot counts (FOSSIER, 1993). The abundance of the red fox (*Vulpes vulpes*) was estimated in late February driving slowly a car by night and counting the number of individuals detected using handhold spotlights per 10 km. An abundance index of mustelids was estimated in August-September through the presence/absence of faeces on 30 1-km lanes per study site (% of lanes with presence of faeces).

2.4. Statistical analyses

We performed analyses on the mean estimations of the variables across 1995-97 to avoid temporal pseudo-replication. We investigated the relationships between the predation rate (of hens and first clutches) and environmental variables using a logistic regression on a dependent proportion response (proc GENMOD, binomial distribution, logit link function model, controlling for overdispersion when necessary - SAS Institute 1994). Predation rate was defined as the proportion of hens/clutches died/destroyed from predation. Hens/clutches whose fate was unknown were not included in the computations. We considered that the proportion of hens/clutches died/destroyed from predation when the cause of mortality could not be determined was the same as the one computed using the cases of determined mortality/failure causes (*i.e.* prorata rule). Relationships between offspring mortality rate (proportion of hatched chicks dead at 6 weeks) and environmental variables were examined using multiple regression (proc REG). Analyses were performed separately to investigate predator and habitat effects on grey partridge demography. Then, we tested whether predator abundance was determined by habitat characteristics using multiple regressions.

3. RESULTS

3.1. Ecology of grey partridge during breeding

Mortality rate of hens during spring and summer varied from 35 to 75% (Fig. 2), differences were significant across study sites ($F_{9,19} = 3.99$ $P = 0.005$) but not across years ($F_{2,17} = 2.20$ $P = 0.142$). 75% of the mortality occurred in May, June and July when hens were laying and incubating. Predation was the main proximate cause of mortality of hens during spring and summer (73%) whereas farming practices were directly responsible for only 6% of mortality cases (REITZ and MAYOT 1997; BRO *ET AL. in press*). Identified predators were mainly carnivores (63%), raptors were responsible for 31% of mortality cases but the proportion varied across study sites.

About 40% of the first clutch failures were due to the death of laying- or incubating-hens. When excluding these cases, predation by ground carnivores was responsible for 41% of clutch failures and farming practices (mowing forages, set-asides, harvesting cereals, watering) for 22%; 37% of causes could not be determined according to field signs (Reitz and Mayot 1997; Bro *et al. in press*).

Chick mortality was 40% within the first two weeks after hatching (Bro *et al. in press*), unfortunately causes of mortality could not be identified.

3.2. Demographic patterns of grey partridge populations

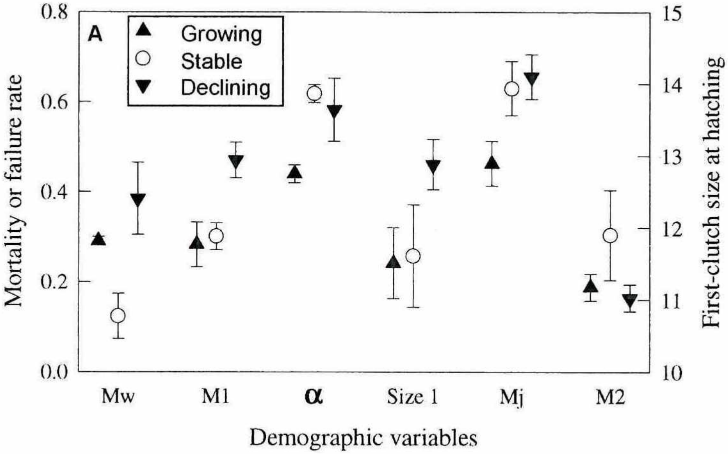
Using population viability analysis (Ferrière *et al.* 1996), we determined that 5 populations (E, F, G, H, J) were declining, 2 (B, C) were stable and 3 (A, D, I) were growing. Compared to growing populations, declining populations displayed a combination of a high mortality rate of hens during breeding, a high clutch failure rate and a high chick mortality rate (**Figure 3a**). However, a noteworthy result is the positive correlation between hen mortality rate during breeding and the size of first clutches at hatching ($r = 0.943$ $P < 0.001$; **Figure 3b**).

3.3. Correlations Demography - Environment

Predation rate on hens during spring and summer increased with the abundance of hen and marsh harriers ($\chi^2_1 = 4.68$ $P = 0.015$ one-tailed test; **Figure 4**). The dispersion of observations at low harrier abundance (cf **Figure 4**) suggests that other factors determine the level of predation rate. However, the abundance of other predator species were not significant correlates ($P > 0.15$).

Predation rate on first clutches was positively correlated to the abundance of mustelids ($\chi^2_1 = 5.27$ $P = 0.011$ one-tailed test ; **Figure 5**).

Mortality rate of offspring to the age of 6 weeks was positively correlated to the abundance of hen, marsh and Montagu's harriers ($F_{1,7} = 9.67$ $P = 0.017$; **Figure 6a** -- but the relationship displays a high dispersion) and negatively correlated to the availability of cereals in arable land ($F_{1,6} = 23$ $P = 0.003$; **Figure 6b**).



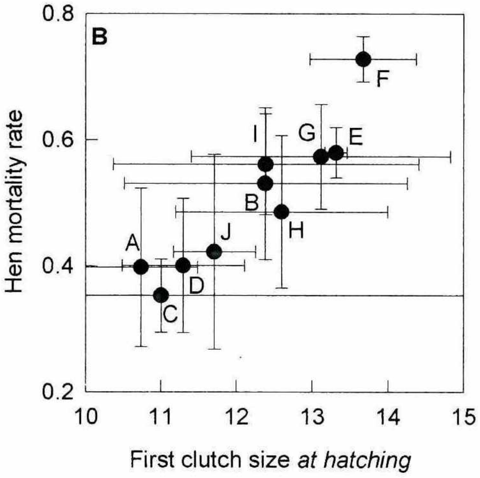


Figure 3a: Demographic patterns of grey partridge populations according to their demographic status. Demographic parameters: *Mw*: overwintering mortality rate, *M1*: mortality rate of hens during the first nesting attempt, □: first clutch failure rate, *Size1*: size of first clutches at hatching, *Mj*: offspring mortality rate, *M2*: mortality rate of hens after nesting; mean ± sd. across study sites.

Figure 3b: correlation between hen mortality rate during spring and summer and the size of first clutches at hatching; mean ± sd. across years.

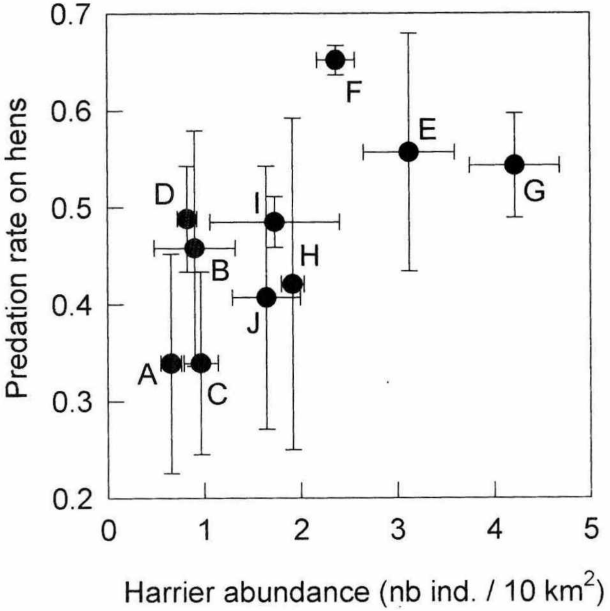


Figure 4: Relationship between the predation rate on adult hens during spring and summer and the abundance of hen and marsh harriers, mean±sd. across years.

3.4. Indirect effects of habitat through predator abundance

Harrier abundance was positively correlated to the mean field size ($F_{1,8} = 4.02$ $P = 0.080$; **Figure 7a**) suggesting that harriers are more abundant in open landscapes.

The abundance of mustelids was determined by a complex component of the habitat, in particular by the diversity of cultivations ($F_{1,6} = 11.61$ $P = 0.014$; **Figure 7b**).

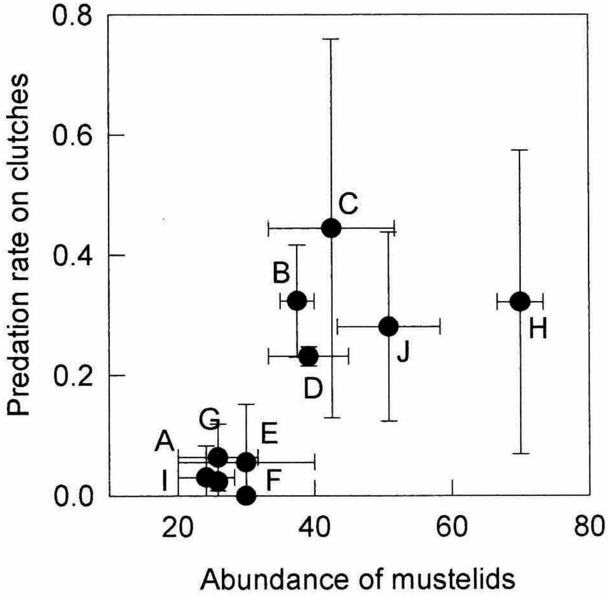


Figure 5: Relationship between the predation rate on first clutches and the abundance of mustelids (% of lanes with faeces), mean±sd. across years.

4. DISCUSSION

Key demographic parameters display an important variability depending upon regions. Mortality rate of adult hens during breeding may be as high as 60-70%. Such high values were already reported since the late 1980s in some cereal ecosystems in France e.g. (SERRE *ET AL.* 1989; BIRKAN *ET AL.* 1992). Added to this high mortality rate of adult hens, we found that both hatching failure and chick mortality could be high (50% and 60-80% respectively). Our results are congruent with those found in England (AEBISCHER 1990; POTTS and AEBISCHER, 1995).

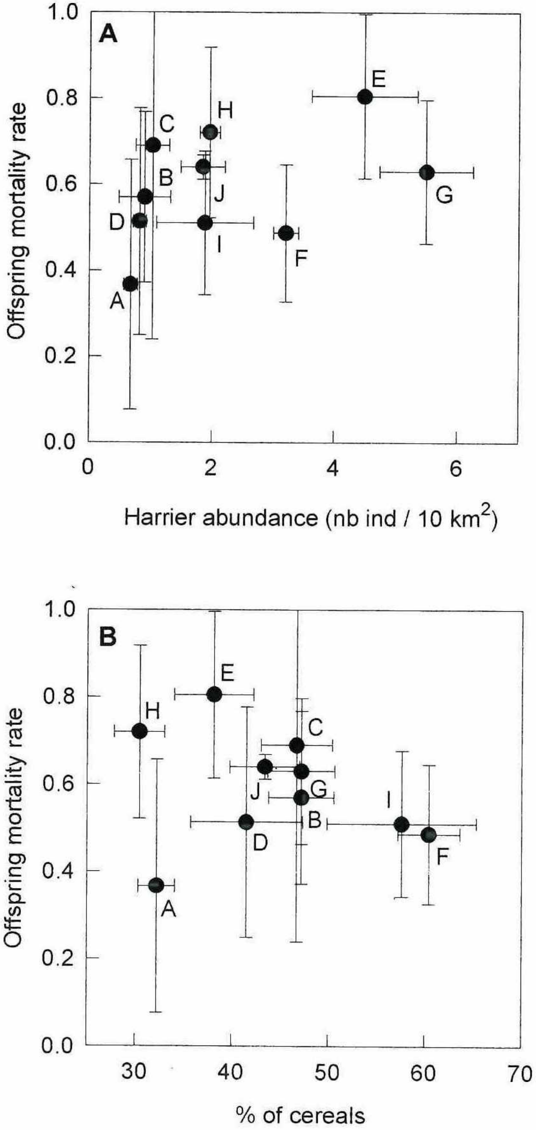


Figure 6: Relationships between the mortality rate of offspring to the age of 6 weeks and **A:** the abundance of hen, marsh and Montagu's harriers, **B:** the availability of cereals in arable land; mean±sd. across years.

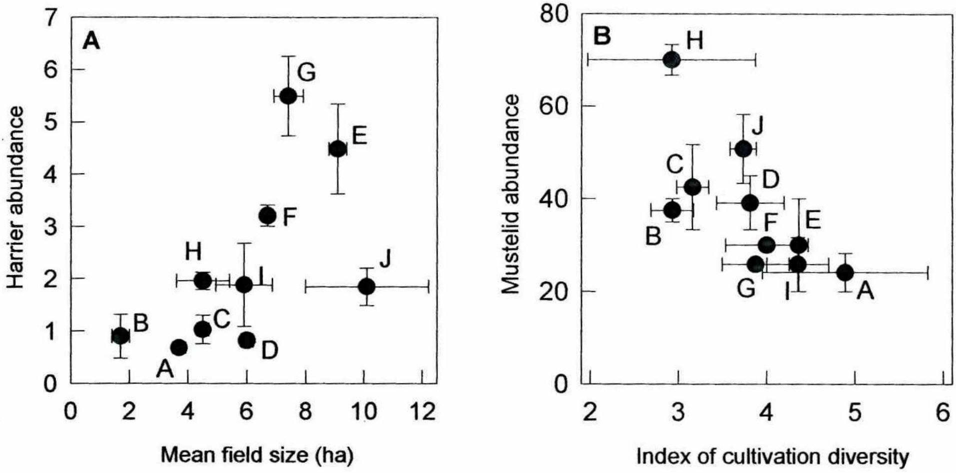


Figure 7: Relationships between **A**: the abundance of hen, marsh and Montagu's harriers (nb ind. / 10 km²) and the mean field size, **B**: the abundance of mustelids (% of lanes with faeces) and the diversity of cultivations; mean±sd. across years.

Predation is an important *proximate* cause of the grey partridge decline in France. Incriminated predators are harriers and carnivores. We have direct evidence of raptor predation on adult hens in "Centre" and "Champagne" regions (REITZ *ET AL.* 1993), but the impact on chicks only relies on a relationship with harrier abundance. However, RILEY *ET AL.* (1998) found that predation (by red fox and mustelids) accounted for > 85% of radiotagged pheasant chick mortality; moreover REDPATH AND THIRGOOD (1997) reported direct evidence of hen harrier predation on red grouse chicks. Relationships between mortality rates and predator abundance across study sites suggest that high predation rates may be attributed to an *additive* predation of raptors on breeding hens and chicks and of mustelids on clutches. Thus, predation is likely to be the cause of the recent decline of grey partridge in some regions in France (see also REDPATH AND THIRGOOD, 1997). However, habitat structure and farming practices are likely to be some ultimate causes that (have) weaken(ed) populations. Indeed, the effects of the loss of nesting cover (e.g. RANDS, 1986), reduction of insect abundance (e.g. RANDS, 1985), farming practices have been extensively documented (e.g. in BIRKAN *ET AL.* 1990; POTTS 1997).

Thus, management policies to recover populations of grey partridge should address two questions: not only predator abundance that increased recently (YEATMAN-BERTHELOT

AND JARRY 1994; HAGEMEIJER AND BLAIR 1997) but also habitat quality in intensive cereal production regions. Limitation of predation could be achieved through both predator control (TAPPER *ET AL.* 1996; CÔTÉ AND SUTHERLAND 1997) and more suitable habitat (POTTS, 1997), in particular covers to escape predators.

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CHARACTERISTICS OF GREY PARTRIDGE MOVEMENTS FROM THE END OF SUMMER TO THE NEXT SPRING: A COMPARATIVE STUDY

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KEY-WORDS : grey partridge, *Perdix perdix*, France, autumn to spring movements, dispersal behaviour, comparative study

ABSTRACT

REITZ, F. and MAYOT, P. : VARIABILITY OF GREY PARTRIDGE DISPERSION DURING AUTUMN AND WINTER : We studied the movements of female grey partridges, *Perdix perdix*, in four study areas that could be classified by three different patterns of life conditions (diversity of habitat and density of partridge populations). 85 birds were radiotracked daily during at least four months in a period beginning at the end of summer (August) and ending with the location of the first nest site (May or early June). Movements of 153 other females that were radiotracked daily for at least two months starting early spring were also studied. The birds' movements were quantified by the successive positions of the average monthly location and by nest location.

The results show that if great movements occur, even in autumn, i.e. before the broods are breaking up, most of the seasonal shifts of the average monthly location are less than 500m. Movement patterns are highly variable among birds, age classes and areas. We could notice the absence of important movements (more than 1km between the first and the last seasonal mean location) of adult hens and a clear tendency towards smaller movements of birds in the area with the highest partridge density and landscape diversity. We wese also able to show that the average May location is quite far away from the first nest location. A very simplified modelling suggests that the distance separating the average August and the next spring first nest locations would most often be less than 1.5 km.

1. INTRODUCTION

Study of population dynamics and management implies a good knowledge of dispersal behaviour and more generally of animal movements from one reproductive season to the next. Quantitative data on grey partridge (*Perdix perdix* L.) movements from brood rearing to the choice of a nest site the next spring are rather scarse, most of the previously published papers focalizing on the end of winter and beginning of spring (e.g. JENKINS, 1951, BLANK and ASH, 1956, CHURCH *ET AL.*, 1980, BIRKAN and SERRE, 1988, CARROLL *ET AL*, 1995). Only WEIGAND (1980) gave results over a large period. None of them, however, studied on large samples of birds possible variations in these displacements among areas showing different habitat types and partridge density.

