

## Nest construction and roosting behaviour of a Crested Lark *Galerida cristata* population nesting on flat roofs in Hungary

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From the two basic types of flat roofs, one covered with shingle and the other with tar-boards, only the shingled roofs were selected for nesting by Crested Larks *Galerida cristata*. Breeding birds preferred the provided artificial breeding nestboxes to the natural, open nest sites. The nest sites were characteristically placed in locations that provided shelter and protection from the South or South-Western direction. As breeding coincides with the warmest months of the year this preference guarantees the highest breeding success, as these sites are the coolest. A roosting period precedes the incubation period, and overlaps with the primary phase of nest construction. Crested larks mostly spent the nights on those roofs where they later built their nests. Sites selected for spending the night were more scattered than nesting sites, and provided protection mostly from the northern direction. As this period is the coolest part of the year, survival of the bird depends to a large extent on the ability of maintaining body temperature and conserving energy most efficiently. This goal might be best achieved through the avoidance of exposure to wind and keeping the feathers dry. Therefore birds prefer the most wind-protected locations on the roofs, which, at the same time, are also the driest.

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### 1. Introduction

Nest site selection of small ground-nesting songbirds (*Passeriformes*) is basically influenced by the microhabitat. The vegetation and micro-configuration of the terrain might offer protection against the wind, rain and overheating caused by direct radiation from the sun (With & Webb 1993, Herranz *et al.* 1994). Placement of nests is of outstanding importance at those areas where the weather is either very windy and cool, or is characterised by sparse vegetation and excessive overheating during the day. In

*Alaudidae*, *Turdidae* (*Cercomela*, *Oenanthe*) and *Fringillidae* (*Bucanethes*) species breeding in these habitats construct their nests at locations protected by stones or grass tussocks, or in underground holes or rock cavities (Bannerman 1953, Cave & Macdonald 1955, Mackworth-Praed & Grant 1960, 1962, 1970, 1973, Etchécopar & Hüe 1967, Maclean 1970, Orr 1970, Blotzheim & Bauer 1985, 1988, 1997, Paz 1987, Afik *et al.* 1991, Herranz *et al.* 1994).

In colder or montane climates the micro-configuration of the terrain and vegetation provide protection mainly against the wind (DuBois 1935, Verbeek 1967,

Cannings & Threlfall 1981), and the position of the nests, namely the direction to which the entrance faces, is determined by the direction of prevailing wind during the incubation period. On open, sun-lit areas the most problematic environmental factor is excessive overheating caused by direct sunlight, and hence nests are placed in a shadowed area. In this case the exposure of the nests depends on the geographical location. In the Northern hemisphere in warm, barren areas the entrance of the nests faces North, North-West or North-East (Ferguson-Lees 1962, Orr 1970, Blotzheim & Bauer 1985, Paz 1987, Afik *et al.* 1991, With & Webb 1993, Herranz *et al.* 1994), while South of the Equator, for example in the Kalahari Desert, the nest entrances face South, South-East or East (Maclean 1970). In the literature the direction of the nest entrances is often not mentioned, only the shadowing effect of the vegetation and micro topography is discussed (Bannerman 1953, Mackworth-Praed & Grant 1960, 1962, 1970, 1973, Alden *et al.* 1995).

Both the shape and the material from which the nest is constructed might influence its ability to provide protection from the environment. The *Mirafra* (*Alaudidae*) species are characterised by nests above which a roof is constructed from grass in order to provide shadow (Maclean 1970). Desert Larks *Ammomanes deserti* (*Alaudidae*) build a protecting wall from stones around their nests (Etchécopar & Hüe 1967, Mackworth-Praed & Grant 1970, Harrison 1980, Paz 1987), which is thought to have a thermo-regulatory effect, and might aid self-incubation (Orr 1970, Afik *et al.* 1991).

Birds can adapt to their environment characterised by different climate by adjusting their metabolism, and hence

within a species cold and warm-tolerant populations might evolve (Trost 1972, Walsberg 1993). But physiological adaptation can only reduce the deleterious effects of the environment to a certain degree; thus birds have to also adjust their behaviour to avoid further damage. Their daily activity may change (Hickey 1993), just like the nest-constructing habits, day-time resting (Ferns 1992) and night-roosting behaviour (Trost 1972, Walsberg 1985, 1986, 1993).

Crested Larks inhabit the Northern Hemisphere (Cramp 1988, Simms 1992), and in Central Europe it is the only lark species that does not migrate, either overwintering individually, or in small flocks in the breeding areas. In Europe this species usually nests in areas with dense plant cover, hence the nests, placed into small depressions in the ground surface, receive continuous shading (Pätzold 1986). Under the dry, semi-desert conditions of the Near-East and North-Africa the nests are usually placed under grass tussocks or in the shadow of a larger stone (Paz 1987). The entrance of the nests faces to the North North-East (Simms 1992).

Crested Larks spend the night on the ground, in natural or self-made depressions, either alone or in pairs but often in flocks outside the breeding season (Cramp 1988). In summer the locations selected for night roosting are usually open areas, while in late fall and winter roosting sites are selected in vegetation covered, snow-free areas (Cramp 1988).

Apart from the original natural habitats of this species (grassy or barren sites) birds often nest either inside, or in the close vicinity of human settlements (Mackworth-Praed & Grant 1960, 1970, Kovács 1984, Hollom *et al.* 1988). This

fact is proved by the observation that this is the only lark species of the region that uses paper and other man-made waste-materials for the lining and insulation of the nest (Etchécopar & Hűe 1967, Harrison 1980, Blotzheim & Bauer 1985, Pätzold 1986, Paz 1987). The phenomenon of using flat-roofs for nesting by this species was reported from several European countries (Nagy 1926, Lindner 1928, Blotzheim & Bauer 1985, Orbán 1999, 2000, Bankovics 1986, Peterson *et al.* 1986, Pellingner & Frank 1987, Simms 1992), but these mainly concern grass-covered flat roofs (Blotzheim & Bauer 1985). Cramp (1988) also quotes other authors who detected night roosts on flat roofs.

The flat roofs of concrete blocks of flats are usually elevated 15-20 meters above the surrounding habitat, and they represent isolated, comparatively small habitat islands characterised by special environmental circumstances. The physical parameters of these habitat islands are very different from those found at ground level. As this species does not migrate, the various behavioural elements can be readily observed and studied throughout the year in the almost laboratory-like, easily manipulated environment of the flat roofs.

My main aim was to explore and describe the microhabitat characteristics of flat roofs, and analyse their effects on the incubating and roosting behaviour of Crested Larks.

## 2. Methods

### 2.1. Study area

This study was carried out from 1984 until 1998 in the centre of Dombóvár, a

Hungarian city in Tolna county, where in an area of approximately one square kilometre around fifty blocks of flats are located, all of them built with flat roofs. Among these houses the ground is grass-covered and sparsely planted with trees and shrubs.

In Dombóvár the average yearly sun-lit hours amounts to approximately 2000 hours, which is near the maximum in Hungary, while the rainfall is only 600-700 mm, which is near the country's average (Udvarhelyi 1968). The prevailing wind direction is North-Westerly (Udvarhelyi 1968).

### 2.2. Flat roofs

During the fifteen years of this study 19 different roofs were checked. The average number of roofs checked in a given year was  $10.6 \pm 3.5$  (SD) (range: 1-17,  $n=15$  years). Two types of flat roofs exist in the study area: one is felted, while the other is covered with yellow shingle, under which there is a layer of black bitumen. These flat roofs are not totally empty constructions, television antennas, air funnels and construction debris can often be found on them. The surface of the roofs is levelled in such a way that water runs down from the edges toward the centre of the roofs, where drain pipes lead the rainfall down to the gutters. All the flat roofs are emarginated with a cornice or ledge of approximately 20-80 centimetres height. These ledges are covered either by tar boards or corrugated iron. On flat roofs covered with tar boards the wind accumulates sand in the corners formed by the ledges, and after 10-20 years the accumulation might be several centimetres thick ( $\bar{x}=11.3$  cm length by 9.0 cm width by 2.6 cm depth,

n=8). On roofs covered by shingle accumulated sand was not detected. Among the studied roofs 11 were shingle covered and 8 were felted. The area of the roofs was quite variable, the average being  $681.6 \pm 287.1 \text{ m}^2$  (SD) (range: 250-1000  $\text{m}^2$ , n=19). The smaller roofs are constructed as a single, continuous unit, while the larger ones are constructed as a facet of sub-units, and these are emarginated with individual ledges. The average number of roof sub-units is  $1.7 \pm 1.2$  (SD) (range: 1-4, n=19).

