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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 & Hüe 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, Pellinger & 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±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±287.1 m^2 (SD) (range: 250-1000 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±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±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 detected 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.

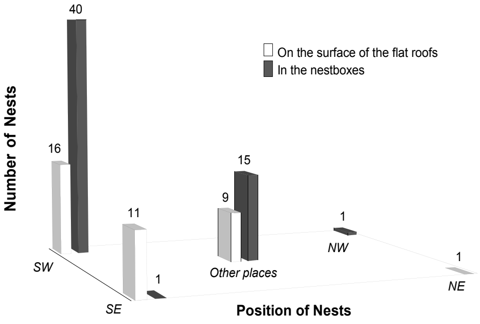

Fig. 1. The spatial distribution of nests according to their position on the surface of the flat roofs (n=37) and within the nestboxes (n=57). Ledge corners and nestbox corners are indicated as SW, SE, NE, NW corners. The open position category indicates nests built in central positions on the roofs 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%) 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).

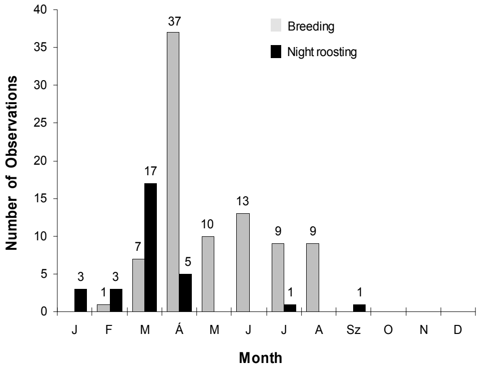

Fig. 2. Temporal distribution of nesting and night roosting on the flat roofs.

In the nestboxes the nest cavities were (diameter×depth) smaller than in the open ones ($\overline{x}_{\text{nestbox}}$=68.2×52.3 mm, n=3; $\overline{x}_{\text{open roof}}$=77.5×76.5 mm, n=2). The open nests were more than eight times heavier than the ones constructed in nestboxes ($\overline{x}_{\text{open roof}}$=309.1±258.4 g [SD], n=6; $\overline{x}_{\text{nestbox}}$=37.1±13.5 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

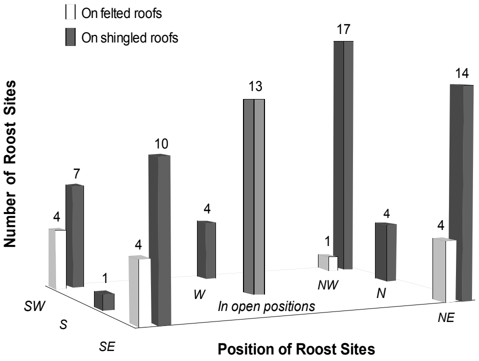

Fig. 3. The distribution of roost sites on the roofs. For legend see Fig. 1.

(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 $\bar{x}$=11.2×8.5×1.9 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 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

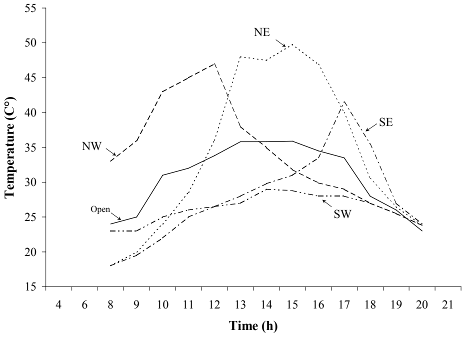

Fig. 4. The daily dynamics of temperature change in the ledge corners and in open positions of a shingled roof. Data was recorded during the daylight hours in completely cloudless weather (16.05.1990.).

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 nestbox 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 (17th May, 1990. 12 hour) the highest temperature, 53C°, 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 ($\overline{x}_{\text{shingle-covered roofs}}$=32.8C°, $\overline{x}_{\text{felted roofs}}$=32.8C°).

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).

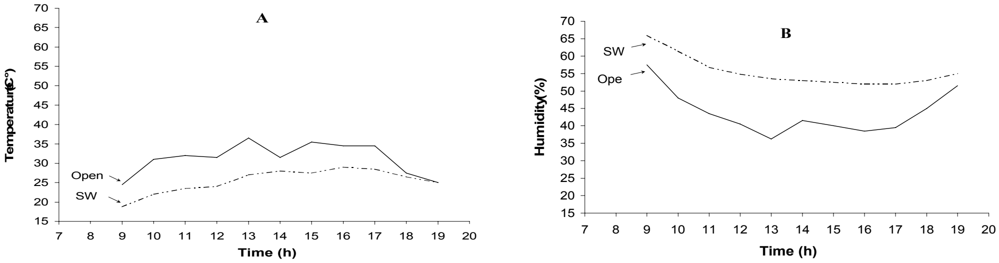

Fig. 5. The daily dynamics of temperature (A) and humidity (B) change on the same roof as in Fig. 4. measured in parallel with each other in open, sunlit position and in the south-western shadowed ledge corners (19.05.1990.).

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 – -15C° minimum temperatures are quite common, and temperatures between -20 – -34C° 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 10C°, while above 25C° 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 depressions 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 1m2 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

Fészeképítés 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 védettség volt a jellemző. Mivel a költési időszak az év legmelegebb hónapjaira esik, e fészekhelyek 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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