Therefore we intended to take advantage of an important mortality study that was carried out in France involving radiomonitoring of many partridge hens all along the year in different areas (REITZ and MAYOT, in press) to analyse the available data for bird movements. We will only present a small part of the results that can be obtained, since we restricted the analysis to one sample of birds, and to the position of their successive average monthly locations and of their first nest.

2. METHODS

Partridges were radiotracked throughout the year in four study areas situated in the Centre-North of France. The areas major characteristics are summarized in **Table 1**. Because they were too scarse, area 1 and 2 data were analysed together.

Partridges were captured by night in early spring or in autumn using a spotlight and a large drop net. Only females were equipped with a radiotransmitter (Biotrack Ltd or Holohill Systems Inc.) weighing about 10g with a theoric life duration of 6 or 12 months. Distinction was made between hens less than one year old (which will be called young) and the others (adults). Each bird was located daily at daytime using a handheld antenna. Locations were transfered to a squared map with a 1-ha grid.

All the present analyses are based on computing the average monthly locations of the birds, i.e. the arithmetic gravity centre of all fixes measured each month from August to May (only when more than 10 fixes concerning at least half of the month were available). To these average locations, the first nest position was added when available. Because of lack of time, we restricted the data set to: i) 85 birds radiotracked during autumn and/or winter, for which at least four successive average monthly locations could be computed (among these birds, some had been radiotracked during the previous reproductive season and some were still being radiotracked during the following spring), ii) 153 birds marked in early spring (before mid-April) that were radiotracked at least untill the end of May.

Table 1 : Area characteristics

area	landscape and type of crops	mean field size	permanent cover	partridge spring density (pairs/km²)
1 & 2	open field intensive, cereal and industrial crops	8 ha (area 1) 9 ha (area 2)	very few, except for some small woods, dirt tracks without grassy banks	5 to 10
3	id	5.5 ha	id. partly delimitated by a large forest	10 to 13
4	semi-open field mixed-farming	1.5 ha	several hedges, groves, woods and grassy tracks	20

Since very few and only adult birds could be radiotracked during the whole study period (from August to the time at which the first nest was located), we tried to estimate the shifts in the average location of partridges during this whole period by simulating the birds' movements. Modelling was based on the successive seasonal shifts of the average monthly locations and on randomly distributed angles between the directions of movement. The distances we used were actual but randomly selected seasonal shifts: i) the autumn shift (distance between the average August and December locations), ii) the winter shift (distance between the average December and April locations) and iii) the spring shift (distance between the average April location and the first nest location). As autumn shifts were only measured for adults, we considered that the movements of young were similar to those of adults during this period. We ran the model 1000 times for each area and age class.The statistical analyses were carried out using the SPSS 7.5 for Windows package.

3. RESULTS

First of all we studied the relative movements of hens belonging to the same brood. This concerned 13 birds and six broods (**Figure 1**). Although some large movements occurred before the broods broke up, the largest shifts between two successive average locations were recorded afterwards (see broods no 2 and 6). Large shifts from the breaking point also concerned adults (broods no 1 and 2). The breaking-up date varied from January (brood 2) to March (broods 1 and 4).

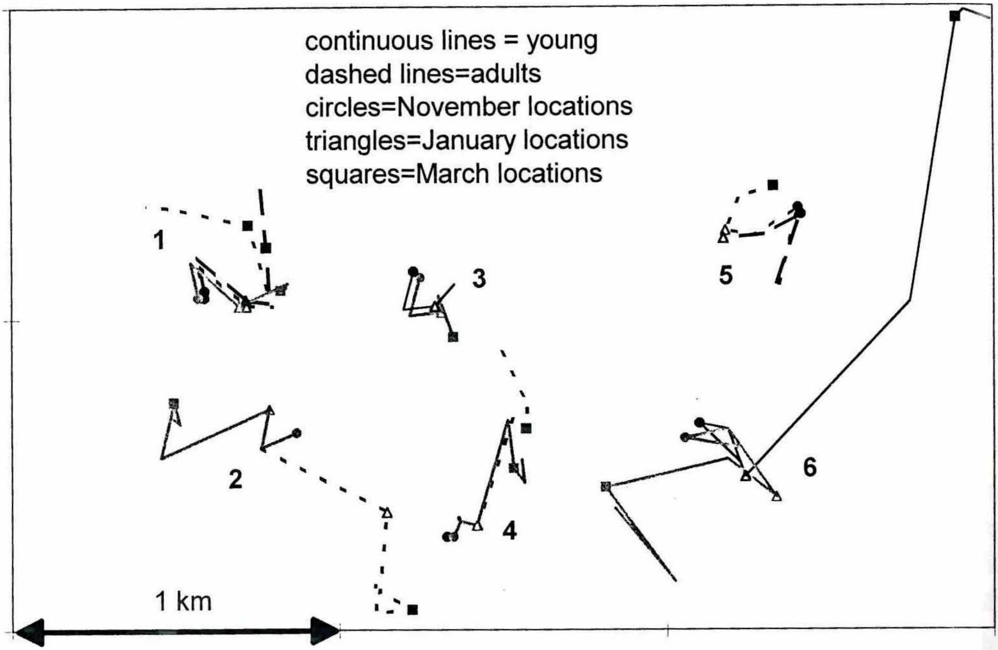

Figure 1: Relative autumn and winter movements of hens seen or captured with the same brood successive positions of the average monthly location.

The distance separating the successive average monthly locations varied greatly among the birds, even when considering only one age class and one area (see the confidence intervals in **Figure 2**). Statistical tests could not be performed because of high heteroscedasticity and dependency of the successive data concerning each bird. However four

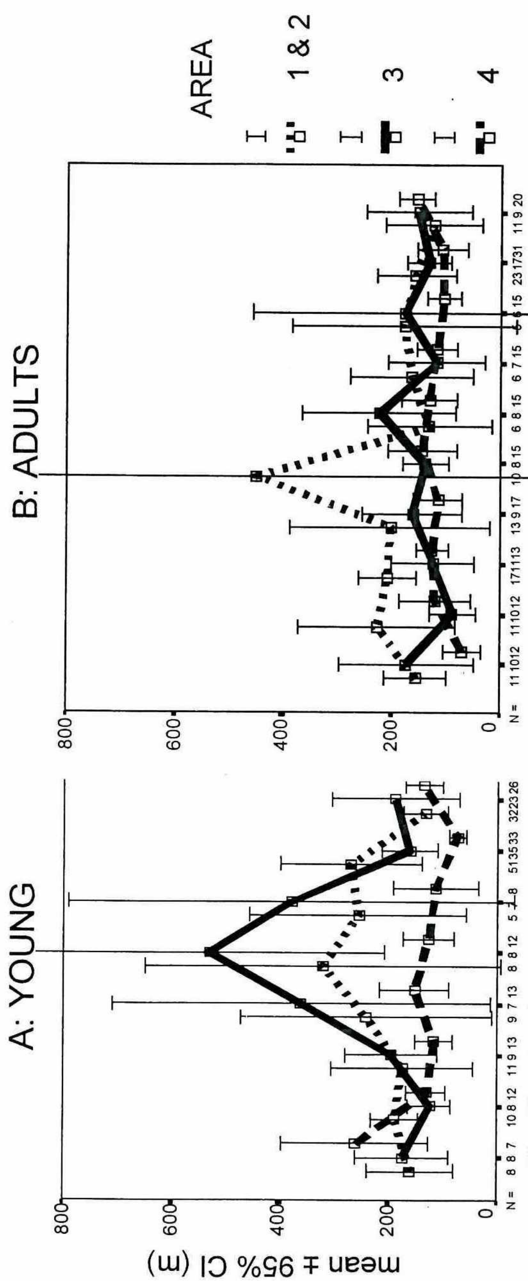

Figure 2: Distance separating the successive monthly average locations and the average may location from the nest site

high tendencies could be distinguished: i) movements of young hens in winter and early spring are smaller in area 4 than in others, ii) great shifts were recorded for adults in areas 1 and 2 in autumn and early winter, iii) there is no evidence of a common peak of movements among age classes and areas: only two age/area groups are showing a real peak which happened between the average February and March locations for the young in area 3 and between December and January for the adults in areas 1 and 2, iv) The average May location and the first nest location were usually not confounded since they were on average separated by nearly 200m (only 51 first nest sites among 121 were distant of less than 100m from the average May location).

Analysed over longer periods, our data show that seasonal shifts were mosly limited to less than 500m during either one of the three study periods (**Figure 3**).

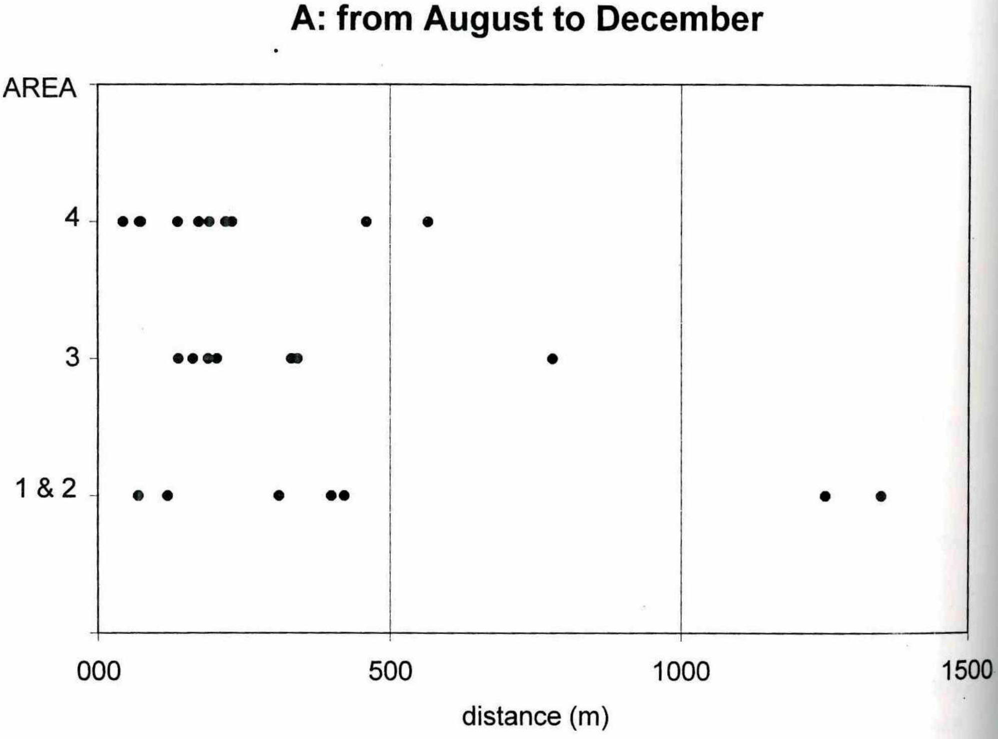
A: from August to December

Figure 3: Seasonal shifts of hen average monthly locations. Each point = a monitored partridge.

However several hens, mostly but not only young ones, moved their average location over more than 1 km, even between April and the first nest. The maximum was recorded for a young hen in area 1 which nested at 3400m from the place where it was first located at the end of March. Birds of area 4 never showed such great movements. Only December to April shifts were significantly different among age classes and areas (Kruskal-Wallis test, $\chi^2=11.8$, df=5, $P=0.037$). This results from smaller shifts for birds in area 4 and from the large movements of three young hens in area 3.

Global shifts of hen location between two successive reproduction periods were estimated by simulation. It shows a clear gradient among areas for adults: most of the adult birds in area 4 would stay from August to the next spring nest location within a 500-m radius and all of them within a 1-km radius while these radiuses respectively are 1 km and 1.5 km for area 3 and 1 km and 2 km for areas 1 and 2 confounded **(Table 2)**. Although these results should be taken into account cautiously because of the modelling hypotheses (see discussion), the comparison among areas undoubtedly shows that adults are moving more when density decreases and/or field size increases. The situation for the young is not as clear as for the adults. If the movements of young in area 4 could be estimated to be very small, and similar to adult ones in the same area, young in area 3 seem to move farther away than the young in areas 1 and 2 and much farther than those in area 4. According to the simulation, less than half of the young hens in area 3 would stay within a 1-km radius. However, even at low densities in a very open landscape, more than 80% of the young hens would stay in a 1.5-km radius.

Table 2 : results of a simulation of partridge shifts. Proportion of the birds that theoretically moved less than the indicated distance from august location to the next spring nest location.

age/area	<=500m	<=1000m	<=1500m	<=2000m
young / 1 & 2	30%	65%	90%	96%
young / 3	17%	36%	78%	98%
young / 4	77%	100%	100%	100%
adults / 1 & 2	32%	71%	95%	100%
adults / 3	36%	94%	100%	100%
adults / 4	72%	100%	100%	100%

4. DISCUSSION AND CONCLUSION

Brood break-up and the behaviour of the grey partridges during the weeks following this crucial period are well documented (see BIRKAN & JACOB, 1988 for a review). From this point of view, our data are a simple confirmation. The original results of our study concern the comparison of shift sizes between areas, age classes and periods. They reveal that extensive movements (e.g. shifts in the activity centre of 500m or more from one month to the next) can sometimes occur when partridges are still grouped in broods, i.e. during autumn, but this is not a general rule even in areas where cover protection from predators or bad weather is scarse.

Another notable result is the existence of large shifts after April. CHURCH *ET AL.* (1980) pointed out the existence of an exploration phase throughout April. The latter probably continues up to the beginning of May. However, our present means of investigation do not allow us to be more precise. It would have been necessary to analyse the data day by day. Such an analysis would also allow us to study why the average location of May, i.e. during egg laying is rather distant from the nest location. Where is the nest location compared to the May activity range of the hen?

Surprisingly, the only clear gradient we obtained in movement sizes from areas 1 and 2 to area 4 was for adult global shifts according to our simulation. Adult movements in autumn and beginning of winter appeared to be higher in areas 1 and 2 than in others, while similar movements were recorded after for this age class in the three area groups. On the other hand, we pointed out a very different pattern for the young which dispersed farther in area 3 than in areas 1 and 2. We have no clear explanation for this. However the area 3 where another study took place before (SERRE *ET AL*, 1995) was known to be probably the place of high dispersal phenomena. Nevertheless it shows that partridge density and landscape diversity are not sufficient to explain dispersal behaviour variations.

Our modelling gives some interesting answers to the questions one may ask when managing populations, in particular those concerning the ideal size of management units. Very few data of bird movements from the end of summer to the next spring are available. The only ones we found are given by POTTS (1986) who reported that a mean distance of 420m for 27 young females was recorded at Damerham for the same period. This corresponds to our simulation results for the young in area 4. In other areas our model shows that movements could be much greater but not like those given by CHURCH *ET AL* (1980) for the only dispersal period. However, our results may be biaised in two ways: first, angles between successive directions were randomly chosen. Thus, it excludes a possible behaviour of progressive return of adults to the previous year nesting place. This behaviour is supported by our data in area 4: five adult hens could be located from August to next spring nest laying with a mean shift of 143m while the simulation gives a mean movement of 400m. Secondly, the size of successive shifts for one bird can be correlated (i.e. existence of birds that constantly tend to move more than others). If so, the variance of our estimates should be underestimated.

In conclusion, this work has confirmed or brought some new data to understand partridge movement behaviour outside the reproduction period. However it should be supplemented with all other available data (birds radioed during less than four months, birds monitored from spring to the end of summer in six other areas, data concerning brood movements from hatching to August) and with a range and a day-by-day movement analyses. Establishing relationships between individual patterns of movements and the habitat characteristics should be the ultimate goal.

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PARTRIDGES IN HUNGARY 1922-1933

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KEY-WORDS: partridge, Hungary

ABSTRACT

POTTS, D. and FARAGÓ, S.: PARTRIDGES IN HUNGARY 1922-1933. We discovered some data on partridge counts and bags from the Duke of Esterházy's estate surrounding the present town of Fertőd, south-east of Lake Fertöd (Neusiedlersee). The counts cover the years 1922-1933, and the bags 1931-1939. There were also data on cropping and field size. In those days the field size was much smaller than now, 85% of the fields were less than 6 ha compared to a present day mean of 50 ha No pesticides were used, and crop diversity was very high.

Analysis of the data suggested a density of 8 pairs per km^2, an average brood production rate of 69%, an extraordinarily high chick survival rate of 75%, and an annual adult survival rate, including shooting, of 32%. The adult survival rate was reduced in one year by severe winter weather, but the population size very quickly recovered. About 25% of the birds were shot per annum which, together with those captured for restocking elsewhere, amounted to a yield of 44%, or 23 per km^2 per annum. The most likely cause of the decline of the partridge in Hungary is pesticide use with an additional effect of nest predation.