### 2.3. Nestboxes

During the study soil-filled nestboxes were placed on shingle covered flat roofs for crested larks (Orbán 2000). On six roofs a single nestbox was placed, while on a roof constructed of three sub-units a single nestbox was placed into every unit. The nestboxes were placed either in the corners or in the middle of the roofs. Between 1984-1994 the average number of nestboxes per year was  $6.1 \pm 2.5$  (SD) (range: 1-9, n=11). As a consequence of the reconstruction of the roofs all the nestboxes were destroyed, and hence in the last four years of the study (1995-1998) there were no nestboxes operated on the roofs.

### 2.4. Flat roof checkings

The roofs were checked all year around, both during the day and night, and I tried to check all the studied roofs on every occasion. During the breeding season (March-August) and outside the breeding season (September-March) at least one check was performed a month. If I detect-

ed any sign suggesting the presence of crested larks on a roof I tried to check it more often, weekly or often daily or in some cases several times a day. If it was possible I removed the nests from the roofs and also from the nestboxes after the incubation was over.

### 2.5. Temperature, humidity and rainfall measurements

The air temperature was measured in the four ledge-corners and in the open centre of a shingle-covered roof at a height of 3 cm. Air temperature was measured both over the yellow shingle and a larger black tar surface at the height of 3 centimetres. A thermometer at the height of 1.5 metres in the shadow was also operated. Temperature measurements were carried out in the May of 1990; the data was collected every hour.

Relative humidity was measured hourly in one shadowed and one sun-lit ledge corner parallel with each other with an analogue humidity-meter.

The rainfall was measured in 250 ml laboratory graduate measuring glasses at the four ledge corners and in the open centre of the same roof where humidity monitoring was also carried out. Rainfall data was collected over four years (1987-1990) in the nesting period from March until August. For the sake of more precise measurements the often minuscule amount, rain was poured into a test tube, and the height of the water was measured with a ruler truncated at zero (Svensson 1995). Measurements were only considered valid when they were carried out immediately after rain, and hence evaporation did not alter the result considerably.

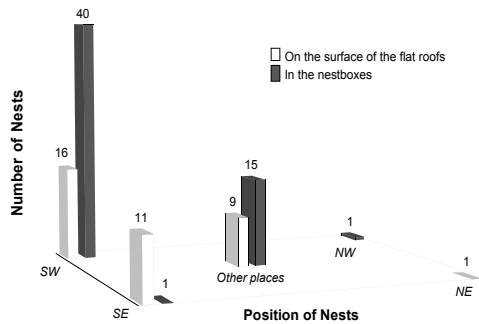


Fig. 1. The spatial distribution of nests according to their position on the surface of the flat roofs ( $n=37$ ) and within the nestboxes ( $n=57$ ). Ledge corners and nestbox corners are indicated as SW, SE, NE, NW corners. The open position category indicates nests built in central positions on the roofs or within the nestboxes, these could be either completely open or protected from one direction if they are built adjacent to some objects.

### 3. Results

#### 3.1. Nest constructing behaviour

During the study 94 nests were monitored. Only a single attempt (1.1%) of nest-construction was detected on a felted roof, in a South-West ledge corner. This nest was not completed, and no incubation was performed. The remaining 93 nests (98.9%)

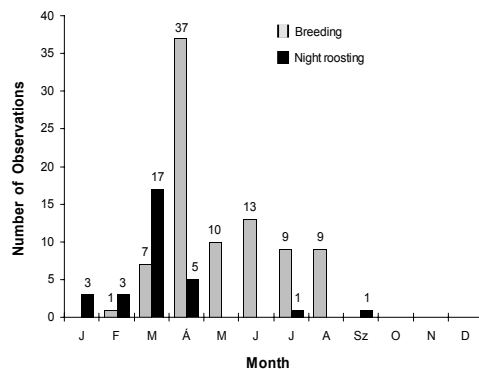


Fig. 2. Temporal distribution of nesting and night roosting on the flat roofs.

were placed on shingle-covered roofs, and 60.6% of these nests were placed in nestboxes, the remaining 39.4% being constructed on the surface of the roofs themselves (Fig. 1).

In the nestboxes the nest cavities were (diameter $\times$ depth) smaller than in the open ones ( $\bar{x}_{\text{nestbox}}=68.2\times52.3$  mm,  $n=3$ ;  $\bar{x}_{\text{open roof}}=77.5\times76.5$  mm,  $n=2$ ). The open nests were more than eight times heavier than the ones constructed in nestboxes ( $\bar{x}_{\text{open roof}}=309.1\pm258.4$  g [SD],  $n=6$ ;  $\bar{x}_{\text{nestbox}}=37.1\pm13.5$  g [SD],  $n=6$ ), and this difference was significant (two-samples  $t$ -test,  $p=0.05$ ). This large difference is caused by the fact that in the open nest the crested larks accumulate pieces of concrete and other stones as nest material (Orbán 1999), and in the open roof nests much more stone is incorporated than in the one in the nestboxes. In the case of four different nests construction took one, four, six and nine days, respectively. Although nest initiations were first detected in February, and the earliest completed nests were found in March, nesting, egg laying and incubation mainly started in April, and continued into August (Fig. 2).

Of the open nests, 75.7% were placed in ledge corners, 24.3% were placed into central areas either in the shadow of some objects or openly (Fig. 1). Inside the nestboxes 73.7% of nests were placed in corners, 26.3% were in the centre more or less covered by plant material or in a completely open position (Fig. 1). Pooling the nests, the majority (94.7%;  $n=89$ ) were protected from one side: 69 (73.4%) nests were protected from South-West, 14 (14.9%) from South-East; 2 (2.1%) from North-West, 1 (1%) from North-East, and finally 3 nests (3.2%) were covered from above completely. Altogether only 5

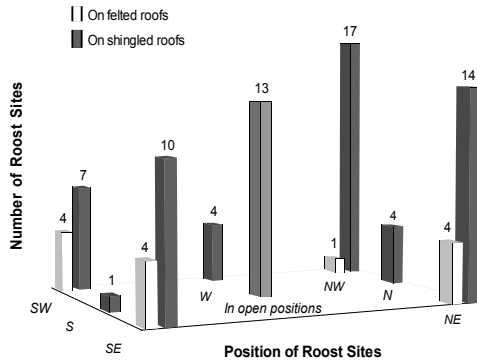


Fig. 3. The distribution of roost sites on the roofs. For legend see Fig. 1.

(5.3%) nests were constructed in a completely open position.

### 3.2. Night-roosting

Two different kinds of traces indicating night roosting were separated: droppings and small roosting depressions. In the former case the accumulated faecal matter indicated roosting, while in the latter case shallow depressions were prepared by the birds, in which they spent the night. The dimensions of these depressions were  $\bar{x}=11.2 \times 8.5 \times 1.9$  cm (length by width by depth) on both types of roofs.

During the study period on the roofs 83 signs of night roosting were found. From these 84.3% were on shingle-covered, and 15.7% on felted roofs (Fig. 3). On the shingle-covered roofs between 1985-1998 every year, while on the felted roofs only in a single year (1991) were signs of night-roosting detected. From the data collected for over 14 years on the shingle-covered roofs, the night roost usually lasted from January until April (Fig. 2), as only in these months were traces of roosting detected every year from more than one roof. In July 1992 and September 1998,

although only from a single roof, I also found traces indicating roosting.

The ratio of droppings only roost type was smaller on tar-board covered roofs (7.7%,  $n=13$  roosts) than on shingle-covered roofs (64.3%,  $n=70$  roosting sites). During the year, on the shingle-covered roofs there is a marked transition from the depression type (January 100%, February 100%, March 2.4%, April 0%) towards the droppings only type roost (January 0%, February 0%, March 97.6%, April 100%). On the more protected parts of the roofs both types of roosts occurred, while on the more exposed parts only the depression type of roost was found. Sometimes (in July and in September) the depressions were located very near each other, the maximum being eight roosting places within a square meter (in July).

The freshness of droppings could be estimated by their colour. Under wet, humid weather conditions the older droppings become brownish, whilst the fresh ones remain white for one or two days. Based on the amount and colour of the droppings it was possible to estimate whether the roosting site was used for a long or short period of time. On the shingle-covered roofs, taking into account both roost types the area covered with droppings was on average  $16.3 \text{ cm}^2$  ( $n=5$  roost sites), and its thickness was several centimetres. They were usually composed of both older brownish and fresh white droppings. Even where thickness of the accumulated faeces was not so thick more than ten droppings were usually found at a single site. Based on these findings we can state that the majority of roosting sites were used over several nights.

Based on the pooled samples from both tar-board covered and shingle-covered



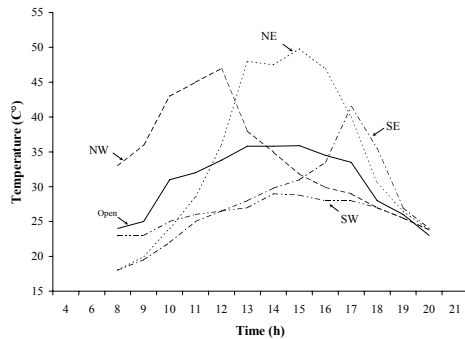


Fig. 4. The daily dynamics of temperature change in the ledge corners and in open positions of a shingled roof. Data was recorded during the daylight hours in completely cloudless weather (16.05.1990.).

roofs 84.3% (n=70) of the night roosts were located at the protected parts of the roofs, from which 48.2% (n=40) were sheltered from North whereas 31.3% (n=26) from the South (Fig. 3). On the single felted roof the southern protection was more frequent (61.5%; n=9), while on the shingle-covered roofs the northern protection was more wide-spread (50%, n=35).

If we compare the orientation of the nest and roost sites on the shingle-covered roofs, the nests (open site and within nest-box nests combined) are characterised by protection from the South (88.3%, n=83), while the night roosts are mostly protected from the North (50%, n=35).

Birds spend the night in depressions prepared in the soil of the nestboxes, placed on shingle-covered roofs, or in the nests remaining from the former nesting season only in January and February.

### 3.3. Temperature, humidity, precipitation

As a consequence of the different shading provided by the ledges and other objects constructed on the roofs the different areas

of the roof get uneven amount of irradiation from the sun. Therefore the directly sun-lit areas warm up more quickly (Fig. 4). The temperature differences disappear as direct sunlight ceases to hit the roof, usually in the evening hours when all the roof area is in shadow, and temperature equalisation takes place very quickly (Fig. 4, see the 20.00 h temperature data). The differentiation in temperatures starts only after sunrise, when sunlight begins to fall directly on the flat roofs (Fig. 4, see the 8.00 h temperature data). All the ledge corners receive direct sunlight, but the greatest exposure to the sun's rays is detected in the Northern corners (Fig. 4). The south-western corner is exposed only for a few minutes in the early morning, and the south-eastern corner is irradiated in the afternoon (Fig. 4). Although the open surfaces are sunlit, they become less hot, than the ledge corners of similar exposure (Fig. 4, for example compare the open and NE, NW locations between 12-14 hours), because the vertical walls of the ledge function as additional heat trapping surfaces, and they radiate the warmth back into the corners. In May (17<sup>th</sup> May, 1990. 12 hour) the highest temperature, 53°C, was measured in the North-western ledge corner. The air temperature at 1.5 metres was equal with the temperature measured in the South-western corner. There was no difference between the temperatures measured on the shingle-covered and felted roofs ( $\bar{x}_{\text{shingle-covered roofs}}=32.8\text{C}^{\circ}$ ,  $\bar{x}_{\text{felted roofs}}=32.8\text{C}^{\circ}$ ).

The humidity values of the directly irradiated open surfaces were lower, than that of those measured in the shadowed South-Western ledge-corners. The humidity changed in indirect proportion to the rise and fall of temperature (Fig. 5A, B).

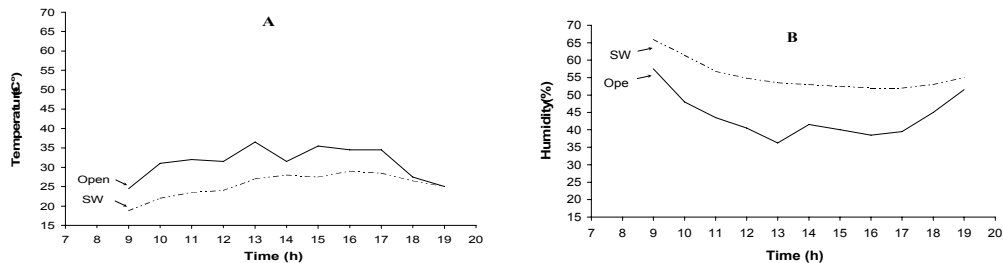


Fig. 5. The daily dynamics of temperature (A) and humidity (B) change on the same roof as in Fig. 4. measured in parallel with each other in open, sunlit position and in the south-western shadowed ledge corners (19.05.1990.).

There is no significant difference among the average amount of precipitation measured in the five rainfall monitoring locations (ANOVA,  $F_{4,35}=1.38$ ,  $p>0.05$ ).

Although there were no instrumental wind pressure measurements carried out on the roofs, it is certain that there are strong wind pressure peaks on them. This is shown by the fact that the precipitation measuring tubes were often turned over by the wind, and their upright position had to be secured by stones.

## 4. Discussion

### 4.1. Nest construction

Under natural conditions Crested Larks nest either in shallow natural depressions in the soil, or in depressions they prepare themselves. As there are no such natural nest sites on flat roofs, and the birds can not scrape a depression into the hard surface, they have to prepare the nest depression in the nesting material they accumulate on the roof. Because of the extra nesting material used for their construction these nests are considerably heavier, and their preparation requires more energy. In the nestboxes smaller and lighter nests can

be constructed, and as the construction requires less energy, it is advantageous for the birds to prepare their nests in these. This might explain why the majority of nests are constructed in the nestboxes (Fig. 1).

The sides of the nest-cups, prepared in the soil are strengthened by the soil surrounding the nest itself. However, nests built on flat roofs can only be strengthened by the objects against which they are constructed, and therefore all the nests on the roofs are prepared adjacent to objects, which can reinforce them, most often in the corners of the ledges. All other Hungarian data also stresses the importance of ledge corners (Bankovics 1986, Pellinger & Frank 1987).

On one of the felted roofs, the wind accumulated several centimetres of sand in the ledge corners, and the Crested larks prepared night-roost sites in this material. In the accumulated sand the birds could have prepared their nests more easily, however, none of the nests made on the felted roofs were located in these sandy corners. Bankovics (1986), and Pellinger & Frank (1987) found nests only on the shingle-covered roofs. This finding is possibly explained by the fact that nestlings leave the nests before they become fully capable of flying (Ferguson-Lees 1962,



Reade & Hosking 1974, Harrison 1980, Blotzheim & Bauer 1985, Paz 1987, Cramp 1988, Simms 1992). Nestlings become capable of flying when they are 15-20 days old (Reade & Hosking 1974, Harrison 1980, Blotzheim & Bauer 1985, Paz 1987, Cramp 1988.) However, based on the observations of the previous authors and myself the nestlings venture from the nest at 8-11 days of age, when they are capable of running and jumping. Hence they can not overcome the obstacles created by the ledges of the roof. Until they become fully capable of flight they must spend 7-10 days on the roofs. Nestlings rely only on their camouflage against birds of prey detected in the study area (*Accipiter nisus*, *Accipiter gentilis*, *Falco subbuteo*, *Asio otus*, *Tyto alba*, *Lanius collurio*, *Corvus frugilegus*, *Corvus monedula*). The post-juvenile feathers with their lighter spots and brownish ground colour match perfectly the pattern and colour of the shingle-covered roofs, but on the black tar boards this appearance would be useless. The assumption could be made that mortality during the nestling phase would be considerably higher on the felted roofs due to the lack of effective camouflage.