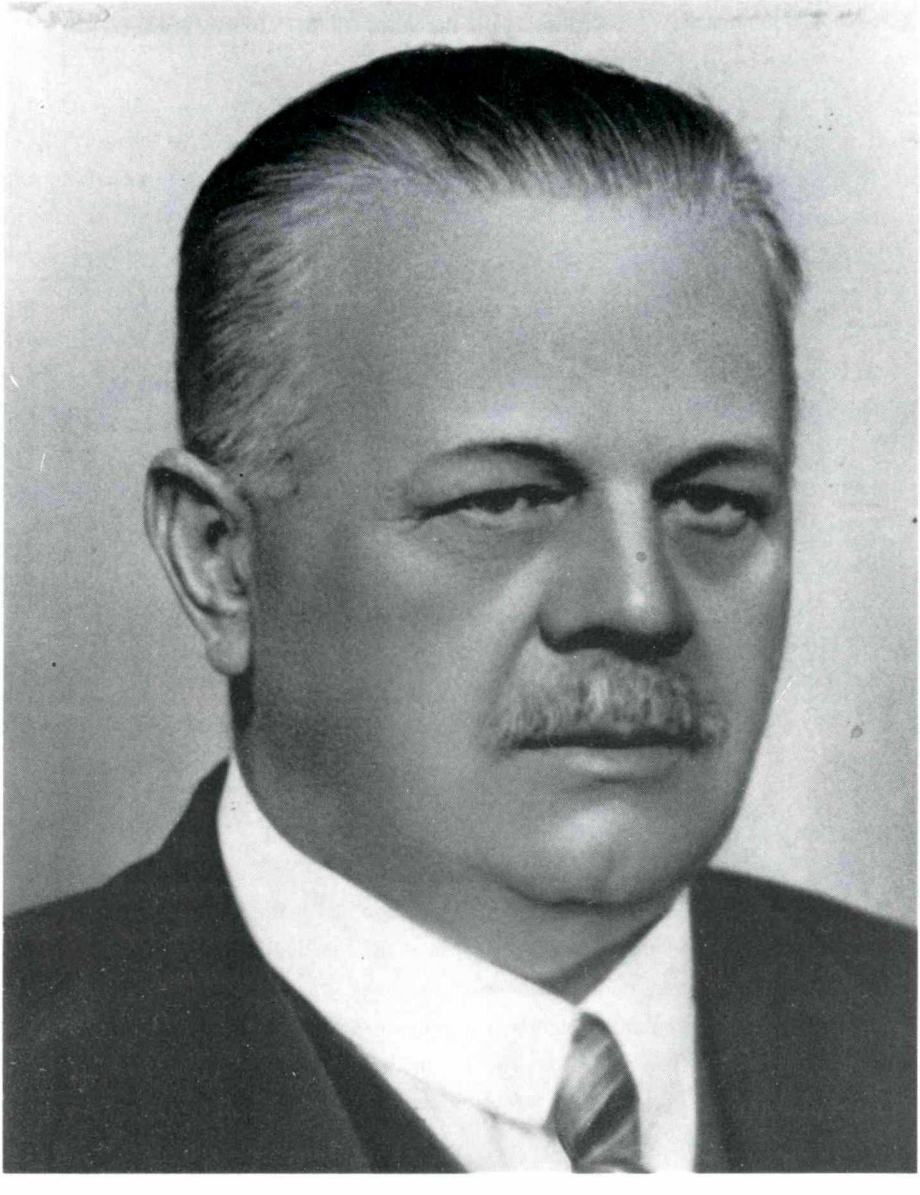
We compared these results with the situation in the current LAJTA Project. At Lajta the recovery will have the highest chance of sustained success if pesticide reduction mechanisms remain combined with improved nest predation control. Raptors have, however, increased fourfold or more. At present there is no clear evidence that they are significantly reducing overall numbers of partridges, but it is possible this is the case. Proportionately, more partridges are now dying of predation of all causes than formerly were shot. This subject demands urgent new research otherwise the partridge may effectively be lost.

1. INTRODUCTION

In the UK there has always been tremendous interest in the partridges of Hungary. Early travellers and hunters had been to the fertile plains of Austria and Hungary and seen large numbers of partridges in "a vast expanse of millet and maize from which the official returns showed about 1½ million partridges shot annually" (MAXWELL, 1911).

Numbers shot in some areas indicate densities of partridge that are today virtually incredible. At the end of the 19th century, for example, a team organised by Count KÁROLYI of Tótmegyer shot 10,000 in ten days on 10,510 ha. In 1904 on The Prince of AUERSPERG's estate near Podebrady, east of Prague, Czech Republic, a party of ten accounted for an extraordinary 4,000 in one day –the all time world record, reaching a total of 17,206 in 8 days (GLADSTONE, 1922; but see **Appendix I**). What is more, numbers remained high for at least two or three decades. At Tótmegyer, for example an average of 10,060 were shot per annum

Richárd SEYWERTH
Headkeeper of Duke of ESTERHÁZY



Prof. Ákos de KARKOVÁNY

over the years 1930 to 1937 inclusive, or 87 km^{-2} (KÁROLYI, 1953). This compares to a mean of 46 km^{-2} for TREBOŇ (Czech Republic) for the years 1876-1916 (NOVÁKOVÁ and HANZL, 1966).

Apparently believing that such a vast production of partridges was more to do with the bird's superior genetics than its habitats, large numbers were imported into the UK. For example, a survey of 16 estates in the UK in 1910 showed that four were regularly importing and releasing partridges from Hungary (MAXWELL, 1911). Large numbers were sent to North America in the early part of the century and, as late as 1940, 50,000 were annually exported to the USA (in POTTS, 1986).

This paper began with a hunting trip to Hungary in December 1934, during which Major H.G. ELEY, of the family that then manufactured most of the cartridges in the UK, and founder of the research that eventually led to the formation of The GAME CONSERVANCY TRUST, met Professor A. de KARKOVANY of The ROYAL AGRICULTURAL ACADEMY, Mosonmagyaróvár, where there was a company similar to ELEY. de KARKOVANY mentioned partridge counts organised by a Mr. SEYWERTH (see **Photo 1**., with eagle owl), headkeeper to the Duke of ESTERHÁZY, covering the 12 years 1922-1933. These were collated by a Mr. RIMLER and sent to Major ELEY in 1935. In October 1998 further data and bag records were discovered through a stock-book inventory covering the years 1931-1939.

Of course, the partridge count data do not include the detailed methodology we expect today, but we have been able to draw conclusions highly relevant to the present situation.

2. METHODS, STUDY AREA AND GAME MANAGEMENT

The ESTERHÁZY estate is centred on the village of Fertőd, known as Esterháza in the 1930s, south-east of Lake Fertő, known in Austria as the Neusiedlersee.

The basic data were counts made after the small grains harvest and before shooting, the purpose being in large part to plan how much shooting could be undertaken, the season opening on 1st August. The central areas are indicated on the map, **Figure 1**. The original data are reproduced in **Table 1.** The coveys would not be counted on the ground but usually after flushing and at a time of year when young and old were, by this method, inseparable.

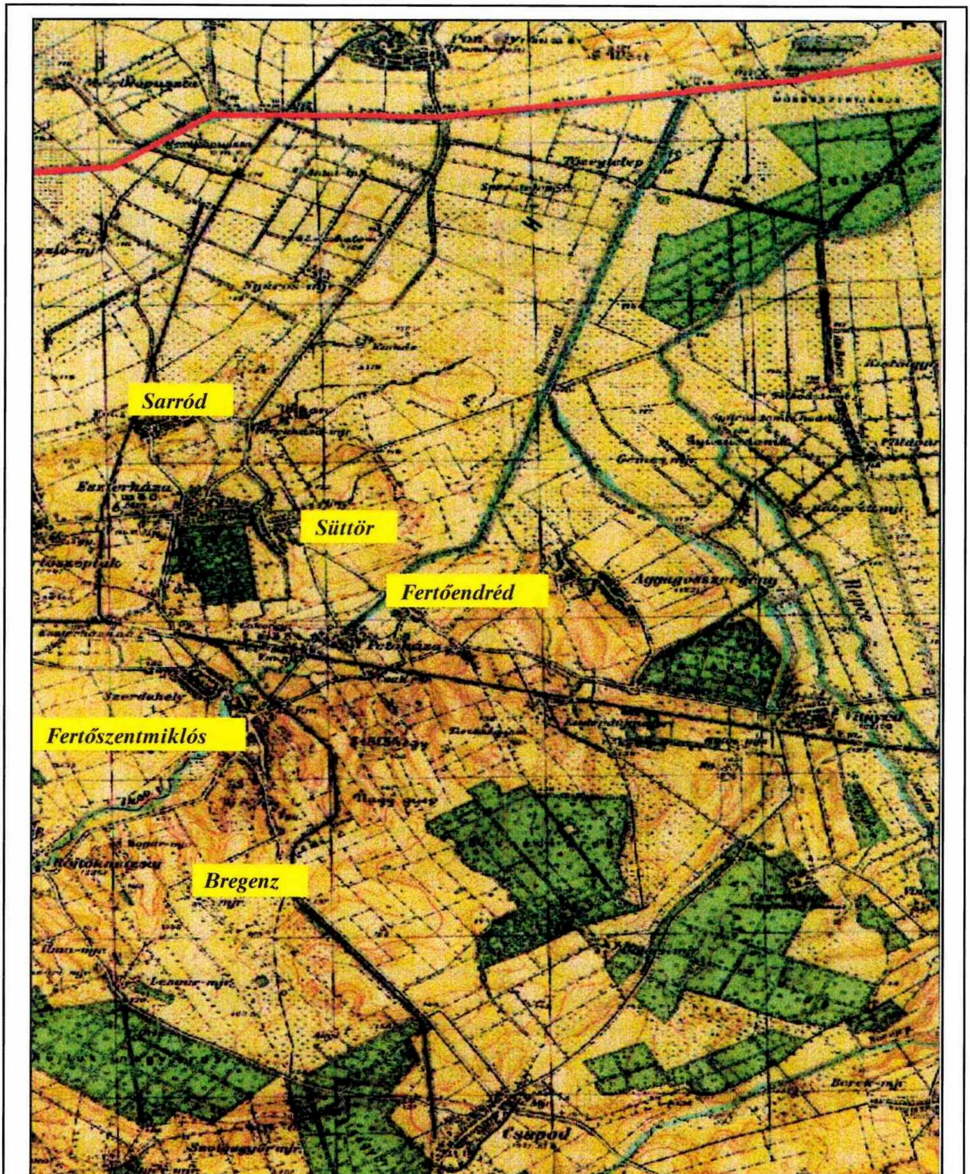


Figure 1.: Contemporary map showing the general area of the partridge counts from 1922-1933.

Contemporary details of the methodology are given in KOTEŠ and KNOBLOCH (1947). Thus, the method of calculating chick survival rates from brood size that we have used elsewhere, given in POTTS (1986), was not appropriate.

Instead, we estimated percentage chick survival (= y) from covey size (= x) by using the Damerham data available from 1947-1960 during which period the annual chick survival rate was determined directly (see **Appendix 1**, POTTS and AEBISCHER, 1991). The correlation between covey size and chick survival rate was very high (see **Figure 2**).

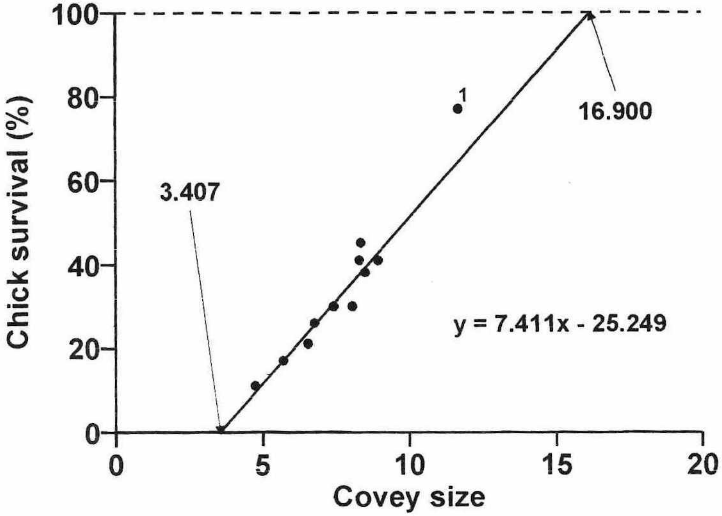


Figure 2.: Relationship between covey size and estimated chick survival rate, Damerham, UK, 1947-1960. The data point labelled [1], for the year 1949, was excluded from the regression, whereupon $r^2 = 0.94$ ($P<0.001$).

Moreover, reference to results of the six-year Salisbury Plain experiment (TAPPER *ET AL.*, 1996) showed that the relationship was not affected by the presence or absence of predation control. Covey size and chick survival rate was affected, but the relationship between the two was not. The original method of estimating chick survival rates has been verified in radio-tracking by GREEN (1984), RANDS (*in* POTTS, 1986), and by AEBISCHER and REITZ (this volume), and in the UK it gives results virtually the same as those obtained by the new method.

Where x is the mean covey size:-

$$y = 7.41x - 25.25; \qquad (1)$$

On this method the number of chicks at hatching is found to be 13.5, the brood size when the chick survival is 100% (16.9 [see **Figure 2**] less the number of old birds per covey equivalent to a chick survival of 0% (3.4 [see **Figure 2**]). But is this realistic for Hungary? Whereas PETERFAY's (1935) (1938a, b) data from Kistápé, County Tolna give a clutch size of 12.7 equivalent to a hatch of only 11.7, lower than here, SZEDERJEI *ET AL.* (1959) further north and east on the Hungarian Plain give a mean clutch size of 16.0, i.e. a hatch of 14.7, higher than here. The average of the two is 13.2, not significantly different from 13.5, so the 'assumption' of 13.5 appears valid, as also is indicated by the geographical variation in clutch size described by PULLIAINEN (1971).

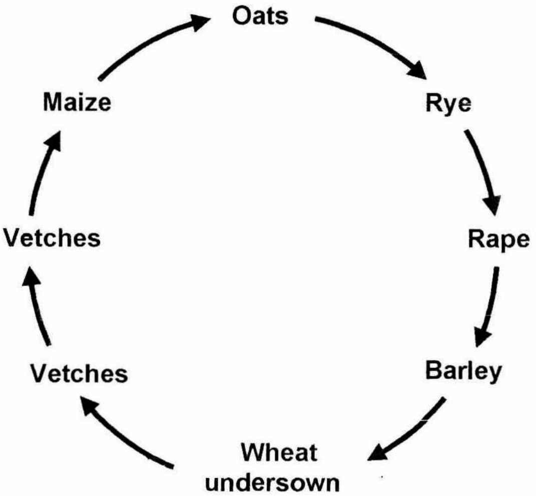


Fig. 3. Crop Rotation near Esterházy Estate, Hungary, 1930s. Source: Szechenyi Museum, Nagycenk.

We compared the total of old birds in the July count (calculated on the assumption of 1 brood per covey) to the overall total counted the previous July to estimate an "annual adult survival rate" incorporates all the adult losses through the year, including shooting. It is calculated as 100 x (number of old birds in August of year t+1) / (total number of birds in August of year t).

On the ESTERHÁZY estate fourteen types of crop were grown, with at least 10% of cereals undersown, and 25% of the total in legumes. One typical rotation on a nearby estate is given at **Figure 3** below.

Field size was small with 85% of fields under 6 ha often bordered by grassy paths, balks and grass banks with some hedges (archive data from ESTERHÁZY, but see also photographs and maps in SZEDERJEI *ET AL.* 1959), compared to 50 ha today (FARAGÓ 1998). Cropping in the main areas counted is given in **Table 2.**

The biodiversity on Hungarian farms at that time and earlier must have been wonderful, for example THAISZ and CSIKI (1912) reported 123 species of plant and 67 of insects in the diet of 257 full grown partridges shot between 31st July and end August at the turn of the century. From 1933-1953, 60 species of plant and more than 16 species of insect were found in the diet of 99 partridges shot in August (VERTSE, *ET AL.* 1955). From 1949-1953 1,400 partridges shot in the Czech Republic and in Slovakia, also in August, contained at least 68 species of plant and 122 species of insects (JANDA 1957).

With open habitats, far fewer trees than today, and one gamekeeper per 760 ha, we can assume resident predators would be extremely scarce. There are no data from ESTERHÁZY itself, but there are some from the estates of Count Andreas Csekonics at Zsombolya, now in Romania, and of Count Károlyi at Tótmegyer that indicate the scale of predator control that was then practised on the main game estates (**Table 3**). The current position at LAJTA is given for comparison.

Results: 1922-1933

The data as collated by Mr. Seyworth were given earlier unaltered as **Table 1**, the derivatives using the methods described above are given in **Table 4**.

Table 2: Four main villages of ESTERHÁZY estate, Hungary. Annual sowings in the years 1936-1938 in an area of 15,124 ha that included the areas where partridges were counted to 1933 and where bags were recorded to 1938. Sowings were recorded on 8,985 cultivated ha

Crop	Percentage area
Wheat	21
Forage legumes	14
Spring barley	12
Rye	11
Maize	10
Sugar beet	9
Oats	6
Peas, beans	5
Potatoes	3
Other	9
Total	100%

Chick Survival Rate and Brood Production Rate

The most astonishing feature of these data, the consistent, very high covey size and hence derived chick survival rate, are at once obvious (**Table 4**).

Since chick survival rate is a crucial parameter, we must assess whether the very high value could be some kind of artefact. Brood amalgamation can occur, but tends to do so when densities are high, which they were not in this case, or later in the season especially when the weather begins to get colder; in fact these counts were done early, at the end of July or early in August. Another possibility may be a relatively high number of old birds in the coveys arising from unusually high nest losses. Although the nest loss rate on the ESTERHÁZY estate is not known, the nearest studies in terms of geography and time are those collected by PÉTERFAY (1935, 1938a, 1938b).

Table 3: Cull of predators on two estates within or near present-day boundaries of Hungary 1889-1937 and a comparison with the LAJTA Project

	Zsombolya (1) 1889-1899 ? ha	Tótmegyer (2) 1930-1937 11510 ha	LAJTA-Project 1992-1997 3085 ha
Hedgehog	<488	4526	0
Fox	1337	19	257
Mustelidae	19857	9115	0
Stray dogs	908	4332	211
Stray cats	904	7403	281
Diurnal raptors	9239	5711	0
Nocturnal raptors	6770	2176	0
Corvidae not magpie	41903	11546	599
Magpie	10783	3223	28
	--------	--------	-------
Total	92,189	48,051	1376

(1) Maxwell (1911)
(2) Károlyi (1953)
(3) Faragó (1998)

Astonishingly, these data give a brood production rate of 69% that is exactly the same as that at Damerham over the period 1947-1960, from which the relationship between covey size and chick survival rate was derived (Potts 1986).