#### 4.2. Orientation of the nests

In the study area July and August are the warmest months. Maximum temperature measured in May (53C°) was higher than those measured by Trost (1972) in the Mojave Desert (47C°), and Orr (1970) in the Negev (43.8C°). Although I measured considerably higher maximum temperature in the Libyan Desert in direct sunlight (57.4C°; Egypt, Marsa Matruh, 15.04.2000.), there is no doubt that the flat

roofs constitute an extreme warm climate due to the lack of vegetation. During more than half of the nesting period in the ledge corners the temperature considerably exceeds 43-45C° established as the critical values for small passerine birds (Trost 1972, Walsberg 1993). Only a single nest was constructed in such a North-West ledge corner, but under a plastic sheet that provided continuous shading. The open, directly sun-lit areas because of the lack of neighbouring heat reflecting surfaces warm up to a lesser extent than the Northern ledge corners. Therefore for nest sites even the open positions are preferable to Northern ledges. The Southern ledge-corners are also receiving direct sunlight, but as the South-Eastern corner is sun-lit only in the late afternoon hours, they do not warm up as much as the North-Western corners, which are hit by the sunlight for about the same length of time but in the warmest hours. The South-Western corners are sun-lit only for a short period of time the early morning hours. This the most advantageous for breeding, because after the chill of the night this corner is warmed up quickly, and than becomes shadowed for the rest of the day. South-Western corners are also more advantageous from the point of view of relative humidity, than the directly sun-lited parts of the roofs. Natural water-loss of eggs during incubation is 9-18%, and the actual value is strongly influenced by the humidity of the immediate environment of the nests (Walsberg 1985). In the South-Western corners, characterised by the lowest and most stable temperature, higher humidity creates more preferable conditions for nesting than the open, directly sun-lit roof sectors.

On the studied flat roofs nests were

most often (73.4%) constructed in locations protected from South-Western direction. This orientation is the most preferable as regards to temperature characteristics, but from the point of view of rain exposure almost the worst, only the completely open roof sectors receive more rain. While overheating caused by sunlight is a daily phenomenon on the flat roofs in the nesting period rain is experienced only weekly or monthly. Overheating at some parts of the roofs exceeds the tolerable physiological maximum daily, while the amount of rain is usually not extreme. Both the daily frequency and the often extreme values of temperature constitute stronger environmental selective pressure for nesting than the infrequent and rarely excessive rainfall, which can not accumulate on the roofs. Through the selection of South-Western corners birds opt for minimising the risk arising from the intolerable overheating, and are choose to withstand the hardships created by precipitation.

### 4.3. Roosting behaviour

In our study area the first part of the period when Crested Larks roost on the roofs (January-April) coincide with the coldest months of the year in Hungary. In January-February  $-10 - -15^{\circ}\text{C}$  minimum temperatures are quite common, and temperatures between  $-20 - -34^{\circ}\text{C}$  might also occur occasionally. In March-April nights are usually milder, but temperatures below zero still occur.

For small passerines the fall in body temperature caused by the wind, humidity and low temperatures pose the greatest hazards during night. Windchill is especially devastating in the cold of the winter

period or in the cool nights. This negative effect is further stressed when the feathers of the birds are wet. Consequently for roosting birds it is essential to find dry and wind-protected sites. Walsberg (1986) measured 18-30% lower wind velocity figures on the roost sites of *Phainopepla nitens* (*Passeriformes*) compared to their immediate surroundings. Roosting birds prefer denser foliage or nests cavities to sites that provide less protection against wind (Walsberg 1985). Most of the roost sites (91.7%) located on the studied flat roofs were at wind-protected sectors of the roof. Besides lowest wind pressure these corners are also providing the best protection against rain driven by the prevailing wind. This helps keeping the feathers dry and hence maintain their insulation capability. Based on my measurements actual exposure to rain is influenced not only by the protection, but also by the actual direction of wind that might change from one rainy period to the other. The actual roosting site is usually selected according the wind direction on the given day, and this might explain the scattered pattern of roost site orientation/exposure experienced on the roofs.

In the lack of properly protecting vegetation some species spend the night in small depressions scraped into the ground (Trost 1972, Cramp 1988), and Crested Larks also use underground cavities on flat roofs (Cramp 1988). According to Trost (1972) Horned Larks *Eremophila alpestris* in laboratory experiments always prepare roosting depressions under  $10^{\circ}\text{C}$ , while above  $25^{\circ}\text{C}$  they never prepare such roosting cavities. On the studied flat roofs in the coldest months, January-February, the roosts were small depressions scraped sometimes inside the nestboxes or more

often in the shingle, but all of them were located in the protection of ledges or the sides of the nest boxes. Roosting in nest-boxes and nests were observed only in this (January-February) period. In March-April a marked warming up starts, and thereafter birds do not scrape depressions for roosting, the roost sites are only marked by their droppings.

The roosting birds even in the warm summer period preferred the protected sectors of roofs. All of the roosting nestlings choose the corners, predominantly the most wind-protected Northern ones. If the roosting site was selected at an open location always a depression was created, where birds get more protection. At most (76.9%) of the roost sites located in open parts there were no droppings, and it suggests that these open sites were either not used at all, or only for a single night. The night-roosts, found on the open part of the roofs in July 1992, also lacked any droppings, and were all depression types. This suggests that even under favourable conditions birds still try to maximise the protection offered by their roosting site.

The location of roosting sites was different on the shingled and felted roofs. On the shingled roofs Northern protection is dominant, while on the single felted roof Southern protection was detected more often (61.6%). On the felted roof wind has accumulated heaps of debris. The thickness of the debris depends on the age of the roofs and wind direction. Under the prevailing North-Western wind more debris is accumulated in the North-Eastern, South-Western and South-Eastern corners than in the protected North-Western ledge-corner. In the thicker debris deeper, more protective roosting depres-

sions can be prepared, and this might compensate for the less favourable exposure.

According to Trost (1972) Horned Larks use roosting cavities alone. Based on the size of roosting depressions Crested Larks spend the night alone, too. But at the non-depression type roost I observed several times to individuals cuddled together during the night. The roosting depressions are also often clumped together in large numbers (Trost 1972, Cramp 1988). Sometimes on the roofs there are several roost depressions scraped near each-other, the maximum was 8 depressions in 1m<sup>2</sup> in July.

Trost (1972) reports that a new depression is prepared in the soft soil every day, while in harder soil the same cavity is used for several days. This is further evidenced by the fact that only 2-3 droppings were found in the depressions prepared in soft soil, while the depressions prepared in hard soil contained 10-15 droppings. On the roofs both the colour (white and brown mixed) and the amount of droppings suggest that the roost sites are used for several days. If we consider that the depressions are prepared during the day, and hence reduce the time available for foraging (Trost 1972, Cramp 1988), prolonged use of the depressions can help save time and energy in the coldest period. Multiple use was also detected in the case of non-depression type of roost sites.

Most of the roosting was performed on shingle covered roofs. A possible explanation might be that roosting precedes and overlaps with the beginning of the nesting period, and roosting site selection might be a prelude to establishing the breeding territories. Hence the felted roofs are not used for roosting because later on nesting is not performed on them.

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## Összefoglalás

### Fészkeképítés és éjszakázó viselkedés egy lapos tetőkön élő búbospacsirta *Galerida cristata* populációban

A lapos tetők két típusa, a gyöngykavicsos és a kátrányos közül a búbospacsirták csak a gyöngykavicsos tetőkön költöttek. A költő madarak a tetőkre kihelyezett költőládákat preferálták a tetőfelszíni fészkelő helyekkel szemben. A fészkek elhelyezkedésére a déli és délnyugati védetség volt a jellemző. Mivel a költési időszak az év legmelegebb hónapjaira esik, e fészkek helyek hőmérséklete a legalacsonyabb, legkedvezőbb a költési siker szempontjából. Az éjszakázási időszak a költési időszakot közvetlenül megelőző és annak korai szakaszára tehető. A pacsirták elsősorban azokon a tetőkön éjszakáztak, ahol később költöttek is. Az éjszakázóhelyek szórtabban helyezkedtek el, mint a fészkek, s azoktól eltérően elsősorban északi irányból voltak védettek. Mivel az éjszakázási időszak az év leghidegebb hónapjaira esik, az éjszakázó madár túlélése a testhőmérséklet energiatakarékos fenntartásának sikerétől függ. Ez a szélterhelés csökkentésével, és a tollazat szárazon tartásával érhető el. Ezért az éjszakázó madarak a legszélvédettebb helyeket részesítik előnyben a tetőkön, melyek egyben a legszárazabbak is.