In short, it is most unlikely that the data are giving an incorrect result. What is more, if chick survival rates were indeed estimated too high, then the *quid pro quo*, despite obviously high breeding success, would be an even higher brood production rate because, axiomatically, there is a "trade-off" between the two estimates (Potts 1986).

The lowest chick survival rate was 68.4% in 1925, and the highest 89.2% in 1930, with the mean being 74.8%. No other site reviewed in Potts (1986), or subsequently published, gives survival rates so high or so lacking in variation proportionally (calculated as a coefficient of variation (Potts unpublished)). The next highest estimates of chick survival rate are those for Jokionen, Finland for 1913-1922 that averaged 66% (Fazer 1925) and for

Perdix daurica from 1978-1983 in a study area south-east of Lake Baykal where the chick survival rate averaged 74% (LITUN 1992).

Table 4: Grey partridge stocks on the Duke of ESTERHÁZY's Estate, Hungary 1922-1933

	Area counted (ha)	Mean covey size	Chick survival %*	Pre-shooting density km^{-2}	Adult survival *
1922	7632	14.3	80.6	21	24.3
1923	7632	14.2	79.9	21	27.6
1924	7333	13.5	75.0	24	36.9
1925	8633	12.6	68.4	28	35.7
1926	8633	13.3	73.1	39	50.0
1927	10039	13.2	72.8	65	29.0
1928	9348	12.9	70.6	77	11.7
1929	9825	14.0	78.1	35	53.9
1930	8525	15.4	89.2	78	20.5
1931	8525	12.9	70.1	60	38.4
1932	9736	12.8	69.6	76	29.4
1933	7654	12.9	70.7	108	-
	-------	-------	-------	------	-------
Total means, ± se	103515	13.5 ± 0.23	74.8 ± 1.7	53	32.5 ± 3.5

* methods in text

Although it is difficult to gather comparable data today, some counts carried out by Potts and Cheng Wang (unpublished) of Daurian partridges (*Perdix daurica*) in the Tian Chi Reserve, Ningwu County, Shanxi Prov. China in 1996 were from an area where farming was also entirely unmodernised. These counts gave an estimated chick survival rate of 59±5%.

Densities

The overall density in the counts including all 55,619 seen, was 54 per km^2 though with a substantial increase from 21 km^2 in 1922 to 108 km^{-2} in 1933. Given 3.4 old birds per covey (see **Figure 2**), and that 56% would be expected to be males equivalent to spring pairing males (see POTTS 1986), then we would have 4,163 coveys with 3.4 old birds in each producing (given 56% males) a total of 7,943 old males. On the 1,035 km^2 counted, this would give a breeding density of 8 pairs km^{-2}, but varying from a little over 3 km^{-2} in 1992 to 16 km^{-2} in 1933.

Annual adult survival rate

The values of annual adult survival rate are given in **Table 4.** They are much as one would expect from results elsewhere (POTTS 1986) averaging 32.5%, or 35.0% excluding the catastrophic two-thirds drop in survival rate to only 12% that occurred in 1929. This was due to the extremely cold February of 1929 when the minimum temperature dropped to an astonishing -26°C, a subject dealt with below. Within one year, however, there had been total recovery. Similar conditions occurred in 1939/40 (KOTEŠ and KNOBLOCH 1947).

Shooting rate

Data on bags and pre-shoot stocks are only available here for three years (see **Table 5**). In view of the possibly anomalous low shooting rate of 1933, it is helpful to compare the average of 13 shot km^{-2} for 1931 to 1933 to the 16 km^{-2} shot over all eight years 1931-1939. This suggests a long-term average of around 25% of the counted birds being shot per annum. Although this is well below the maximum sustainable yield (= MSY), in fact half the theoretical MSY with this productivity (see POTTS 1986) there is a complication, winter capture.

Winter capture

Data on shooting and capture are only available for the years 1931-1939. They show a high capture rate. On the basis that the 12,879 shot imply 38,637 surviving the shooting, (i.e. 25% per annum shot), then at least 20% of the survivors were caught up (**Table 5**).

Table 5: Grey partridge stock exploitation on the Duke of ESTERHÁZY's Estate, Hungary 1931-1938

	Total present	Of those shot	Captured	Total	Total exploitation
1931	5155	1142 (22%)	1186	2328	45%
1932	7435	2035 (27%)	1650	3685	50%
1933	8294	984 (12%)	2417	3401	41%
1934	-	787	0	787	-
1935	-	3453	0	3453	-
1936	-	4243	1195	5438	-
1937	-	183	211	394	-
1938	-	649	896	1545	-
		------	------	------	
Total		13476	7555	21031	

The caught-up birds may have been used for either of two purposes, or both:-

1. For the extensive restocking practised in Western Europe and North America at that time.

2. For over-wintering and release in spring at ESTERHÁZY.

In all likelihood, both of these were involved, but the very low survival rate through the winter of 1928/9 suggests either that method (1) was not used in that year, or it was ineffective. More telling is the fact that birds were not caught up every year, nor was the winter survival higher in the year when most were caught up, namely 1933, judging by the very poor numbers in 1934. It is of interest that this method of over-wintering has been used in Russia and Poland, but there is nothing in the literature anywhere to show that it has been effective (see DITS 1917, KOTEŠ and KNOBLOCH 1947). Even NAUMANN (1833) doubted its value, though suggesting it would be best to retain only old birds for the purpose (i.e. ones that have had the experience of breeding). In fact, all this suggests that so few were shot in 1933 because the birds were being saved to export for restocking elsewhere.

Hence we conclude that most captured birds were caught for sale for export elsewhere including North America. If so this could explain how the shooting rate generally fell so far below the maximum sustainable yield (MSY) values, whereas the two together produced an exploitation rate of 40%, 25% + (20% of 75%), in line with the MSY of a partridge population with the productivity as observed at ESTERHÁZY.

The decline

The most recent data on chick survival is that from the Andau plain, just north-west of the Esterházy Estate, where counts in 1964 revealed 15 broods of average size 12.7 (ASH 1965) giving a chick survival rate estimate of 91%. Since then, the partridge population has collapsed, as it has in many other countries. In Hungary the decline essentially took place between 1977 and 1993 (FARAGÓ 1997a).

Elsewhere, POTTS (1986) put forward two causes of decline that have been verified in the UK. First there has been a decrease in chick survival rate due to pesticides, and second there has been an increase in density dependence of brood production rates due to nest predation, an effect exacerbated by increases in predator numbers and losses of nesting cover.

POTTS (unpublished) gained some insight on the decline in Hungary during a visit to the Fácánkert Research Station near Szekszárd, County Tolna in April 1981. I reported "The overall use of pesticides on the state farms nearby appeared at least as great as in the UK at that time. Certainly herbicides seem to have been used on all the cereals I saw and they were remarkably weed-free". In fact, official statistics for 1978 already showed 4 million ha treated out of a total area of 4.868 million ha, equivalent to 82% (ZASHCHITA RASTENII 1979 [in Russian]). Hungary was suddenly amongst the top ten markets for pesticides in the world.

What is more, the organo-phosphate insecticide monocrotophos, always banned in the UK but recently causing huge mortality to the Swainson's hawk *Buteo swainsoni* in Argentina (GOLDSTEIN *ET AL.* 1996), was being used extensively on maize (at least 10% of the crop in 1980) against the beetle *Tanymechus dilaticollis*. Monocrotophos had significant direct toxic effects against gamebirds, as would be expected from its toxicity profile, and as was shown locally by the research of Arpád Zaják and Denes Farkas of Fácánkert Research Station.

Effects were compounded by the large maize fields in the area, of which there were several plots of around 100 hectares. The net result was a pauperate population of partridges (**Table 6**).

Table 6: Results of census of grey partridges on two farms near Szekszárd, County Tolna, Hungary in April 1981

Farm	Area	Partridge pairs per km^2
Bartaszek Co-operative	10,000 ha	0.41
Tengecic	13,000 ha	0.38

The evidence above, together with that given in FARAGÓ (1997a, 1997b and 1998) is, we believe, overwhelmingly that pesticides, especially herbicides, reduced the food supply to partridge chicks in Hungary, and caused starvation just as they did in the UK. Interestingly, the first published account of an adverse effect of a herbicide (2,4-D) on chick-food insects resulted from research in Hungary in 1960 (UBRIZSY 1968).

The situation today – the LAJTA Project

This project has been described elsewhere (FARAGÓ 1997a, 1997b, and especially 1998). Astonishingly, the productivity of this population over the years 1989-1997 is *higher* than was the case on the ESTERHÁZY estate in 1922-1933, as is shown in **Table 7.**

Table 7: Grey partridge, Hungary: comparison of young : old ratios in August 1922-1933 and 1989-1997.

		Partridges counted in August		
		young	old	ratio
1922-1933	Esterházy	41436	14183	2.92
1989-1997	Lajta	3095	827	3.74

On this basis there is no doubt that the conservation measures at LAJTA are capable of restoring partridge production rates; poor production of young is clearly not the reason why partridge numbers have been unable to recover on the LAJTA area.

The data on numbers and on adult survival are assembled in **Table 8.**

Table 8: Grey partridge, Hungary: adult survival rates overall and at two seasons, LAJTA Project (from FARAGÓ 1998)

Calendar Year	Total Partridges	Partridges and survival rates		
t	August year *t*	to March	from March to August	to August *t*
	t + 1	*t* + 1	to August *t* + 1	
1989	158	58 (37%)	47 (81%)	30%
1990	248	54 (22%)	49 (91%)	20%
1991	344	173 (50%)	129 (75%)	38%
1992	842	231 (27%)	159 (69%)	19%
1993	435	306 (70%)	176 (58%)	40%
1994	1184	311 (26%)	152 (49%)	13%
1995	386	82 (21%)	40 (49%)	10%
1996	124	44 (35%)	36 (82%)	29%
1997	201	50 (25%)	46 (92%)	23%
1998	209	N/A	N/A	N/A
	------	-------------	-------------	-------
means ± se	413 ±102	145±35 (35±5%)	93±19 (72±5%)	25±3%

Although the August density at LAJTA, 14 km^{-2}, has been far lower than it was at ESTERHÁZY (where from 1922-1933 the mean density was 53 km^{-2}), the subsequent annual survival of the birds is much *lower* at LAJTA, only 25±3%, despite the absence of shooting. Moreover, from August to March, losses were not density-dependent, and at ESTERHÁZY they took place almost entirely after the shooting season. The opportunities for compensatory effects were, therefore, minimal. This being the case, using the 25% shooting rate (**Table 5**), we can correct the average annual adult survival values on the ESTERHÁZY estate for the effect of shooting. To do so gives a survival rate of 43%, rather than 32.5±3.5% (**Table 4**). Putting aside the matter of the captured partridges, because to correct for those would increase the difference still further, it is clear some new factor is today killing far more adult partridges than formerly were shot (42% compared to 25%). One such factor might be raptors, given that they are not controlled at LAJTA (**Table 3**) and have greatly increased (**Table 9**).

Table 9: A comparison of numbers of raptors seen by two members of GAME CONSERVANCY TRUST staff on the plains east of Neusiedlersee: to show increase from 1964 (J. S. ASH) to 1996 (G. R. POTTS)

	ANDAU	FERTÖ, LAJTA and MOSON
	5th – 11th August 1964 per day *	Thursday pm Friday am 29th & 30th August 1996 per day
Buzzard	3	40
Marsh harrier	9	35
Kestrel	10	17
	------	------
Total	22	92

* Ash (1965), say 6 days, and rounding up.

It has long been known that raptor predation on partridges intensifies under severe winter weather (CHURCH 1980, POTTS 1986). For example, data on stomach contents of buzzards in Slovakia are conclusive that a higher proportion of their food consists of partridges in severe winters such as 1962-63 (SLADEK 1966). This is important because if it is the increased number of buzzards and other partridge-eating raptors that is the cause of the recent high adult mortality rates at LAJTA, then we would expect to find higher losses now than formerly, but particularly so in severe winters, when other raptors, rough-legged buzzard and hen harrier, were also numerous (FARAGÓ 1998).

Where y = the annual adult survival rate (AASR), and x is the mean of the monthly minimum temperatures from December to March inclusive (always negative), we have a clear overall relationship ($r^2 = 0.64$ $P<0.007$). Separating the two eras we have :-

For ESTERHÁZY $y = 0.59 + 0.025\,x$ ($r^2 = 0.67$)
and LAJTA $y = 0.39 + 0.015\,x$ ($r^2 = 0.25$)

The difference between the slopes is almost statistically significant (ANOVA $P<0.067$), but these results suggest no exacerbated effect of winter weather, indeed at –15°C the effect reduces to nil (**Figure 4**). What is more, the mean monthly survival rates during April to August are similar to those in August to March, 91% and 88% respectively. In two seasons, 1994 and 1995, spring and summer adult survival rates were similar to those during the two coldest winters (see **Table 8**).

Although breeding success and young : old ratio was not dependent on spring density, adult losses between spring and August (= y) did decline with spring density (= x).

$$y = 0.833 - 0.0009x \ (r^2 = .40)$$

Although not significant, ($P = 0.10$) the slope is suggestive. At densities ten times higher than now, such as were widely reported in former times, (SZEDERJEI *ET AL.* 1959), (KOTEŠ and KNOBLOCH 1947), adult survival would be less than zero! Raptor predation is not known to be a density-dependent source of mortality in the partridge in contrast to the situation with other nest predators (POTTS 1986) so seems not to be implicated at this time of year.

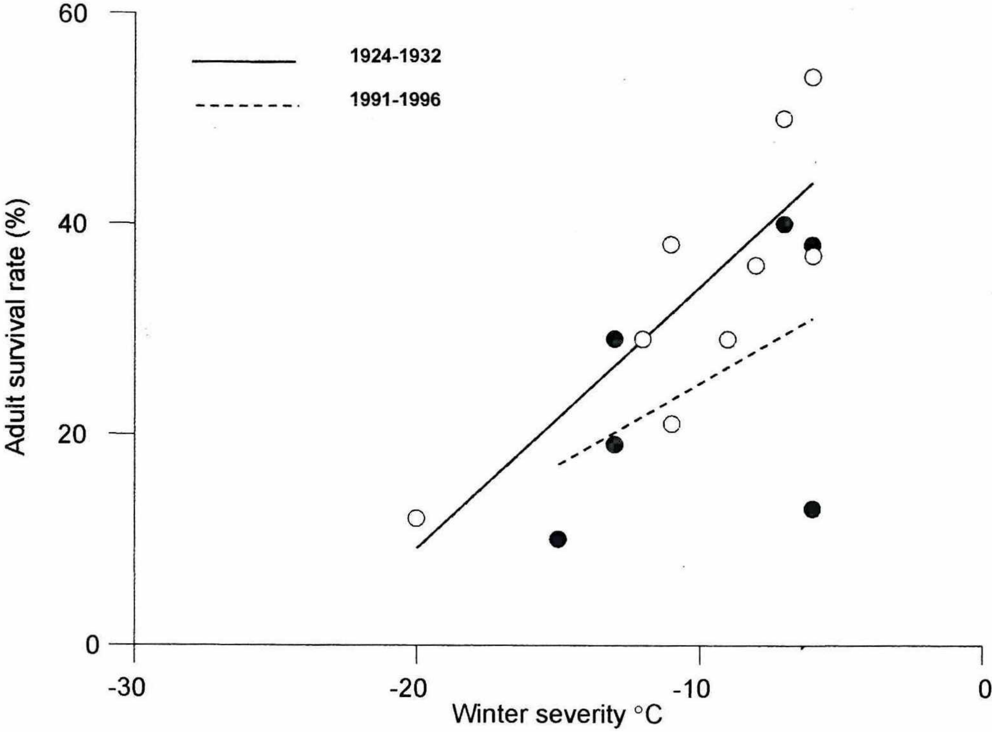


Figure 4: Hungary, grey partridge relation between annual adult survival rate and winter severity comparing ESTERHÁZY (where 25% were shot per annum) 1924-1932 and LAJTA (where none were shot) 1991-1997.

3. DISCUSSION

In the UK the fox is by far the most important cause of adult mortality, when it preys on the incubating female (POTTS 1986, POTTS and AEBISCHER 1989). The losses are density-dependent because predation is higher with higher densities of incubating females per unit nesting cover, the foxes hunting by scent.

Although foxes were controlled in the Lajta area the numbers killed were high, 1.4 km^{-2}, relative to Tótmegyer 0.02 km^{-2}, Steiermark, Austria 0.11 km^{-2} - 0.22 km^{-2} (SCHWENK

1992) or 0.15 km^{-2} at TRĚBOŇ, Czech Republic (NOVÁKOVÁ and HANZL 1966). Also, during any one year probably more than 40% of foxes are killed at Lajta after the partridge hatch and thus present before it (from FARAGÓ 1998, see especially data for 1995). Maybe also, control has become more difficult through the use of rabies vaccine and the increased numbers of foxes this brings about (SZEMETHY *ET AL.* 1999). At LAJTA, the number of foxes killed in 1997 was the highest since control began there despite constant effort.

If foxes or other ground predators, killing incubating females, are to blame for the summer losses, then the effect would not necessarily lower the young:old ratio in August. If the single males were vulnerable to predation by raptors such as marsh harrier this would not occur. Differential predation on males has been reported by BRÜLL (1964), (1965) and (1969) in the case of the goshawk, and suggested for marsh and hen harriers in FRANCE (AEBISCHER and REITZ this volume).