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## Male badge size is related to clutch volume in the Kentish Plover

Á. Z. Lendvai, A. Liker and J. Kis

Lendvai, Á. Z., Liker, A. and Kis, J. 2004. Male badge size is related to clutch volume in the Kentish Plover. – Ornis Hung. 14: 15-21.



Shorebirds show large interspecific variability in melanin-based breast coloration, although the adaptive value of this trait is largely unknown. In this study, we investigated whether variation in the size of breast bands (badge) in male Kentish Plovers (*Charadrius alexandrinus*) is related to the start of their breeding and volume of their clutches. We found that males with large badges started breeding earlier than males with small badges. Large-badged males also had larger clutch volumes than males with smaller badges, after controlling for seasonal effects. These results suggest that large-badged male Kentish Plovers may have a reproductive advantage over small-badged ones, because usually both early breeding and large egg volumes increases reproductive success in shorebirds. These results suggest that badge size may signal male quality that affects either the females' investment in eggs or the success of males in territory defence.

Key words: sexual selection, cryptic female choice, melanin, egg size, *Charadrius alexandrinus*.

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### 1. Introduction

Plovers and their allies (suborder Charadrii) exhibit a large interspecific variation in melanin-based black breast coloration (Bókonyi *et al.* 2003). Although the variability of these melanin ornaments have drawn the attention of researchers for a long while (*e.g.* Bock 1958, Graul 1978), their adaptive value is still poorly known. The few studies carried out in plovers and allies have suggested two main functions of these melanin ornaments. First, melanin plumage ornaments may be signals of individual quality that affects mating success via mate choice and/or success in intrasexual contest for mating partners

(Edwards 1982, Owens *et al.* 1994, Bókonyi *et al.* 2003). Second, melanin-based colours may have roles in territory defence, because variable plumage badges may promote neighbour recognition and thus may facilitate territory defence against unfamiliar intruders (Whitfield 1986).

In this study, we investigated the significance of male breast band size for breeding in the Kentish Plover (*Charadrius alexandrinus*), a small ground-nesting shorebird. Kentish Plovers are sexually dichromatic birds: females are drab, whereas males have black eye stripes, a horizontal head bar, and two conspicuous black breast bands ('badge' henceforth), one on each of the right and



left side of their white breast plumage. Amat *et al.* (1999) suggested that females may use the head bar as a cue of male quality during mate choice. Observations suggest that breast plumage may also be important for breeding: during courtship and male-male conflicts, males display their badges by puffing up their breast feathers (Perrins 1998). Furthermore, Lendvai *et al.* (2004) showed that large-badged males may have an advantage in aggressive male-male encounters. Note that sexual selection should be intense in this species because mate desertion and sequential polygamy are frequent in most populations (*e.g.* Székely & Cuthill 1999 and citations therein).

In this study, we used field observations to investigate whether variation in badge size is related to components of sexual selection. According to sexual selection theory, we hypothesized that badge size may be a signal indicating male quality. One prediction of this idea is that males with large and conspicuous badge size are able to acquire better quality mates who produce larger number and/or more viable offspring than mates of small-badged males. As shorebirds are determinate layers (*e.g.* Kentish Plovers usually have a clutch of three eggs), we used clutch volume as a surrogate to estimate female quality.

## 2. Methods

We carried out the fieldwork between 18 April and 7 June 1999 in an area of about 140 ha at Tuzla Lake (36° 42' N, 35° 05' E) in the Çukurova-Delta, southern Turkey. Approximately 1000 pairs of Kentish Plover breed around the lake each year.

The study site is a salt marsh, where bare patches of mudflats alternate with patches of *Artrocnemum fruticosum*, *Salicornia europea* and other halophytes. The study was licensed by the Turkish Ministry for Natural Parks (licence number: 880973/06/04/1999).

We searched for nests throughout the breeding season, and we measured the size of the eggs for each clutch. Clutch volume (mm<sup>3</sup>) was calculated as the sum of egg volumes, where egg volume was estimated as  $0.486 \times \text{length} \times \text{breadth}^2$  (Székely *et al.* 1994). All studied nests ( $n=60$ ) contained 3 eggs. We defined laying date as the number of days elapsed since 1 March until the laying of the 3<sup>rd</sup> egg. For nests found after the clutch completion, laying date was estimated by floating eggs in lukewarm water (van Paassen *et al.* 1984, and J. Kis & T. Székely unpubl. data).

We caught both the male and female on their nest by a funnel trap ( $n=60$  pairs)  $4.3 \pm 2.9$  (mean  $\pm$  SD) days after clutch completion. They were ringed by a numbered metal ring and an individual combination of colour rings. Their body mass ( $\pm 0.1$  g), tarsus ( $\pm 0.1$  mm) and wing length ( $\pm 1$  mm) were measured. In males, we measured the size of their breast bands (badge) as the sum of the left and right black patches, measured from the shoulder to the breast. We put an overhead transparency strip tightly around the birds' neck and breast, and traced the size of their badge on the strip with a marker pen. We scanned these transparencies and measured the area of badges in mm<sup>2</sup> using Scion Image software (Scion Corporation 1998). Badge area was traced and measured twice for each male and we used the mean of these two measurements in the analyses. The repeatability of badge size



was high ( $R=0.941$ ,  $F_{1,60}=17.127$ ,  $P<0.0001$ ; Lessells & Boag 1987). Finally, we also estimated the minimum age of the plovers, *i.e.* we knew the age of birds ringed as chicks and assumed that birds ringed as breeding adults were one year old in the year of ringing (minimum age ranged from 1 to 4 years).

Each male was included once in each analysis, *i.e.* we used data from the first known nests of the males. We used multivariate linear regression models to investigate the relationships of male badge size to male and female characteristics and clutch volumes. We used Spearman rank correlation to investigate the relationships of male badge size to age, because the latter variable could not be included in parametric models without violating their assumptions. We used SPSS 11.0 for Windows for statistical testing, and give two-tailed probabilities and mean  $\pm SE$  throughout the paper.

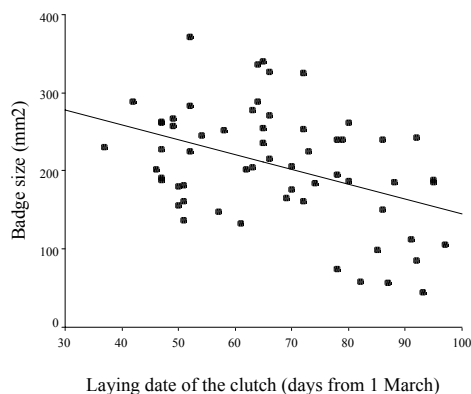


Fig. 1. Relationship between the breeding date of male Kentish Plovers ( $n=60$  males) and their badge size.

### 3. Results

#### 3.1. Body size characteristics and laying date

Male badge size was related to the laying date of clutches: males with early nests had larger badges than males with late nests (Tab. 1., Fig. 1.). Neither body size (measured as tarsus and wing length) nor body mass of males was related to badge size; furthermore, male badge size was not related to the female mate's tarsus length, wing length, and body mass in a model that also controlled for the effects of laying date (Tab. 1.). Variation in badge size was also unrelated to the minimum age of males ( $r_s=0.193$ ,  $P=0.139$ ,  $n=60$ ), and to the minimum age of their mates ( $r_s=-0.091$ ,  $P=0.489$ ,  $n=60$ ).

#### 3.2. Clutch volume

Clutch volume tended to increase with female body mass and was also related to laying date, early clutches being of smaller volume than later clutches (body mass:  $r=0.252$ ,  $P=0.053$ ,  $n=60$ ; laying date:  $r=0.424$ ,  $P=0.001$ ,  $n=60$ ) thus, in the following analysis of clutch volume we controlled for female body mass and laying date. The badge sizes of male plovers were

Tab. 1. Standardized coefficients of independent variables from a multiple linear regression model with male badge size as dependent variable ( $F_{6,53}=2.429$ ,  $P=0.038$ ,  $R^2=0.216$ ).