Few matters can be more important to resolve than this. At the one extreme, raptors may be the reason why partridge densities at LAJTA are not increasing, despite high productivity. If so, a solution involving raptor control for isolated oasis areas like LAJTA would be as impracticable as it is politically unacceptable. At the other extreme, if ground predators, especially foxes, are the problem then the solution, more nesting cover and more efficient fox control that would also improve the nesting success of other ground-nesting species, would not only be effective and acceptable, but would also be a huge contribution to conservation through wise use.

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APPENDIX I

WORLD RECORD NUMBER OF PARTRIDGES SHOT IN ONE DAY?

There is some confusion relating to the occasion in 1904 when a party of ten accounted for a world record bag of 4,000 in one day on the Prince of Auersperg's estate. First, it is not clear where the partridges were shot and there is no record of the area covered. GLADSTONE (1922) gives the Cábuzi estate but we could not locate this, despite the help of the AUERSPERG family. KOTEŠ and KNOBLOCH (1947) give the estate at ZELENA HORA, near Poděbrady, east of Prague with the name Horsuv Tyn, but none of these names could be found on a map.

Second, "in order to increase the partridge population, AUERSPERG released a great number of partridges which he purchased in other regions, and they considerably refreshed the domestic bloodstock". The latter could suggest some spring releasing, but pre-shoot releasing certainly took place prior to the record bags being made. There was, however, no rearing (KOTEŠ and KNOBLOCH 1947).

Densities of partridges were estimated in the Mseno and Mestec Kralove regions also near Poděbrady, and prior to shooting were 115 km^{-2} in 1939. In 1935 the number shot in the Poděbrady region was 126 km^{-2} the highest density shot amongst the 79 regions of Czechoslovakia (SEKERA 1956), equivalent to perhaps 250 partridges km^{-2}. Nowhere is there a suggestion that density was EVER as great as that in the UK when the record of 2,069 in one day was obtained, when it was about 400 km^{-2} (see POTTS 1986).

In conclusion, it is clear, especially given the introduction of birds prior to shooting, that the 1904 world record bag does not indicate a world record pre-shoot density, though all the associated information suggests it was extraordinarily high, especially by comparison with anything known today.

THE SITUATION OF PREDATOR CONTROL IN HUNGARY AND THE POSSIBILITIES OF PREDATOR MANAGEMENT

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KEY-WORDS: predator control, possibilities of predator management, Hungary

ABSTRACT

SZEMETHY, L., HELTAI, M. and BÍRÓ, ZS.: SITUATION OF PREDATOR CONTROL IN HUNGARY AND THE POSSIBILITIES OF PREDATOR MANAGEMENT: The small game population density is regulated by the environment, the population itself and the predation. The effective predator control is very important in such a poor partridge population as in Hungary. But the density and dispersion of the predator populations are not known and thus neither the effect of predator control. Mail questionnaire surveys were made among the hunting associations six times between 1988-1998. The population density, burrow density, brood size, used hunting methods and the timing of hunting were reported. The bag size derived from the National Wildlife Management Database. The effect of immunization against rabies and the effectivity of the predator control were evaluated. The vaccination has a real impact on the growth of the fox population, but there are other causes too. The recently applied predator control is not sufficient. The used methods, the timing of culling, the planning of control is not adequate. Moreover, also the protection of some carnivores should be revised, because the density and area of them are continuously increased during the past years. The solutions could be the change of the unadvised predator control to the planned predator management, the application of powerful density-dependent methods for culling or new methods to decrease the fertility of females.

I. INTRODUCTION

The small game population density is regulated by different factors. The first is the environment: abiotic factors, like the weather conditions, food supply (enough and suitable insect species for the partridges and pheasants) or the shelters. The second is the self regulation of the population, like density dependant fertility and mortality, the behavioural features of the individuals, like migration, home range size, territoriality or the mating strategy. Third, the predation can affect the prey populations, especially at small density level of the population.

The resistance of the small game populations to the predation is high, when it is a good quality, high density population in a good environment. In this case the predator control is an economical question. The costs and benefits have to be compared. The predator control has to be kept on that level, where the incomes from the small game populations balance the costs of the predator control.

In contrast with this situation the partridge population density is very low in Hungary. Moreover the environment is not suitable for this species, but it is a very vulnerable population.

It has to be protected, which means strong effort for the predator control too. It is not an economical question in this case.

However, there are some problems in the predator management in Hungary. Most of the seventeen carnivore species of Hungary are protected, but the predation of the protected carnivores could be also an important factor (like badgers). The red fox, the immigrating species (raccoon, raccoon dog, golden jackals) are allowed to be hunted during the whole year and the polecat and the stone martens have a hunting season. Thus we can control only six carnivore species more or less, but the others could cause damages in the small game populations too. The methods of control are strictly restricted by the new law of hunting. The shooting and the live-trapping are the only permitted methods. The control strongly depends also on the interest of game managers (AUBERT 1994).

Onother proplem is that there are no sufficient information about the populations of carnivores, except of bag data of red fox. We do not know the dispersion, the density of the populations and the effectivity of the predator control.

Beyond these, the population density of red fox continuously increases in whole Europe and there is an increasing tendency in the fox bag in Hungary from 1990 (NATIONAL WILDLIFE MANAGEMENT DATABASE, 1998). There are several possible causes e.g. habitat changes,the adaptability of red fox,but the immunization against rabies is the main factor by the opinion of some researchers (VOS 1995, BREITENMOSER *ET AL.* 1995). This immunization campaign has been in progress in Hungary since 1992. The 15,8 %, 26,3 %, 39,5 % and 100 % of Transdanubia were treated between 1992 and 1996 consequently (KEREKES unpublished data).

Hungary is in a good situation for the investigation of the population changes of foxes and the effect of per oral immunization against rabies. Whereas Transdanubia is only the 40 % of the country, so we have a treated and a control areas (Great Plain). We have a country-wide database about the bag records, the estimated population density, the distribution of used hunting methods and the timing of hunting from mail questionnaire surveys since 1988. We can compare the population density changes in these regions, before and after the vaccination campaign. We can estimate the real effect of vaccination and we can evaluate the effectiveness of predator management.

2. METHODS

Mail questionnaire surveys (FILION 1980, SZEMETHY AND HELTAI 1996) were made among the hunting associations in six years between 1988-1998 (1988, 1990, 1994, 1995, 1997 and

1998). Multichannel surveys were in the first two case among game managers, foresters, nature conservancy wardens and rangers. The game managers were the most interested group as the response rates showed. They sent the most reliable and the most detailed answers. Thus the surveys were continued only among the game managers.

There were 708 questionnaires in 1988 and 1990, 751 pieces in 1994 and 1995 and 1050 pieces in 1997 and 1157 pieces in 1998. Because there was a change in the hunting law in 1996, which altered the size of hunting estates and the number of hunting associations.

The response rate was 34 %, 26.4 %, 42 %, 51.4 %, 40.8 % and 47 % in the consecutive surveys. The covered area were 46.4 %, 23.4 %, 36.6 %, 43.8 %, 40.9 % and 47.3 % of the whole Hungary. Population density, burrow density of foxes, the used hunting methods, the time period of culling and the brood size of foxes were reported and analysed.

The number of hunted individuals (bag data) during the former time interval was derived from the NATIONAL GAME MANAGEMENT DATABASE (1998). The efficiency of control was also evaluated. The killing rate (density of bag devided by estimated fox density) was calculated and it was assessed in the function of the density of foxes. Theoretically to the successfull population control of the fox the game managers should keep the killing rate on the level of reproduction rate of the whole population, if the natural mortality is not considered. Moreover, there is the practice, which calculated from the bag data and from the estimated density.

The statistical analyses were made by SPSS for Windows (SPSS Inc.). Two-way ANOVA was used to evaluate the effect of the areas and years and one-way ANOVA with Duncan range-test was used to estimate the difference among years. Two independent samples t-test was used to compare the population densities between the two areas before the vaccination (in 1988-1990). The relationship between the bag records and estimated population density was evaluated by linear regression analysis, and the difference between them by two independent sample t-test for equal variance. Curve fit and regression analysis were used to evaluate the relation between the killing rate (density of hunted/estimated fox) and the density of foxes.

3. RESULTS

Red fox (Vulpes vulpes)

The red fox population really increased in Hungary among 1988-1998. However, the growth rate of the population density was significantly different in Transdanubia and in the Great Plain (**Figure 1**.). The population density was higher in Transdanubia in 1988, than in the Great

Plain (two independent samples t-test for unequal variances: t=-2.76, df=166.51, $p<0.01$), but in 1990 there was already no significant difference between the two regions (two independent samples t-test for equal variances: t=-0.36, df=184, NS). There was a stronger increase in the population in Transdanubia only from 1994, after the beginning of vaccination (two-way ANOVA: for the areas $F_{1,1847}=67.62$, $p<0.001$, for the years $F_{5,1847}=29.41$, $p<0.001$, and for the interaction between areas and years $F_{5,1847}=4.98$, $p<0.001$).

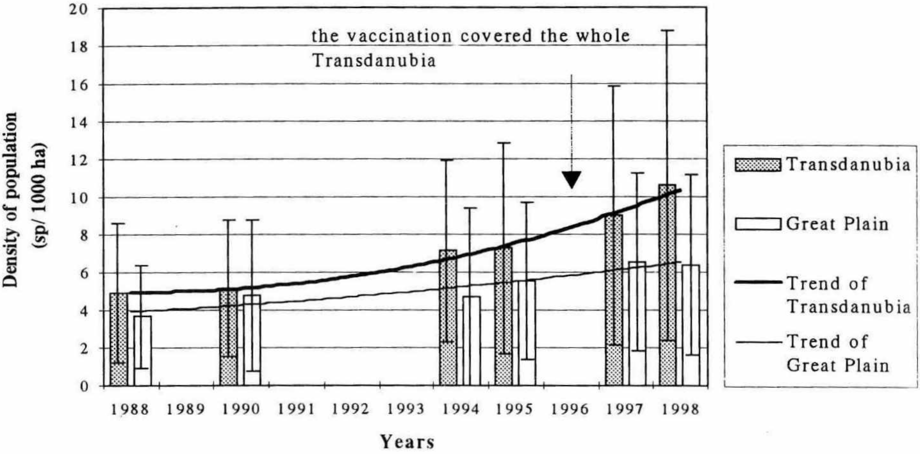

Figure 1: The change in the population density of foxes in Transdanubia and in the Great Plain among years (averages±SD). Significant differences were between the two areas and among the years.

Even larger burrow density was found in Transdanubia, than in the Great Plain (two-way ANOVA: for the areas $F_{1,2020}=6.63$, $p<0.01$, for the years $F_{5,2020}=21.29$, $p<0.001$, and for the interaction $F_{5,2020}=1.79$ NS).

The one-way ANOVA analyses for the population density among the years showed significant differences in Transdanubia from 1994 between each years ($F_{5,754}=16.83$, $p>0.001$). On the other hand there was a significant difference in the Great Plain too ($F_{5,1093}=11.12$, $p<0.001$), but only from 1997 and there was no difference between 1997 and 1998.

The analyses of change in the burrow density among years also showed the significant difference in Transdanubia from 1994 ($F_{5,824}=19.75$, $p<0.001$), and in the Great Plain from 1997 ($F_{5,1196}=10.22$, $p<0.001$).

The average brood size did not change during the years (two-way ANOVA for the years: $F_{4,1690}=1.9$, NS). Only the two areas differ significantly ($F_{1,1690}=34.05$, $p<0.001$), there was larger average brood size in the Great Plain.

The bag records also increased during this interval, the relationship between the bag and the population density was significant ($r=0.98$, bag density=0.43*pop.density+1.17, ANOVA: $F_{1,4}=127.44$, $p<0.001$ for the whole country). However, the bag was significantly lower than the estimated population density (t-test: $t=3.65$, $df=10$, $p<0.01$). The bag increased mostly in Transdanubia, where the vaccination was made, although the population density increased also in the Great Plain.

The hunting methods were not used equally by the hunters. They preferred mainly the shooting. 83.87% of the responding game managers used this density independent method, whereas the methods specified for the young fox culling (excavating; 43.69%, spring out; 50%) or the box trap (6.3%) were fewer used methods. There are more than 100%, because one hunter used various methods for the culling.

The preferred aim of the hunting was the fur. The foxes of the fur season (49.6%) were hunted during four months, whereas the rest (50.4%) during eight months. Thus the hunting pressure was much higher during the fur season, when the control was less effective.

At last, the hunters could control the fox population only at small density level, the hunting pressure significantly decreased with the increasing population density. There were significant inverse relationships between the killing rate and the population density in both areas. The linear regression between the ratio and the inverse of the population density was significant positive both in the Great Plain and in Transdanubia: $y=(2.75*1/x)+0.75$; one-way ANOVA: $F_{1,638}=182.07$, $p<0.001$; $y=(2.9*1/x)+0.54$; one-way ANOVA: $F_{1,435}=94.12$, $p<0.001$. The practical hunting rate did not reach the theoretical requirement in the larger part of the hunting associations, especially in those territories, where the fox population was high. Thus, the culling would be a less effective regulator in the population dynamics of red fox.

Badger (Meles meles)

Badgers occur almost everywhere in Transdanubia and the middle altitude mountains. Locally high relative densities (max. 15 specimen/1,000 ha) were reported. The badger population density increased and it expanded especially on the Great Plain, where badgers occupy new habitats between 1990 and 1994 (**Figure 2 and 3.**). The density is one or two orders lower then in the hills.

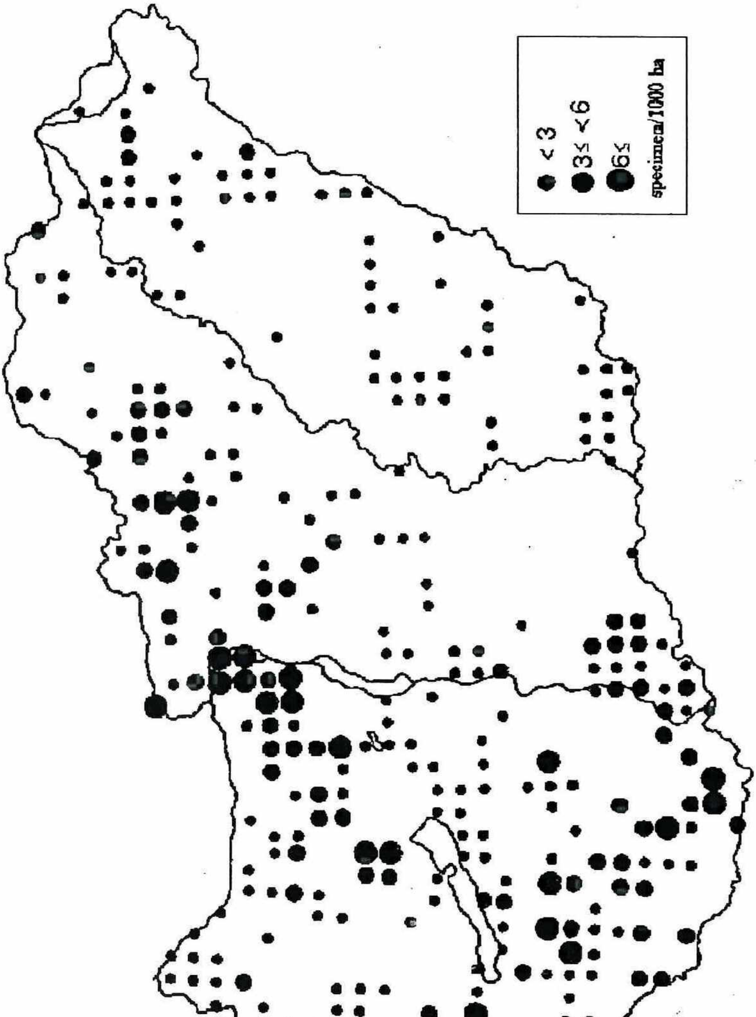

Figure 2: The relative density and occurence of badgers (*Meles meles*) in Hungary in 1990.

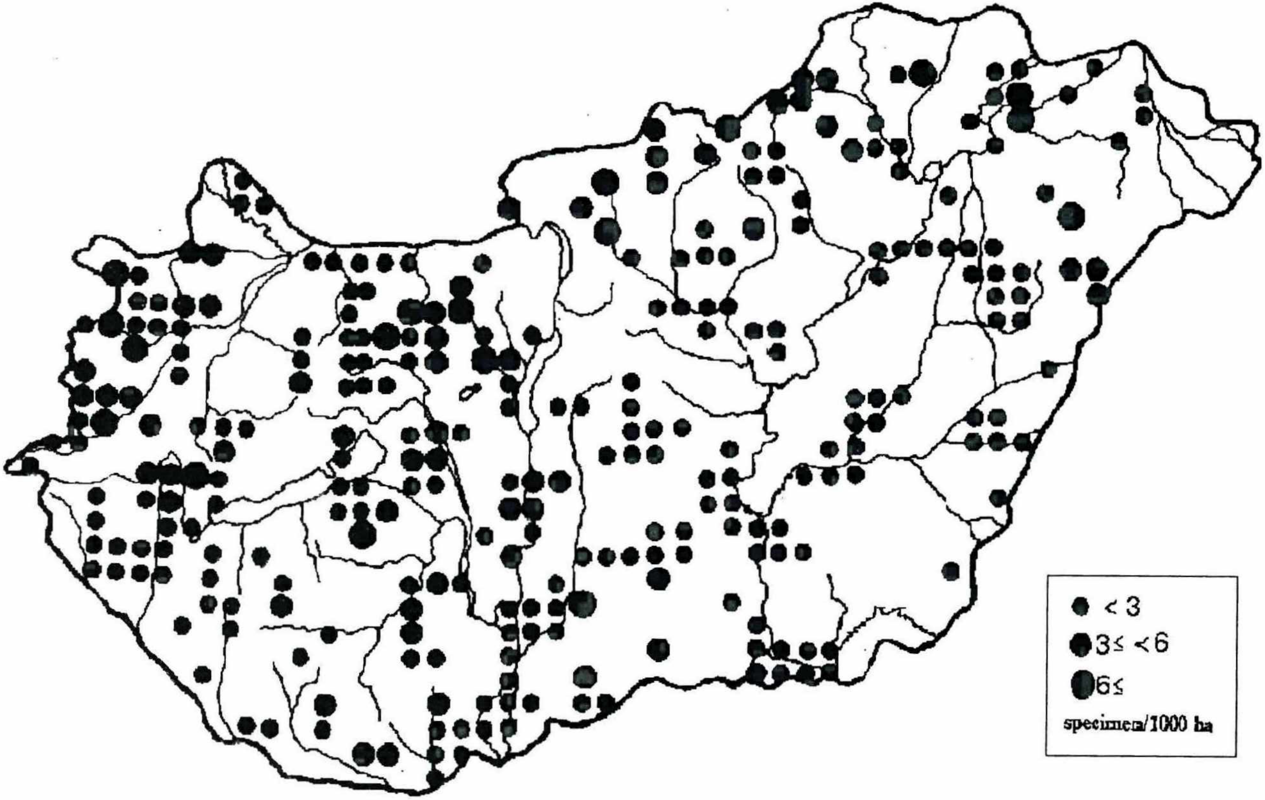

Figure 3: The relative density and occurent of badgers (*Meles meles*) in Hungary in 1994.

4. DISCUSSION

One of the main factor in the regulation of small game populations is the predation, so the adequate predator management is very important to maintain a vulnerable prey population (like partridge in Hungary). But the predator management had some problem in Hungary.

It could be seen that the population density of red fox increased in the whole country during the past years. On the other hand there was a significant difference between the rate of the population increase in Transdanubia and in the Great Plain. The estimated population density grew faster in Transdanubia. Even the burrow density was larger in Transdanubia, but the trendlines did not separate so intensively. However, it could be due to the change in the social structure of red fox population: formation of the familiar groups (LINDSTRÖM 1989, REYNOLDS AND TAPPER 1995).

The immunization had a real influence on the population dynamics of red fox. The effect of immunization was the decreased mortality, because the average brood size did not change. Even the brood size was larger in the Great Plain, where the growth rate was smaller. Similar result was found by MÜLLER *ET AL* (1995) in Germany, and BREITENMOSER *ET AL* (1995) in Switzerland, where the ratio of the young foxes in the population would be higher, because of the better survival of them due to the immunization. But this impact was not so strong as the game managers stated. The vaccination only quickened the growing process. The increase began more earlier, than the vaccination against rabies. There were other causes behind the growth of red fox population. Probable causes of growth could be the changes in the agriculture, like insufficient rodent control or increasing proportion of fallow lands and the insufficient preddator control.

The change in the regulation of hunting decreased the number of the available methods, the less effective hunting methods were used and timing of hunting was not suitable. The game managers did not interested in the fox hunting. They had not enough time for the predator control and they did not want to spend time on it. Because the effective control was not profitable, as the foxes should be hunted during the reproduction and the period of rearing of cubs for an effective control. But the fur is valuable only in winter, so it was the main fox-culling interval.

Beyond these the used hunting method, i. e. shooting seemed to be not efficient. KAUHALA and HELLE (1999) also showed, that the shooting was not density dependent method, when the population density increased, the hunting efficiency decreased. Despite of it the game managers preferred the shooting in Hungary. However, the killing rate showed similar trend also in our country as in Finland. The game managers could control the fox population only at small density levels.

There are many protected carnivore species, which could not be managed. The badger population, which can cause damages in the eggs and chicks of partridges or pheasants continuously increased and expanded in Hungary during the past years.

Thus there are many problems in our predator control, which have to be solved. What could be the solution?

The unadvised and uncontrolled hunting has to be transformed to the planned predator management. The bag size should be determined on the basis of estimated burrow density and actual brood size. Furthermore, the timing of hunting should be changed, foxes have to be hunted also during the period of birth and rearing of cubs. Powerful methods should be applied to manage the fox population (e.g. density-dependent live-trapping). New methods should be used to decrease the fertility of the females, like immunocontraception (ARTOIS, 1999). The protection of some carnivore species should be revised.

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THE LAJTA PROJECT - THE PILOT PROJECT OF THE HUNGARIAN PARTRIDGE CONSERVATION PROGRAM (HPCP)

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KEY-WORDS: Grey partridge, LAJTA Project, Hungarian Partridge Conservation Program, habitat improvement, predator control, Hungary.

ABSTRACT

FARAGÓ, S.: THE LAJTA PROJECT - THE PILOT PROJECT OF THE HUNGARIAN PARTRIDGE CONSERVATION PROGRAM (HPCP): The author reports on his long-term investigations refering to the grey partridge population (1989-1997) and its environment (1992-1997) covered by the LAJTA Project in the area of the Lajta-Hanság Joint Stock Company in Western Hungary (47°51' N and 17°12' E). The Project extending over approximately 3100 ha represents the pilot project of the Hungarian Partridge Conservation Program.

In the first part of the report, ecological conditions determining the existence and dynamics of the species are outlined.

Having reviewed the basic ecological background, author present essential methods of habitat development (chemical-free field margins, unmowed grassland and alfalfa margins, weedy strip between crops, partridge field strip, cereal field margins harvested later, harowed strips, fallows, chemical-free fields) and their parameters, reviewing various data referring to changes in ecotone density. Total legth of linear microhabitats characteristic for the LAJTA Project amounted to 105.9-108.6 m/ha in the period 1992-1994 and to 106.8-114.6 m/ha in the years 1995-1997.

Results of predator control representing the other essential element of game management testify the necessity of regulating the population numbers of fox, magpie and hooded crow. Feral dogs and cats should be prevented from entering the area dealt with.

In the initial phase of investigations (1989-1991) with traditional game management, density of the Partridge population did not reach 2 ind./km^2. After introduction of habitat management, population size and density increased, -at first abruptly (1992: 173 birds=5.61 ind./km^2), later on continously but in a decelerating rate until 1995 (311 birds=10.08 ind./km^2). Afterwards we observed drastic regression in population size: spring number of birds dropped to 44, i.e. 1.43 ind./km^2. In August, population size amounted merely to 158 individuals (5.12 ind./km^2). The letter value experienced permanent increase until 1992. In that year 842 birds were registered. (27,28 ind./km^2). The year 1993 proved to be less successful: in late summer 435 birds were counted. (14.10 ind./km^2). However, in August 1994 population size amounted to 1184 individuals, i.e. 38.38 ind./km^2.

Due to wet summer weather in 1995, merely 386 birds were counted, thus population density was as low as 12.51 ind./km^2. As a result of the latter severely unsuccessful year, break-down of population size ensued in 1996. (Spring numbers: 82=2.66 ind./km^2). In 1996 reproduction period was found to be of similarly low efficiency, verifield also by low population size amounting only to 124 individuals and by August population density of 4.02 ind./km^2. Consequently, breeding populatios suffered further decrements. However, reproduction period being more successful in 1997, size of breeding population increased to 201 individuals and density to 6.52 ind./km^2.

Fertility of partridge population (CSR) was found to be highly variable, ranging from 27% to 77%, proportionately to egg and chick losses. Adult birds suffered increased losses, however, from winter losses no tendency could be deducted.

Key factor analysis indicated that mortality factors leading to most severe deficits were losses of eggs and chicks (k_1) as k_1 provided the greatest slope from a regression against K (b=0.617). It is unquestionable that

as compared to egg and chick losses (k_1) summer losses of adult individuals (k_2) regression coefficient: (b=0.301) and winter losses (k_3) (b=0.083) were of lesser significantly.

Between average mean temperature of the reproduction period and the number of reared chicks definite positive reletedness existed (b=1.68) with medium correlation (r=0.57) i.e. if average mean temperature increased, also numbers of successfully reared chicks experienced increments. The same correspondence can be stated in respect of mean temperature in June and numbers of reared chicks, although the latter relationship was found to be somewhat weaker (b=1,35, r=0,47).

Spring and summer mortality of adult birds (k_2) was lowest in 1991 (0.042), from that time on suffering gradual increments until 1996 (0.032), thus the degree of exacerbation proved to be 7,5 fold (!). Change of such extent can be attributed exclusively to growth of fox population.

Age structure of population present in August manifests close connection with CSR values and with the size of breeding population. Proportion of young birds ranged from 60% to 88%.

Causes for regression in the partridge population that had formerly manifested great results, are summarized by the author as fallows:

- Due to privatisation, in approximately one half of the area covered by the Project, system of farming on small holdings was developed. Consequently, fallows practically ceased to ceased to exist, disturbances reached a high degree but technological intensity of cultivation (mechanization) did not experience considerable decrements.
- Habitat development of emphasized intensity was continued, however, exclusively in the area covered by the competence of the Lajta-Hanság Joint Stock Company, i.e. limited to one half of the area included in the Project.
- Up to now, it has been impossible to carry on negotiations with the new landowners in respect of habitat management, -partly because of their great resoluteness manifested in regard of farming, partly due to small sizes of holdings and also to lack of up-to-date attitude.
- Resulting from immunization against rabies, fox population has experiences powerful increments in spite of intensive thinning.
- Winter period 1995-1996 was long and cold, with crusty deep snow cover; during the reproduction period of the year 1996 weather conditions proved to be extremely disadvantageous, and also the winter season 1996-1997 was cold and long-lasting.

The author of the present report approves further practical enforcement of the principle of "wise use" in the Project. This being the only way for the rehabilitation of partridge population. Long-term monitoring can reveal basic relationship and also demonstrate effects and results of activities carried out in the scope of game management.

1. INTRODUCTION

Grey partridge populations of Hungary have suffered severe reduction in course of the latest 25 years. At the time of perceiving the onset of this process, as only way of solution stock conpensation by means of hand-rearing was pointed out. This solution having proved unsuccessful, in 1978 shooting ban was introduced for partridge. The latter measure is still valid and has led to rapid lessening of interest manifested by hunters for this species.

Problems having become more and more numerous, Hungarian Partridge was included in the Red Book in its own home country (RAKONCZAY, 1989). Neither competent authorities, nor investigators made sufficient efforts to reveal the above problems and find ways for their solution. Consequently, in the early 1990s in Hungary, no recent study was available in which the causes of stock reduction were analysed and alternative solutions offered. Intolerability of the above situation and necessity of searching for solutions was formulated in a study (FARAGÓ, 1986), delineating the possible ways for improvement and also the *"gene centres"* in which the necessary investigations could be started. However, the latter publication did not succeed in attaining significant changes in attitude. Such fundamental changes were made possible only by changes in the political system of Hungary in 1990, allowing new conceptions to be evolved freely. In this way the HUNGARIAN PARTRIDGE CONSERVATION PROGRAM (HPCP) was established, assisted by the DEPARTMENT OF GAME MANAGEMENT AND FISHERY OF THE MINISTRY OF AGRICULTURE and fitted into the conceptions of the latter. Projects of the HPCP are in "*gene centres*" defined earlier. The LAJTA Project serves as the pilot project of the Program. The Project comprises a long-term monitoring on habitats located in agricultural areas and on small game populations living in these sites. An important aim of the Project is to investigate grey partridge considered as indicator species.

2. THE AREA OF THE PROJECT

The area covered by the Project at the time of its establishment is identical with the Mosonszolnok district of the LAJTA-HANSÁG JOINT STOCK COMPANY extending over 3100 ha. The landscape was characterized by intensive large-scale cultivation and predominance of arableland. After 1994 nearly one half of the area was privatized.

Arborescent vegetation in present primarily in the form of forest belts with widths of 15-25 m, length of each belt amounting approximately to 1 km., and their total area covering roughly 110 ha. The stucture of the Project area experienced nearly no alterations during the initial period of our investigations. After privatisation of holdings smaller fields became establishment.

Referring to climatic conditions of the study area conclusions can be drawn on the basis of data supplied by the Meteorological Station of the town Mosonmagyaróvár:

Mean annual temperature	9.6C°
Annual amount of precipitation	504 mm
Relative atmospheric humidity	73%
Days with rough weater (min≤-10C°)	13 days
Days with winterly weather (max.=0C°)	29 days
Frosty days (min=0C°)	95 days
Days with summerly weather (max≥25C°)	62 days
Heat days (max≥30C°)	12 days

In respect of hydrology, the area of the Project is fairly poor, possessing no watercourses.

As in the Project, conditions of plant cultivation for the purposes of fodder production predominated, those years were considered as advantageous in course of which the ratio of perennial plants, of those sown in autumn and of fallows reached or exceeded 60% (1994 and 1997) as well as those in which autumn harvesting of root crops was performed gradually (1993, 1994, 1995), furthermore years with protracted reclamation of stubbles (1993, 1994) and those in course of which winter cereals were sown at an early date (1993, 1994, 1995). In the area covered by the LAJTA Project structure of sowing was found to have been more advantageous for partridge in the first 3 years than in the last 3-year period.

Positive effects are to be observed primarily owing to the fact in course of privatisation, large fields were divided into smaller ones.

The Project area is rich in small game, their population numbers amounting to the following: pheasant: 450, brown hare: 600, roe deer: 190 individuals.

3. MATERIAL AND METHODS

3.1. Number of the populations

For examining the populations of bird and mammal species living in the Project area, we apply the mapping method based on continouos complex population assessment. The gamekeeper employed in the territory covered by the Project spends annually about 250 days in this area, carrying out assessments with the help of 6-8 students of our Faculty. These assessments are carried on for approximately 30 days. In this way it is possible to keep registers referring to each partridge family from the time of pair formation and home range occupation to the winter period. In course of on-site recording, results are fixed on data sheets and maps. In course of performing counts the method of POTTS (1986) was applied.

On the basis of population sizes determined in the breeding period and in August, causes of mortality responsible for population dynamics, and also the significance the aforementioned causes were determined by the key factor analysis (POTTS, 1986; CHLEWSKI AND PANEK, 1988)).

Simultaneously with permanent investigations on game birds populations, total aviafauna of the Project area is also being examined continously, with special regard to forest belt. These investigations have supplied data reffering also to densities of breeding populations of avian predators in the period 1989-1997, as well as the result of monthly counts performed in 1996 and 1997 reffering to birds of prey.

In the breeding period of partridge, marsh harrier (*Circus aeruginosus*) and buzzard (*Buteo buteo*), whereas in the winter season buzzard and hen harrier (*Circus cyaneus*) may threaten young birds reared by partridges. However, in the LAJTA Project the role of marsh harriers as predators is unsignificant.

Assessment of burrows of badgers and foxes (1996 and 1997) indicated that densities of badgers (*Meles meles*) are low (max. 0,13 family/km^2) whereas fox (*Vulpes vulpes*) population consists mainly of large numbers of immigrants that soon become killed. Owing to the effectivenes of the Immunization Program against rabies, mortality of *Vulpes vulpes* has been considerably reduced in Western Hungary, and bag sizes increased approximately to the double.

3.2. Methods of the habitat improvement

The structure of sown area described above being not definitely advantageous for partridges, it has to be altered if our efforts are aimed at increasing the game carrying capacity of the respective area and thereby the density of the partridge population breeding there. Beneficial changes are to be achieved by increasing the length of field margins and by enhancing the extensivity of farming carried out in such areas.

In course of habitat improvement we applied the following methods:

- Chemical-free field margins
- Chemical-free fields
- Weedy strips between two crops
- Fallows
- Unmowed margins of grassland and alfalfa fields
- Cereal field margins mowed at later dates
- Partridge fields

We were able to realize further advantageous alterations by introducing ban for mowing in forest belts possessing no zone of brushwood. Since the introduction of this measure, egg mortality has experienced decrements.

4. RESULTS

Due to our activities total leght of the ecotons characteristic for the LAJTA Project amounted to 105,9 - 108,6 m/ha in the period 1992-1994 and to 106,8 - 114,6 m/ha in the years 1995-1997.

Results of predator control representing the other essential element of game management testify the necessity of regulating the population numbers of fox, magpie and hooded crow. Meanwhile they demand that feral dogs and feral cats should be prevented from entering the area dealt with.

In course of the period covered by our investigations, a welcome tendency of regression was observed in the ratio of feral animals present in bags (1992: 70%→1995: 35%). Meanwhile some increments ensued in the ratio of fox (1992: 24%→1997: 46%) and hooded crow (1992: 6%→1997: 14%), demanding enhanced observation and regulation referring to the populations of these species. But the breeding population sizes of hooded crow (*Corvus corone cornix*) and magpies (*Pica pica*) have dropped to very low levels owing to intensive predator control performed by shooting and selective poisoning (*3-chloro-4-methylaniline hydrochloride*). As hooded crows continuously arrive from the floodlands of the Danube and from Austria, it is desirable to maintain the present level of control. Performing the latter task is one of most important duties of the gamekeeper employed in the Project, and it will bear the same importance in the future too.

In course of analysing partridge population the following were examined: population size and density, fertility and mortality, sex- and age conditions.