Independent variable	$\beta$	$P$
Laying date	-0.393	0.004
Male tarsus length	0.066	0.606
Male wing length	0.120	0.365
Female tarsus length	-0.001	0.997
Female wing length	-0.031	0.807
Female body mass	-0.121	0.340

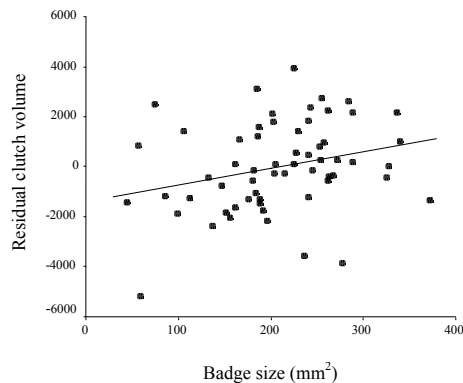


Fig. 2. Relationship between clutch volumes and male badge size ( $n=60$  clutches). The residuals of the dependent variable (clutch volume) are calculated from a linear regression model with the following independent variables: laying date, female body mass, female tarsus and wing length, male tarsus and wing length. See text for the details of model selection.

positively associated with the volume of their clutches (Tab. 2., Fig.2.). Other body size measurements of the males and females were unrelated to clutch volumes (Tab. 2.).

#### 4. Discussion

Our study provided two results that may help to understand the adaptive significance of badge size in the Kentish Plover. First, we found that males with early nests have larger badges than males breeding

Tab. 2. Standardized coefficients of independent variables from a multiple linear regression model with clutch volume as dependent variable ( $F_{7,52}=3.697$ ,  $P=0.003$ ,  $R^2=0.332$ ).

Independent variable	$\beta$	$P$
Laying date	0.570	< 0.001
Male badge size	0.295	0.025
Male tarsus length	0.062	0.616
Male wing length	-0.011	0.928
Female tarsus length	-0.072	0.533
Female wing length	0.149	0.215
Female body mass	0.236	0.052

later in the season. At least two alternative explanations can account for this relationship. On the one hand, it is possible that males with larger badges can start breeding earlier than males with small badges, e.g. because large-badged males arrive earlier to the breeding ground, are better in establishing territories, or are more attractive to females. It is unknown for any Kentish Plover population whether arrival of males is related to their badge sizes. In a recent experiment, Lendvai *et al.* (2004) found no evidence for the effect of badge size on remating time of male plovers, but showed that large-badged males may have an advantage in aggressive male-male encounters. Thus, male success in territory establishment may be related to early breeding by large-badged males. If large-badged males can breed early in the season this may increase their reproductive success relative to small-badged males, because nest predation is lower and offspring survival is higher in early Kentish Plover nests than later in the season (Fraga & Amat 1996, Székely & Cuthill 1999). On the other hand, seasonal decline in badge size may be explained by the wear of breast feathers during the season, a fact demonstrated in several bird species (e.g. Bogliani & Brangi 1990). We cannot rule out this latter explanation, although a recent study of Kentish Plovers' breast feather length suggests that this would require significantly quicker abrasion in males than females (Kis & Székely 2003).

As the second main result, we showed that the badge size of males was related to the volume of their clutches. This relationship cannot be explained by a coincidence of seasonal variation in both clutch volume and badge size, because (1) the direc-

tion of seasonal changes in these variables was the opposite and (2) we statistically controlled for seasonal effects. In the sexual selection framework, this result may be explained by several hypotheses.

First, large-badged males may get 'better-quality' mates who are able to increase their parental investment and produce larger eggs (the 'mate quality hypothesis'). Second, it is possible that females of large-badged males could lay larger eggs, because large-badged males may acquire better territories with richer food supplies where their mates may have favourable nutritional conditions. However, both of these explanations are unlikely because neither female body size, body mass nor the minimum age of females were related to their mates' badge size. Third, large-badged males may be better able to defend their mate against harassment of other males, so their females may spend more time feeding, may feed more efficiently, or may avoid detrimental hormonal consequences of frequent fighting. For instance, it has been shown that female Kentish Plovers produce larger eggs when they are in good condition (Amat *et al.* 2001b). Alternatively, repeated aggressive interactions may increase the female's testosterone level, which may have deleterious effect on egg formation and hatching success (*e.g.* Mazuc *et al.* 2003). Finally, it is possible that females preferentially invest in their eggs when paired to a large-badged male (the 'preferential allocation hypothesis'). Our observation seems to support the latter hypothesis, since the relationship between clutch volume and badge size was significant after controlling for female condition (body size and body mass). In line with our result, recent experimental studies of 'cryptic female

choice' revealed that in some birds females lay larger eggs for attractive males than for less preferred mates (*e.g.* Cunningham & Russell 2000). Note, however, that following an experimental manipulation of badge size, new mates of male Kentish Plovers with enlarged badges did not lay larger eggs than new mates of males with control badge size (Lendvai *et al.* 2004). Several explanations can account for the difference between the observational and experimental results. First, in the present observation much larger sample sizes were used than in the experiment to investigate the relationship between badge size and clutch volume (this study:  $n=60$ , experiment:  $n=23$ ). Second, it is possible that the badge manipulations produced somehow 'unnatural' traits and the females used other cues to assess male quality (Lendvai *et al.* 2004).

Increased clutch volume in large-badged males' nests may significantly influence their reproductive success. For instance, clutch volume is related to brood survival in several precocial birds including the Northern Lapwing *Vanellus vanellus* (Galbraith 1988), the Whimbrel *Numenius phaeopus* (Grant 1991) and the Lesser Scaup *Aythya affinis* (Dawson & Clark 1996; but see also Williams 1994). In the Kentish Plover, within-clutch comparisons showed that chicks hatching from larger eggs were heavier than chicks from small eggs (Amat *et al.* 2001a). Furthermore, chicks hatched from larger eggs were more likely to recruit to the breeding population than their siblings hatched from smaller eggs (Amat *et al.* 2001a). Thus our results suggest that large-badged male Kentish Plovers may have a reproductive advantage over small-badged conspecifics. However, we should

suggest some caution with this interpretation of our results, because we had observations from only one year. Since breeding conditions may differ in many important respects between years (e.g. seasonal variation in clutch volumes differs between years in the Kentish Plover; Amat *et al.* 2001a, T. Székely pers. com.), data from several years or more breeding populations would be very valuable to corroborate the conclusion of this study.

Taken together, this study suggests that the badge size of male Kentish Plovers may be affected by sexual selection. The relationship between male badge size and clutch volume can be explained by increased female investment and/or increased success of large-badged males in male-male competition. Further studies are needed to separate the effects of inter- and intrasexual selection.

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## Összefoglalás

### A hím széki lilék begycsík méretének kapcsolata a fészekalj térfogattal

A partimadarak melanin alapú begymintázatában igen nagy a változatosság a fajok között, de ezen bélyegek adaptív értéke jórészt ismeretlen. A jelen vizsgálatban arra a kérdésre kerestük a választ, hogy a hím széki lilék (*Charadrius alexandrinus*) begycsíkjának változatossága összefügg-e költésük kezdetének időpontjával és fészekaljuk térfogatával. Vizsgálatunkban azt találtuk, hogy a nagyobb begycsikkel rendelkező hímek hamarabb kezdtek költetni, mint a kisebb begycsíkú hímek. A szezonális hatásra történt kontrollálás után összefüggést találtunk a begycsík mérete és a fészekalj össztérfogata között: a nagy begycsíkú hímek fészekaljának térfogata nagyobb volt, mint a kisebb begycsíkú hímeké. Ezek az eredmények arra utalnak, hogy a nagy begycsikkel rendelkező hímek reprodukatív előnyben vannak a kisebb begycsíkú hímekkel szemben, mivel a partimadaraknál a korai költés és a nagy tojásméret is növelheti a szaporodási sikert. Mindezek arra engednek következtetni, hogy a begycsík a hímek minőségét jelző bélyeg, mely szerepet játszik a tojók preferenciális befektetésében vagy befolyásolja a hímek sikerét territóriumuk védelme során.