In the initial phase of investigations (1989-1991) with traditional game management, density did not reach 2 individual/km^2. After introduction of habitat management, population size and density increased, - at first abruptly (1992: 173 birds=5,61 birds/km^2), later on continuously but in a decelerating rate until 1995 (311 birds=10,08 birds/km^2). Afterwards we observed drastic regression in population size: spring number of birds dropped to 44, i.e. 1,43 birds/km^2.

In August, population size amounted merely to 158 individuals (5,12 birds/km^2). The latter value experienced permanent increase until 1992. In that year 842 birds were registered. (27,28 birds/km^2). The year 1993 proved to be less successful: in late summer 435 birds were counted. (14,10 birds/km^2). However, in August 1994 population size amounted to 1184 individuals, i.e. 38,38 birds/km^2 (**Figure 1.**).

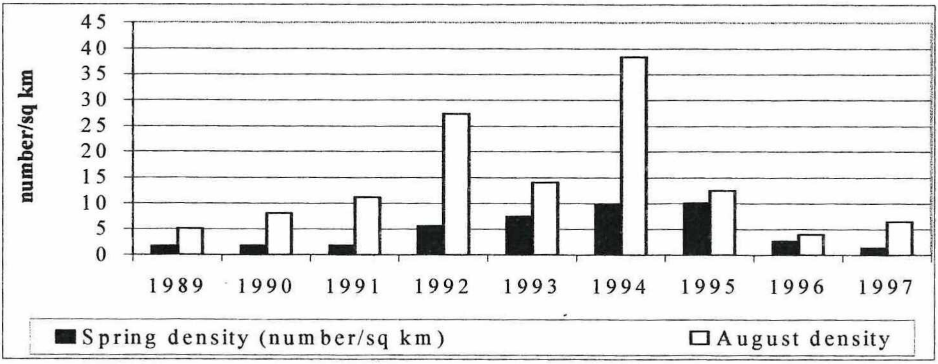

Figure 1: Density of partridge population in the LAJTA Project, 1989-1997

Due to wet summer weather in 1995, merely 386 birds were counted, thus population density was as low as 12.51 birds/km^2. As a result of the latter severely unsuccessful year, break-down of population size ensued in 1996. (Spring numbers: 82=2.66 birds/km^2). In 1996 reproduction period was found to be of similarly low efficiency, verified also by low population size amounting only to 124 individuals and by August population density of 4.02 birds/km^2. Consequently, breeding populations suffered further decrements. However, reproduction period being more successful in 1997, size of August population increased to 201 individuals and density to 60.52 birds/km^2.

Fertility of partridge population (CSR) was found to be highly variable, ranging from 27% to 77%, proportionately to egg and chick losses. Adult birds suffered increased losses, however, from winter losses hno tendency could be deducted.

Age structure of population present in August manifests close connection with CSR values and with the size of breeding population. Proportion of young birds ranged from 60% to 88% (**Table 1**.).

By key factor analysis could be defined, which type of mortality occuring in various phenological periods exerts influence on population dynamics and which of the types mentioned afore has to be regarded as determinant.

Key factor analysis indicated (**Table 2 and Figure 2.**) that mortality factors leading to most severe deficits were losses of eggs and chicks (k_1) as k_1 provided the greatest slope from a regression against K (b=0.617). It is unquestionable that as compared to egg and chick losses (k_1) summer losses of adult individuals (k_2) regression coefficient: (b=0.301) and winter losses (k_3) (b=0.083) were of lesser significancy.

Table 1: Parameters of the partridge population in the LAJTA Project, 1989-1997.

Parameters	1989	1990	1991	1992	1993	1994	1995	1996	1997
Birds observed in spring	52	58	54	173	231	306	311	82	44
Spring density (number/sq km)	1,69	1,88	1,75	5,61	7,49	9,92	10,08	2,66	1,43
Number of males	26	29	27	93	125	161	168	45	22
Number of females	26	29	27	80	106	145	143	37	22
Sex ratio (male:female)	1,00	1,00	1,00	1,16	1,18	1,11	1,17	1,22	1,00
Successful pairs	26	29	27	67	84	112	39	13	15
% successful adults	100	100	100	77	73	73	25	32	68
Successful adults	52	58	54	134	168	224	78	26	30
Total birds in August	158	248	344	842	435	1184	386	124	201
Adult birds in August	39	47	49	129	159	176	152	40	36
Young birds in August	119	201	295	713	276	1008	234	84	165
Young:adult ratio	3,05	4,28	6,02	5,53	1,74	5,73	1,54	2,10	4,58
Chick survival rate (CSR%)	22,9	42,1	77,4	76,4	15,76	56,6	29,7	30,7	75
August density	5,12	8,04	11,15	27,29	14,1	38,38	12,51	4,02	6,52
Winter losses		63,3%	78,2%	49,7%	72,5%	29,6%	73,7%	78,8%	64,5%

Between average mean temperature of the reproduction period and the number of reared chicks definite posotive relatedness existed (b=1,68) with medium correlation (r=0,57). I.e. if average mean temperature increased, also numbers of successfully reared chicks experienced increments. The same correspondence can be stated in respect of mean temperature in June and numbers of reared chicks, although the latter relationship was found to besomewhat weaker (b=1.35, r=0.47).

Spring and summer mortality of adult birds (k_2) was lowest in 1991 (0.042), from that time on suffering gradual increments until 1996 (0.032), thus the degree of exacerbation proved to be 7,5 fold (!). Change of such extent can be attributed exclusively to growth of fox population.

Table 2: Changes in k-values in the LAJTA Project , 1989-1997

Év	**K**	**k1**	**k2**	**k3**
1989	0,98	0,419	0,126	0,435
1990	1,026	0,272	0,092	0,662
1991	0,463	0,123	0,042	0,298
1992	0,85	0,16	0,128	0,562
1993	0,977	0,662	0,16	0,155
1994	0,967	0,145	0,241	0,581
1995	1,409	0,715	0,311	0,383
1996	1,342	0,581	0,312	0,449
1997	0,731	0,242	0,088	0,401

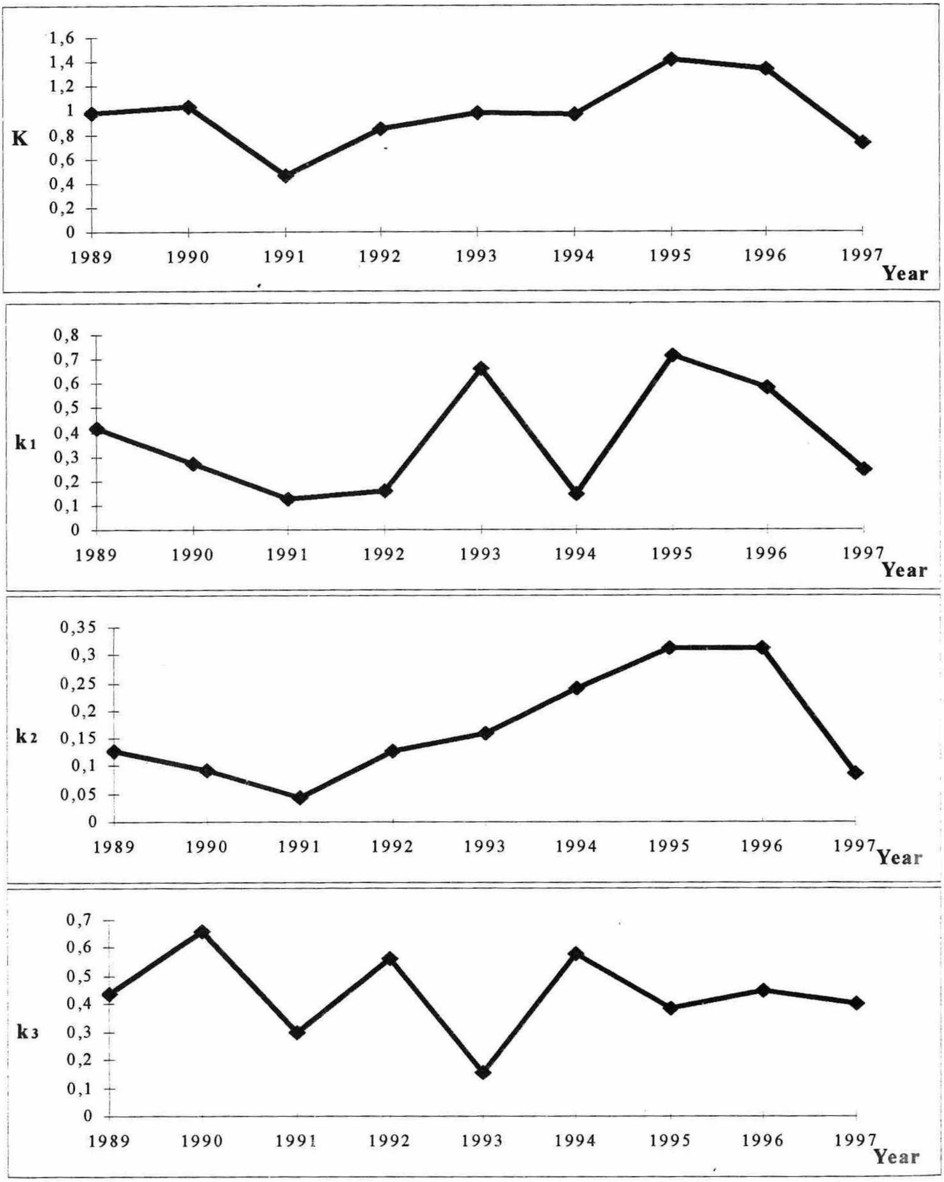

Figure 2: Graphical key factor analysis for partridge population in LAJTA Project, 1989-1997.

5. DISCUSSION

The conception that egg mortality i.e. clutch losses can play an extremely important role among the causes leading to low density of partridge populations was contained by our original hypothesis as well, on the basis of which we started habitat improvement. By investigations carried out since that time, the correctness of our hypothesis and the efficacy of management performed in the Project area have been confirmed. Investigations have also supported opinion stated earlier according to which conservation of *Perdix perdix* can be realized only in exactly defined areas, periods of time and under exactly defined conditions.

Causes for regression ensuing in course of the years 1995-1997 in the partridge population that had formerly manifested great results, are summarized as follows:

- Due to privatisation, in approximately one half of the area covered by the Project, system of farming on small holdings was developed. Consequently, fallows practically ceased to exist, disturbances reached a high degree but technological intensity of cultivation (mechanization) did not experience considerable decrements.
- Habitat improvement of emphasized intensity was continued, however, exclusively in the area covered by the competence of the LAJTA-HANSÁG JOINT STOCK COMPANY, i.e. limited to one half of the area included in the Project. Up to now, it has been impossible to carry on negotiations with the new landowners in respect of habitat management, -partly because of their great resoluteness manifested in regard of farming, partly due to small sizes of holdings and also to lack of up-to-date attitude.
- Resulting from immunization against rabies, fox population has experiences powerful increments in spite of intensive thinning.
- During the rproduction period of the year 1995 weather conditions proved to be extremely disadvantageous. Winter period 1995-1996 was long and cold, with crusty deep snow cower. In the reproduction period of 1996 weather conditions proved to be extremely disadvantageous repeatedly, and also the winter season 1996-1997 was cold and long-lasting.

It is advisable to perform further enforcement of the principle of "wise use" in the Project, this being the only way for the rehabilitation of partridge population. Long-term monitoring can reveal basic relationship and also demonstrate effects and results of activities carried out in the scope of game management.

We can adopt methods that have proved to be successful elsewhere, but their introduction will be effective only if factors influencing population dynamics locally are revealed, and introduced methods are aimed at eliminating or decreasing negative factors.

In the practice of Hungarian small game management there used to be some endeavours that tried to simplify problems in extreme manner and solve them confined only on certain - sometimes second-rate - factors, or considered handrearing and releasing as the only possible solution.

Consquences of these errors are testified by statistical data and also by undetected wasting of millions of forints. Purely economic interests also require enhanced predomination of ecological attitude as the availability of financial sources is limited in hunting ranges as well.

Only fulfillment of the above-mentioned requirements will allow us to shoot partridges in Hungary again, after so many years, - however, in the spirit of wise use.

THE HUNGARIAN PARTRIDGE CONSERVATION PROGRAM whose pilot project is the LAJTA Project is primarily aimed at the objectives presented in my report.

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GAME MANAGEMENT IN HUNGARY

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1. INTRODUCTION

To evaluate and to understand the present situation one must look back for the past two years events. In 1996 three Acts have been accepted by the Hungarian Parliament, the ACT ON NATURE CONSERVATION NO. LIII., the ACT ON FORESTS AND FORESTS CONSERVATION NO. LIV, and the ACT ON GAME CONSERVATION, GAME MANAGEMENT AND HUNTING NO. LV. Please not that the act numbers come one after the other indicating that the three relating legal measures were discussed and passed in Parliament at the same time. These Acts not only interact but harmonise in many respect.

The new Act on Game Conservation, Game Management and Hunting - shortly referred to as Hunting Act - accepted in July 1996 came into force on the 1st of March 1997. It has basicly changed hunting right from state ownership to landownership with the game remaining state owned. The minimum size of a hunting area can be no less than 3.000 hectars, that is 30 km^2. Landowners within the hunting area have to associate compulsorily.

The boundaries of the hunting area are fixed by the administrative authority of first instance. This type of hunting authority is operated in Hungarian state administration at a county level in the form of COUNTY HUNTING AND FISHING INSPECTORATE. The inspectorate is a department of the COUNTY AGRICULTURAL OFFICE.

It is important to note that the average size of a hunting area is 8.000 hectars, that is 80 km^2. We think that it is one of the greatest achievement of the new act, that the hunting areas were not fragmented into the oder of 100 hectars. This way sustainable game management remained possible. Area size is offcourse very important for larger game such as red deer and wild boar, enabling a certain level of management on a subpopulational level. Harvest of game and stock management is a key to correct game management.

The special purpose areas can be three types a) genetic reserve, b) nature conservation, c) research and education areas. These special purpose are given by the ministers of agriculture and of environmental conservation together. These areas were nominated for the following:

The **genetic reserve areas** have very valuable stock of huntable animal species, they form a kind of genetic pool of natural populations of game. They area mostly state owned.

The **nature conservation areas** are protected areas for their natural assets, they mostly belong to national parks and are also mostly state owned.

The **research and education areas** are linked with some institute of higher education or research. They provide ground for practical education and field project.

The landowner community brought together in a hunting area can decide how they want use their hunting right. They can associate and exercise their hunting rights themselves. This is marked by yellow. Or they can decide to lease their area to a hunting club or any other legal entity. This is marked on the figure by green.

2. CONCEPT OF GAME MANAGEMENT

The hunting act puts game conservation first in our priorities. Thus our concept is based on natural populations of game species that can be sustained and harvested in the long run only, if necessary habitat is available.

Regulations regarding hunting only come after habitat conservation and game management. The hungarian hunting low is one of the strictest regulations compared to that of the EU and the rest of Europe. Hunting is part of game management that performs stock regulating, recreational and economic functions. The internationally accepted wiseuse principle that renewable natural resources such as game can be used sustainably is more and more recognised in Hungary. The portfolio of agriculture and our shooters and hunters must realise what nature conservation and game management has in common. The natural interest is to sustain strong natural populations of animals - including game - in a diverse habitat. The modern ecological game and wildlife management in this respect is part of nature conservation, conservation and hunting pressure, each other. One must not forget that nature conservation evolved from hunting.

3. HUNGARIAN GAME STOCK

Let us look briefly at the major huntable species, how their populations performed in the past years until today. There are five members of European big game species resident and permanently hunted in Hungary.

BIG GAME MANAGEMENT

3.1. Red deer (*Cervus elaphus*)

The most important big game of the region is the red deer (**Figure 1.**). According to intensiv agriculture developing in the 1960›s red deer population expanded equally. Large field sizes mainly wheat and mays favoured all large bodied herbivores. It can be seen that there was a strong harvest in the 90›s to cut back forest damage. Still there is strong debate between foresters and hunters about the maintainable size of red deer population. The hunting authority says the annual bag of 20 thousand should be sustained. The last years estimate given by the hunting areas is definitely biased, because the new areas gave higher numbers of deer in order to get higher culling quotas.

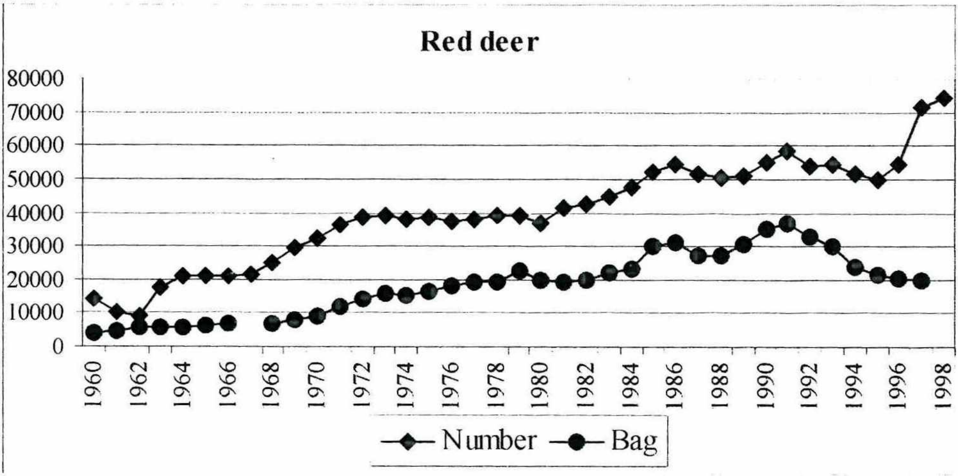

Figure 1: Trend of stock and bag dynamics of Red deer in Hungary

3.2. Roe deer (*Capreolus capreolus*)

Figure 2. shows roe deer dynamics and bag. Notice the marked underharvest of the population. This is possibly due that roe deer is exposed most to predators, accidents and poaching. Some people say that roe deer has one big evolutionary defect, that is fits into a backsack.

The quality of hungarian roebuck is hallmarked by the fact that 3 out of the first 5 in the trophy world ranking is Hungarian.

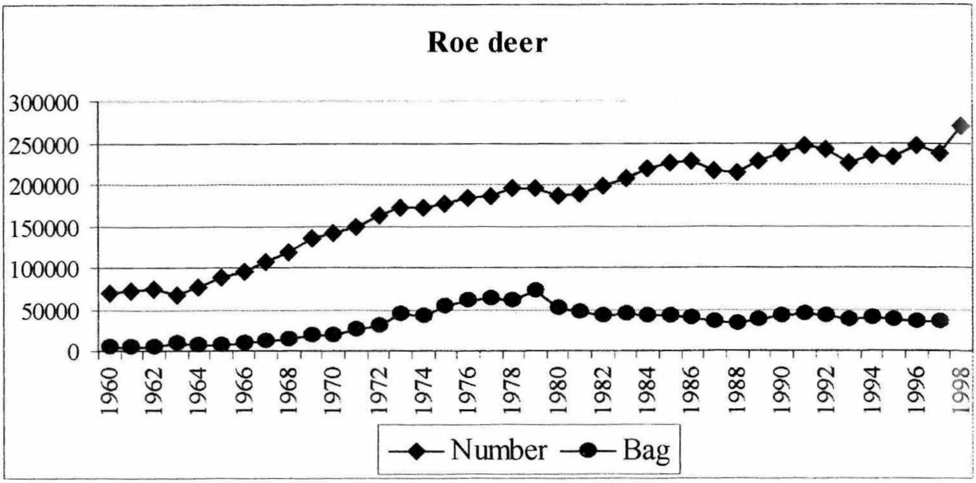

Figure 2: Trend of stock and bag dynamics of Roe deer in Hungary

3.3. Fallow deer (*Cervus dama*)

Figure 3. shows fallow deer that lives in the open hunting areas of Hungary since the past few decades. Before the II. World War the fallow deer was not widely distributed in our country. It has found such a favourable habitat in some forested landscapes, that has been manifested in trophy quality and size very much. In the trophy world ranking list out of the first 20 12 have been shot in Hungary !

3.4. Wild boar (*Sus scrofa*)

The wild boar dynamics and annual bag shows the **Figure 4**. The wild boar is a very versatile animal, it can double its numbers in an average year. It is a favorite game species, that causes a lot of animal health, management and crop domage problem.

3.5. Mouflon (*Ovis musimon*)

Mouflon has been introduced to historical Hungary more than 100 years ago. It can be found in hilly areas of Transdanubia and North-Hungary. The stock is rather small (**Figure 5**.), but still there are problems with this wild sheep demaging medium range mountain flora elements.

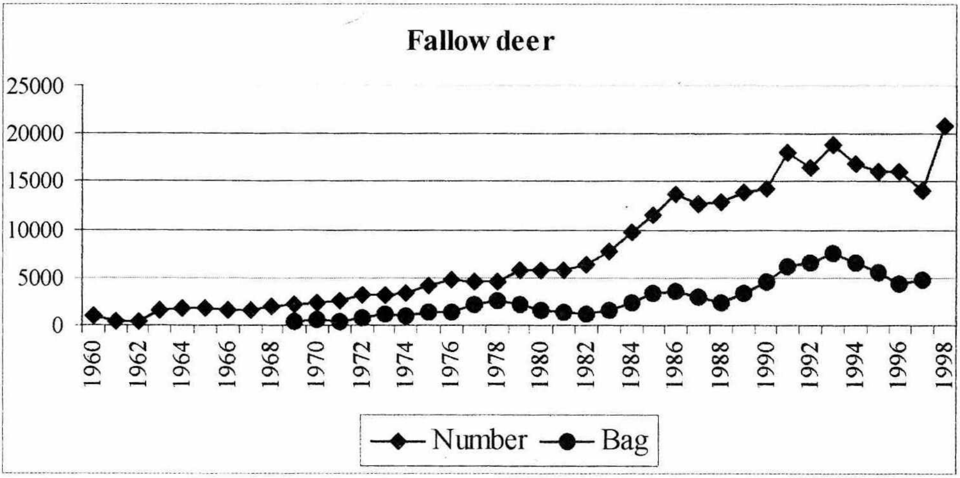

Figure 3: Trend of stock and bag dynamics of Fallow deer in Hungary

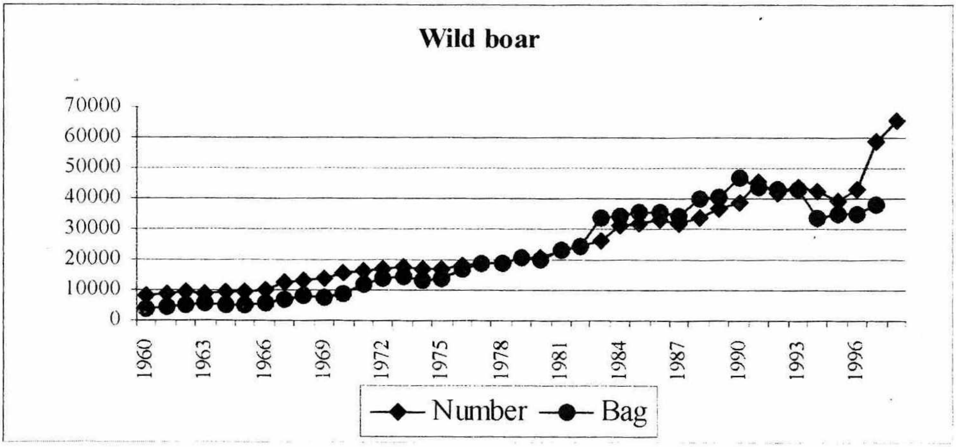

Figure 4: Trend of stock and bag dynamics of Wild boar in Hungary

Strongly opposed and unwanted by nature conservation as not indigenous species. Research work has been carried out by INSTITUTE OF WILDLIFE MANAGEMENT of the SOPRON UNIVERSITY to determine in which regions can the population be sustained and from which regions the numbers should be cut back.

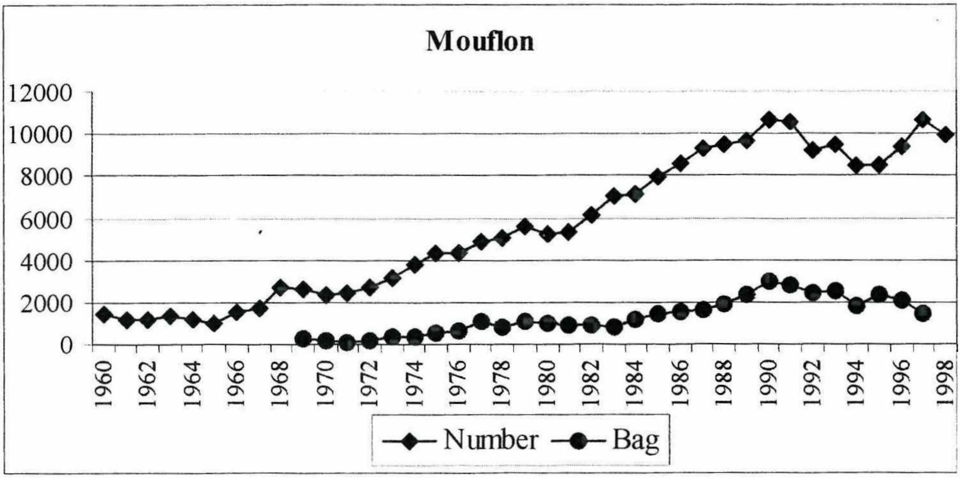

Figure 5: Trend of stock and bag dynamics of Mouflon in Hungary

SMALL GAME MANAGEMENT

Reminding to what has been seen happening to big game populations, the opposite changes occured to small game stocks. Intensive agriculture favoured big game, unfortunately it did not do any good to pheasants, partridges and hares. Management of winged game has much been effected by rearing. Artificial breeding techniques of galliforms have been worked out to a very sophisticated degree and mass production of pheasants and mallards were at their peak in the 1970's. So the picture is very much distorted in connection with natural populations. Breeding techniques did not work out for brown hare so this small game remained the last unspoilt one for shooters.

The MINISTRY OF AGRICULTURE AND REGIONAL DEVELOPMENT has been financing long term research projects for monitoring waterfowl and grey partridge. The HUNGARIAN GAME MANAGEMENT FUND finances among, other tasks - the HUNGARIAN WATERFOWL RESEARCH GROUP and HUNGARIAN PARTRIDGE RESEARCH GROUP. The research groups and the projects have been planned and set up according to THE GAME CONSERVANCY example.

In 1996 another long term research project was launched to monitor small mammal predators. These predators are very difficult to see and to detect their presence. Some indirect results indicate that we know very little about the conservation status of those species such as the weasel, martens and some others.

3.6. Brown hare (*Lepus europeus*)

The brown hare population and annual bag remained more or less stable in the 1990's (**Figure 6.**). Due to privatisation of arable land agriculture became less intensive and habitat better for brown hare. Expectations were that hare population and bag should have been increasing. As you can see this was not the case, it seems that these changes were only suitable to stabilize the population, although in some spots there were reports on outstanding stocks.

It must be stated that changes in agricultural habitat in general were favourable for small game in the 1990's.

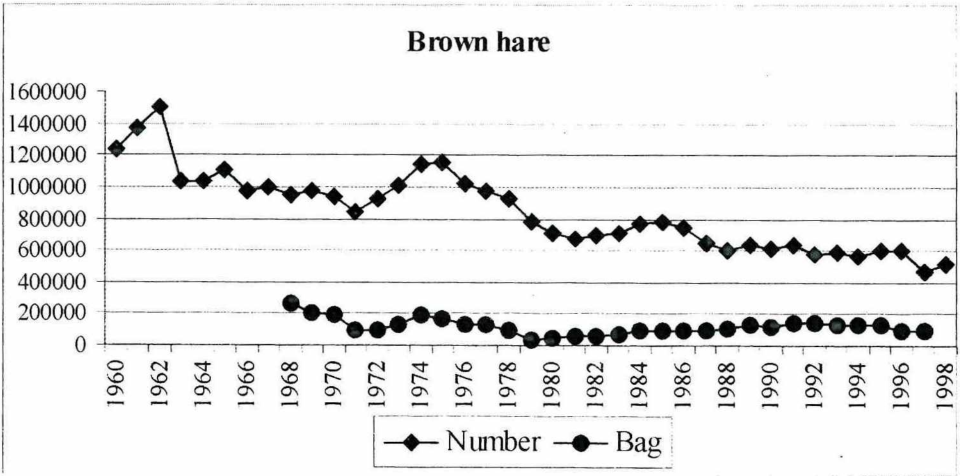

Figure 6: Trend of stock and bag dynamics of Brown hare in Hungary

3.7. Pheasant (*Phasianus colchicus*)

The pheasant population - as mentioned earlier - has been much effected by rearing. It seems that natural population collapsed in the late 1970's early 1980's when rearing was at its peak. The 2 million reared birds totally covered the natural stock, and breeding hens were shot unnoticed (**Figure 7.**). Agricultural intensitivity developed from the 1960's and reached full swing between 1975 and 1985. Due to economic circumstances both rearing and agricultural intensitivity dropped back in the late 1980's early 1990's. Today there is a better natural stock with relatively low level of rearing with an annual bag of about 500 thousand. It must be noted that female pheasant can only be shot in areas where rearing has excluded 2000 birds, and only 20% of the bag can be hens in a radius of 1 km around the rearing site. In addition permit to shoot hens must be received from the hunting authority.

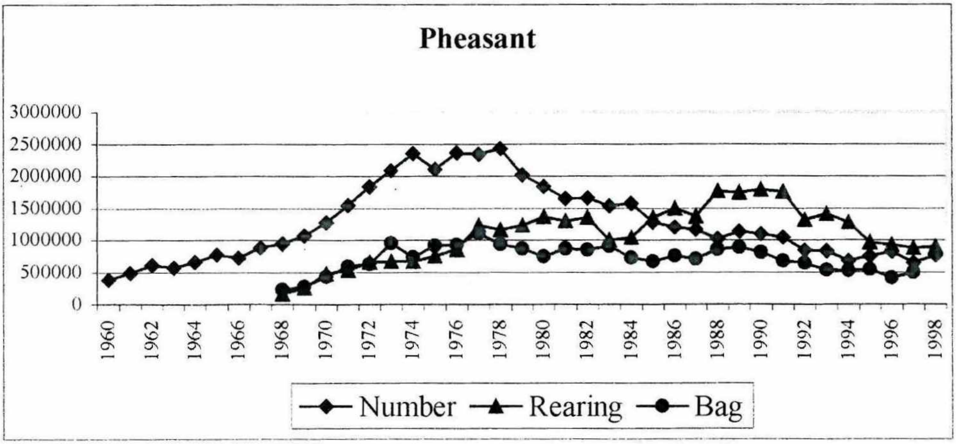

Figure 7: Trend of stock, bag and rearing dynamics of Pheasant in Hungary

3.8. Grey partridge (*Perdix perdix*)

The grey partridge can be regarded as an indicator species towards agricultural intensitivity. Remembering what I have said about agriculture reaching its highest between 1975-1985, it can be seen that partridge population dropped down to about 50 thousand by 1980 (**Figure 8.**).

In the 1990's advantages of privatisation can be seen, with agricultural intensitivity cathing up by the mid 1990's. In addition the winter of 1995/96 and 1996/97 were heavy with a lot of snow covering. The last four years including 1998 are regarded as wet years, will annual rainfalls over the average.

To sum up the future of Hungarian partridge with heavy predatory pressure is not very promising.

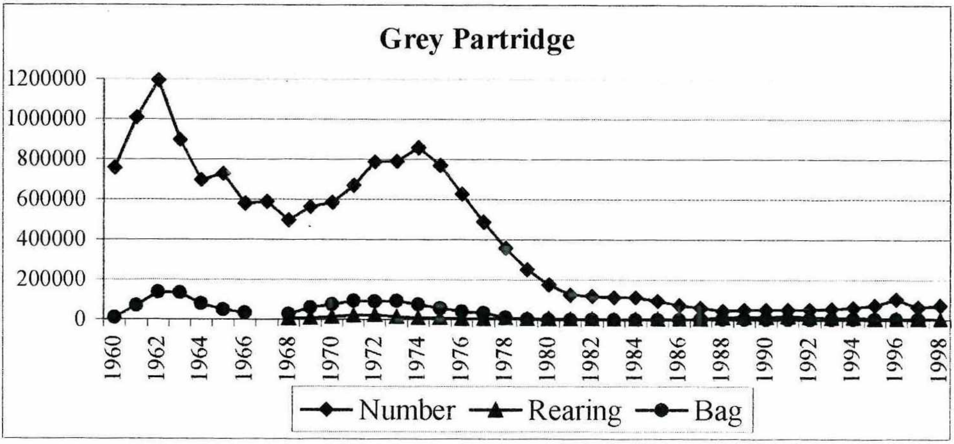

Figure 8: Trend of stock, bag and rearing dynamics of Grey Partridge in Hungary

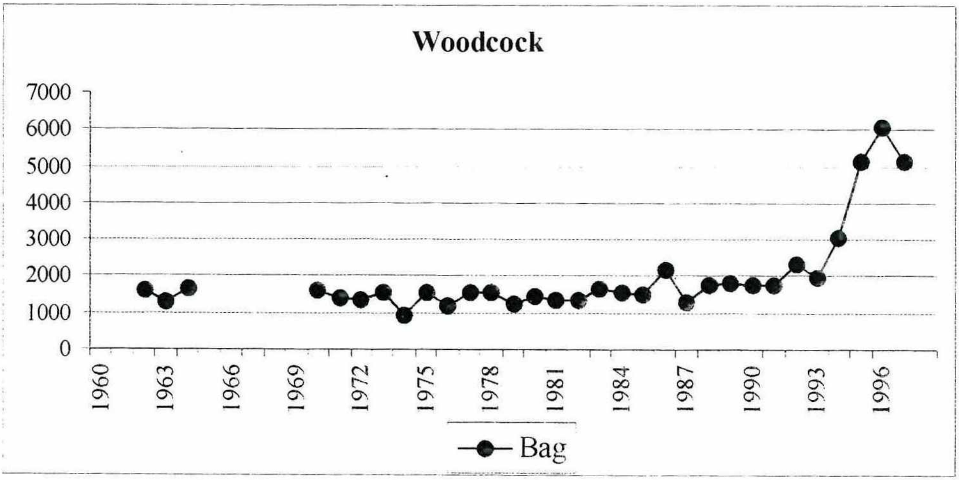

Figure 9: Trend of bag dynamics of Woodcock in Hungary

3.9. Woodcock (*Scolopax rusticola*)

Finally we have left a success story. Woodcock is shot in Hungary traditionally on spring roding only. Interestingly the woodcock bag has tripled in recent years (**Figure 9.**). A phenomenon that is difficult to explain. The world population of woodcock is reportedly stable. Others say that there is more hunting pressure on woodcock in Hungary, because shooting possibilities are shrinking. Still others say that they bag double the number of birds than before with the same effort. One possible explanation could be that strict regulations coming into force in the Mediterranian region on the flyway. Seemingly there is no clear explanation to the pleasant problem.

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