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## Short communications - Rövid közlemények

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### Insects inhabiting Saker (*Falco cherrug*) nests in Hungary

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**Merkl, O., Bagyura, J. and Rózsa, L. 2004. Insects inhabiting Saker (*Falco cherrug*) nests in Hungary. – Ornis Hung. 14: 23-26.**

**This study describes the species composition of insects reared from larval assemblages collected from Saker nests. Eight coleopteran and one dipteran species had been reared, none of which appear to be specific to raptors's nests as a habitat. They are either characteristic to carcasses, or known to occur in manure, or commensals living in a variety of mammalian and avian nests. Some of these species may participate in the transmission of pathogens.**

**Keywords: falcon, nidicolous, nest-dwelling, insect**

#### 1. Introduction

Nests of altricial and semialtricial birds tend to harbour species-rich insect faunae (Nordberg 1936, Hicks 1971). Apparently, nests of cavity nesting birds and nests of large bodied birds represent particularly suitable habitats for the development of arthropods (see *e.g.* Krištofik *et al.* 1994,

1996, 2002, Masan & Krištofik 1995, Szabó *et al.* 2002). A recent description of a species new to science collected from raptors' nests in Hungary (Papp 1998) further highlights the need of exploring this segment of the Central European fauna.

Falconiform raptors are characterized by semialtricial nestlings living in relatively large nests throughout long periods of development. Typically, large quantities of food remain, such as body parts of prey animals, bone, skin, hair, feather and pellets accumulate under the chicks and the emergent smell tends to attract a variety of insects. Most insects deposit eggs onto the food remains and disappear from the nests, thus only larvae represent the majority of species. Larvae are difficult to identify and therefore most authors rear them into adults for identification. The importance of this nest-dwelling insect fauna is poorly understood. Nest faunae comprising raptor specialist parasites and commensals may well represent a valuable component of biodiversity (Rózsa 1992). On the other hand, however, if this fauna contains parasitic species or species acting as vectors of pathogens, its presence may also exert a negative effect on nestling development.



Here, we aim to describe results of our efforts to rear and identify insects collected from Saker (*Falco cherrug*) nests in Hungary. To our best knowledge, this is the first study to explore the insect fauna occurring in Saker nests.

## 2. Materials and methods

Samples were taken from 25 nests (15 natural and 10 artificial sites) during the summer of 2000 by János Bagyura. Each sample comprised of about 200-400 cm<sup>3</sup> rotting material taken directly from below the Saker chicks. Samples often included avian and mammalian body parts such as legs of Pigeons (*Columba livia*), heads of small passerines (e.g. Blue Tit, *Parus caeruleus*), skin fragments of Suslik (*Spermophilus citellus*). Lajos Rózsa carried out rearing of adult insects. Samples were kept in plastic boxes on a balcony under natural climate conditions, but not exposed to direct sunshine. A large number of small holes on the top and bottom of boxes let in fresh air while prohibited insects larger than 0.5 mm to get into the boxes from the outside. Boxes were opened on every 2nd day to provide moisture by means of a water aerosol and to collect emergent adult insects. Most of these were found after 2-6 weeks of rearing, and rearing was given up when 2 weeks passed after the collection of the last adult specimen. Admittedly, rearing was far from being efficient, thus only a minority of larvae could be reared into adults and identified to species. Firstly, the natural supply of food remains was cut off in our boxes, thus insect larvae could have starved. Secondly, some samples dried during the hot summer period, while

others were too wet and became invaded by fungi. However, similar conditions may often occur in the falcons' nests as well.

## 3. Results and discussion

Adults of 8 coleopteran and 1 dipteran species were reared. Beetles were identified by Otto Merkl, while the flies were identified by L. Papp, Hungarian Natural History Museum (HNHM), Department of Zoology. All specimens are found in the collections of HNHM, Budapest. A list of species is presented in Table 1, completed with some information about their previously known habitats and feeding habits, date and localities of our collections and the number of individuals. Due to raptor conservation interests, we use only county names to refer to localities.

Overall, none of the species found in our study are specific to raptors' nests as a peculiar habitat, but either characteristic to different types of carcasses, or known to occur in manure, or nidicolous species living in the nests of a variety of mammalian and avian hosts. The hematophagous fly *Carnus hemapterus* was widespread and abundant on Saker chicks, however, this species was not reared from the samples. These larvae develop in avian nests, overwinter there as pupae, and the emergence of the parasitic adults is synchronised with the hatch of nestlings (Liker *et al.* 2001), thus we could not rear it within our short study period.

Apparently, Saker nests and poultry farms share some insect species. At least one of these, the lesser mealworm (*Alphitobius diaperinus*) is a well-known vector organism (see e.g. McAllister *et al.*



Tab 1. A list of insects reared from saker nests.

Taxa	Characteristics	Date (all in 2000), locality (county)	Number of individuals
<b>Coleoptera:</b>			
<b>Dermestidae</b>			
<i>Dermestes bicolor</i> (Fabricius, 1781)	This species inhabits nests of a variety of animals and feeds on feather, hair and dried meat.	19. 05., Jász-Nagykun-Szolnok	1
		11. 05., Borsod-Abaúj-Zemplén A	1
		11. 05., Borsod-Abaúj-Zemplén B	3
		14. 05., Heves A	1
		14. 05., Heves B	2
<b>Tenebrionidae</b>			
<i>Alphitobius diaperinus</i> (Panzer, 1797)	A cosmopolitan pest occurring in stored food such as bran and flour. Also occurs in avian nests (Šustek & Krištofik, 2002, 2003) and common in poultry farms where it feeds on droppings and preys on fly larvae.	11. 05., Borsod-Abaúj-Zemplén A	3
		11. 05., Borsod-Abaúj-Zemplén B	2
<b>Trogidae</b>			
3. <i>Trox scaber</i> (Linnaeus, 1767)	Common on dry carcasses, also known to occur in nests of predators. Larvae feed on keratin.	11. 05., Borsod-Abaúj-Zemplén B	3
<i>Trox perrisii</i> (Fairmaire, 1868)	Living exclusively in nests, this species feeds on feathers and remains of carcasses. Relatively rare in Hungary, with about 20 known occurrences.	11. 05., Borsod-Abaúj-Zemplén B	2
<b>Histeridae</b>			
<i>Carcinops pumilio</i> (Erichson, 1834)	A cosmopolitan species that occurs in avian and mammalian nests, stables, pens etc., had also been collected at rubbish-heaps. Preys on fly larvae.	19. 05., Heves	5
		11. 05., Borsod-Abaúj-Zemplén A	3
<i>Gnathoncus nanus</i> (Scriba, 1790)	Known to occur in avian and mammalian nests, rare in stables and pens. Feeds on fly larvae.	19. 05., Heves	1
		11. 05., Borsod-Abaúj-Zemplén B	1
<i>Saprinus tenuistrius sparsutus</i> (Solsky, 1876)	Common on carcasses, preys on fly larvae.	19. 05., Heves	1
<i>Saprinus subnitescens</i> (Bickhardt, 1909)	Common on carcasses, preys on fly larvae.	21. 05., Heves	1
		12. 06., Heves	1
		11. 05., Borsod-Abaúj-Zemplén B	1
<b>Diptera:</b>			
<b>Carnidae</b>			
<i>Meoneura prima</i> (Becker, 1903)	New to Hungary, previously known from North America, North Africa, Europe, Jordan and Afghanistan, where it was collected from the manure of domestic animals, and also from umbelliferous flowers (Papp 1978, 2001)	17. 05., Pest	4

1996, Watson *et al.* 2000) potentially capable to transmit pathogens to Saker nest either from poultry farms, or from other raptors' nests. It may be worth mentioning here, that Saker nestling morbidity due to *Mycoplasma buteonis* infection had already been documented in Hungary (Erdélyi *et al.* 1999). Recently, this beetle was also abundantly found in nests of cavity nesting birds in Slovakia (Šustek & Krištofik 2002, 2003), thus its occurrence in the nest fauna of the Saker is not surprising. Unfortunately, we cannot compare our result to the nest-dwelling insect fauna of other falcon species due to the lack of information on other species.

Briefly, insects inhabiting Saker nests

are either nidicolous species or species typical to carcasses or manure. Some of them may have a role in transmitting pathogens from poultry farms or from other raptors to Saker chicks.

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## Összefoglalás

### Rovarfajok előfordulása magyarországi kerecsensólyom (*Falco cherrug*) fészkekben

Dolgozatunk célja leírni a kerecsenfészkekből gyűjtött rovarlárvákból kinevelhető kifejlett rovarok fajlistáját. Nyolc bogár- és egy légyfajt sikerült kinevelnünk, azonban ezek egyike sem a ragadozómadár-fészkek specialistája. Egy részük dögökről ismert, mások jellemzően trágyában fordulnak elő, megint mások a legkülönbözőbb madarak és emlősök fészkeiben is élnek. Néhány faj a madárkórokozók továbbításában jelentős lehet.

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## Predation of artificial nests in a marshland: site and visibility effects

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**Báldi, A. 2004. Predation of artificial nests in a marshland: site and visibility effects. – *Ornis Hung.* 14: 27-30.**

**I studied the effects of site (location) and nest visibility on the predation rate of artificial ground nests in islands of the Kis-Balaton marshland, Hungary. There was a strong site effect, i.e. nest predation was different among the three studied sites. No difference was found between visible (100% visibility) and hidden (<20% visibility) nests. In addition, the identified predators (Corvidae and Mustelidae) of hidden and visible nests were similar, but different at the three sites. The lack of visibility effect was unexpected, but can be explained by the increased water level of the marshland after drought years. This may have resulted in the concentration of both predators and nests on islands, causing extremely high predation pressure.**

**Key words: artificial ground nest, brood survival, Hungary, water level change**

### 1. Introduction

The loss of nests due to predation is probably the most important factor determining the survival of clutches (e.g. Martin 1988, Hoi & Winkler 1994, Schmidt & Whelan 1998, Batáry & Báldi 2004, Purger et al. 2004). Nest predation is often

studied by artificial nest experiments to avoid disturbance to target species and habitats. Although the experiments seem to provide sufficient data for comparative purposes (Major & Kendal 1996, Matessi & Bogliani 1999), several experiments were conducted on plots of comparable size to the home range of potential predators (e.g. Corvidae). Consequently, the results may be biased, reflecting simply the presence of one or a few predators (Møller 1988), or the proximity of predator dens or nests (Rönkä & Koivula 1997, Larivière & Messier 1998). Besides the site (locality) effect, the visibility of nests seems to be the most important factor determining depredation rates. More visible nests suffer higher predation rates than less visible nests (Leimgruber *et al.* 1994, Vanderhaegen & Degraaf 1996, Jobin & Picman 1997, Miller 1999, Rangen *et al.* 1999, but see Götmark *et al.* 1995, Wiebe & Martin 1998), although not all studies supported this hypothesis (Burhans & Thompson 1998, 2001, Braden 1999).

In the present study I investigated the effects of site and nest visibility on nest predation of passerine ground nests in a marshland in Western Hungary.

### 2. Study area and methods

The study area was in the 15,000 ha Kis-Balaton marshland, W-Hungary (46°42'N,

17°21'E). I used artificial nests resembling the nest of Stonechat (*Saxicola rubetra*) in the breeding season of 1999 (detailed area description is in Lőrincz *et al.* 1990, Báldi 1999, Moskát & Báldi 1999), selecting islands on Lake Fenéki for three study sites within 3 km. The islands had similar size and isolation, mainly by reedbeds. Grasses with a few trees and bushes covered the islands. The average height of grass layer was ca. 30 cm, with 100% cover on all islands. Artificial passerine nests made of chicken wire and lined with grasses were used, containing 1 quail egg, and one plasticine egg with similar size and pattern to a small passerine egg. The nests were placed in pairs at 3 m distance from each other. One nest had 100% visibility, without any cover. The other nest of the pair was hidden in the grass, under a tussock, and only small part of the nest (<20%) was visible from above. Ten pairs of nests at 20 m intervals were used at the three sites (a total of 60 nests). The nests were exposed for 2 days.

### 3. Results and discussion

More than 60% of the nests were predated within two days. Similarly high predation pressure was found for open ground nests with chicken eggs along the dikes in the area (Báldi 1999). The number of lost nests were significantly different, by site and treatment ( $G$  test of homogeneity on the  $2 \times 3$  contingency table of treatments  $\times$  sites:  $G=11.4$ ,  $d.f.=2$ ,  $P<0.01$ ). Visibility alone, however, had minor influence on the differences, because the daily nest survival rates, calculated by the Mayfield method (Mayfield 1975), were not different between treatments, within sites (Tab.

1). Therefore, hidden and visible nests were pooled within sites. The nest losses were significantly different among sites: the number of predated nests at sites I, II and III were 7 (35%), 10 (50%) and 20 (100%), respectively ( $G$  test of homogeneity with Williams' correction:  $G_{cor}=7.2$ ,  $d.f.=2$ ,  $P<0.05$ ).

I tested the hypothesis that the predation of paired (hidden and visible) nests is aggregated, that is, the chance of being predated of one of the nests is non-independent of the fate of the other. Only the first two sites were included, because at the third site all nests were predated. Predation of a nest, however, did not depend on the fate of its paired nest ( $G_{cor}=0.7$ ,  $d.f.=2$ ,  $NS$ ).

Nest predators were identified based on their beak or tooth marks in the plasticine eggs. Eleven marks were identified from the 37 predated nests. Six were of medium sized birds, probably Corvidae, and 5 were mammal traces, probably by Mustelidae. Surprisingly, there was no difference between the predators of hidden and visible nests. There were 3 bird and 3 mammal marks on hidden eggs, and 2 mammal and 3 bird marks on open eggs ( $G_{cor}=0.1$ ,  $d.f.=1$ ,  $NS$ ). Again, however, there was a significant site effect, one mammal at site I, 5 birds at site II, and 4 mammals + one bird at site III ( $G=10.2$ ,  $d.f.=2$ ,  $P<0.01$ ). The hypothesis that visible nests are predated by birds, using visibility keys for searching, and hidden nests by mammals, using olfactory keys, was rejected. There was no difference in the predators of hidden and visible nests. This is not surprising for mammals, since both hidden and visible nests have similar olfactory attractiveness. For birds, the finding of hidden nests at a similar rate

Tab. 1. Mayfield's daily nest survival rates of open passerine ground nests (100% visibility), and hidden nests (<20% visibility) at three study sites in the marshland Kis-Balaton, Western Hungary. The degree of freedom was 18 for all cases.

	Open	Hidden	<i>z</i>	Significance
Site I.	0.0297	0.0902	0.499	$P > 0.1$
Site II.	0.0004	0.0178	1.045	$P > 0.1$
Site III.	0.0000	0.0000	–	–

that the visible nests was an unexpected result.

Is there any explanation for the unexpected lack of visibility effect, lack of aggregation of depredated nests, and lack of difference between bird and mammal predations on hidden and visible nests? Although it is not possible to rule out alternative hypotheses, the most possible explanation is based on the changes in the environmental conditions. After several years of drought there was a lot of winter precipitation in 1998/99, and an artificial inundation occurred covering about 30% of the marshland. Therefore, formerly dry areas disappeared, and only the islands remained available for terrestrial species. They included both the potential predator mammal and bird species, as well as the ground nesting passerine species. As a consequence, the crowding of nest predators might led to a diverse and dense predator community. Consequently, many individuals and species with different searching strategies predated the nests. This high predation pressure of the diverse predatory community may have resulted in the lack of the expected differences.

The site (location) had strong effect on the depredation rate, and on the predatory community, which is not surprising.

Therefore, in spite of the supposed high density of the predators on the islands, still a high level of differences among the communities may exist.

The results of this study from a rarely studied habitat and geographic area supports earlier findings of site effects in nest predation studies. Further, the results highlight that environmental changes may confuse the expected "natural" patterns of nest predation.

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## Összefoglalás

### Mesterséges fészekaljok predációja a Kis-Balatonon: a hely és a láthatóság hatása

A mintavételi hely és a fészkek láthatóságának hatását vizsgáltam mesterséges madárfészkek predációjára a Kis-Balatonon. Erős lokalitáshatást találtam, azaz a három mintavételi hely között szignifikánsan eltérő predációs ráták voltak. Azonban nem volt különbség a rejtett (<20% látható a fészkek aljából), és látható (100% láthatóság) fészkek között. A predátorok (elsősorban varjúfélék és kismellős ragadozók) között sem volt különbség a rejtett és a látható fészkek között, de jelentős különbség volt a három mintavételi hely között. A láthatóság hatásának hiánya meglepő eredmény, de a Kis-Balaton vízszintjének emelése talán magyarázattal szolgálhat. Feltételezhető ugyanis, hogy a megemelkedett vízszint a még szárazon maradt területeken, mint ahol a vizsgálati helyek is voltak, kiugróan magas predátor sűrűséget koncentrált, ami extrém magas predációt eredményezett.

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