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# Availability of Kentish Plover (Charadrius alexandrinus) prey on a Central Hungarian grassland

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We studied the composition and density of potential prey of Kentish Plovers by 'sticky trapping' both on foraging and breeding areas. Collembola (64%) and Diptera (27%) were the most numerous prey by number out of 14063 items, although Diptera represented the greatest proportion by dry mass (86%). Peak density of prey occurred at the end of May on both types of areas. Both density and dry mass of prey were significantly higher on the foraging area, compared to the breeding area. The expected number of clutches hatching over time was positively correlated with both prey density ($r_s$=0.65), and prey mass ($r_s$=0.56). This supports the hypothesis that females time egg-laying so that hatching date coincides with high prey-abundance.

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## 1. Introduction

A knowledge of prey availability is important to many aspects of avian behaviour and ecology. Food resources can affect mating patterns (Emlen & Oring 1977, Davies 1991), parental care (Beissinger & Snyder 1987, Lyon *et al.* 1987), breeding dispersion (Lack 1968), clutch-size (Lack 1954, Bengtson 1971) and egg-size (Bolton *et al.* 1992). However, despite the importance of food availability, few studies have attempted to gather quantitative data about the composition and abundance of potential food resources in shorebirds (but see Maxson & Oring 1980, Lank *et al.* 1985, Baines 1990, Grant *et al.* 1992).

Food availability could determine egg-laying patterns in two ways. Females may lay eggs when the food availability is high, or they may time their egg-laying so that hatching coincides with the peak abundance of prey. Abundance of insects varies dramatically over a breeding season (Maxson & Oring 1980), so females should decide whether to wait until food abundance reaches a critical level and then start laying, or whether to start laying right after returning from wintering grounds. Lank *et al.* (1985) suggested that an increase in nutrient availability initiated the onset of breeding in Spotted Sandpiper *Actitis macularia*. However, in a previous study we found no evidence in support of this suggestion in Kentish Plovers: egg formation occurred during a period of low food availability (Székely *et al.* 1994). In this study we investigate an alternative hypothesis: whether egg-laying is timed to provide the chicks with high levels of food availability at hatching and during brood rearing (Lack 1954). This study, then, has two aims: (i) to report on the composition

Tab. 1. Composition and height of vegetation in one m around five traps in the foraging and breeding area (mean±SE). Height of plants were estimated in five random points. Vegetation was sampled on 9 July, 1992. Probabilities of Mann-Whitney U tests are shown.

| | Foraging area | Breeding area | P |
|---|---|---|---|
| Cover by all plants (%) | 80±8 | 36±10 | 0.02 |
| Cover by | | | |
| *Puccinellia distans* (%) | 96±3 | 22±14 | 0.007 |
| *Lepidium cartilagineum* (%) | 2±2 | 64±15 | 0.007 |
| *Camphorosma annua* (%) | 0±0 | 14±8 | 0.05 |
| *Phragmites communis* (%) | 2±2 | 0±0 | 0.32 |
| Height of vegetation (cm) | 3.6±0.7 | 7.7±0.7 | 0.01 |

and density of potential prey, and (ii) to relate prey density and biomass to the timing of hatching in the Kentish Plover.

## 2. Methods

### 2.1. Study site

The study was carried out in 1991 in an alkaline grassland of about 2000 ha in central Hungary (Miklapuszta) (46°40'N, 19°10'E). Miklapuszta is the most important breeding area for Kentish Plovers in the Carpathian Basin with about 60-80 pairs breeding each year. Field work started in the last week of March, and finished in the second week of July. Clutches were typically found in early stage of incubation. Once a chick started to peep in the egg, nest visits were usually made every day. Hatching date of 10 nests were known ('successful clutches'). The expected hatching dates of 46 additional clutches were calculated based on the 'floatation stage' of egg (Noszály 1992) and assuming a 24 d incubation period (unpubl. data). These clutches either failed during incubation (N=22) or were involved in a clutch-size manipulation experiment (N=24) (Székely *et al.* 1994).

### 2.2. Prey sampling

Arthropods were sampled on both foraging and breeding areas of Kentish Plovers (Fig. 1). Traps in the foraging area were located between the road No. 53 and a canal ('Sós-ér'), 100 m from a shepherd's hut ('Piros-szin'). This was the first place where we saw Kentish Plovers in 1991 (25 March), and where Kentish Plovers foraged throughout the breeding season e.g. 11 Kentish Plovers on 11 April. The traps in breeding area were between the highest point of Miklapuszta ('Kuksos-domb') and a canal ('Sós-ér') approximately 600 m from 'Kuksos-domb'. Seven clutches were laid within 300 m of the traps on breeding area. Vegetation consisted of *Puccinellia distans*, *Lepidium cartilagineum* and *Camphorosma annua* on both areas. Vegetation cover was lower on the breeding area than on the foraging area (Tab. 1).

Ten traps were used to estimate prey availability on both the foraging and breeding areas (Fig. 1). The traps were arranged in two lines on each area and the distance between traps was 50 m. Each trap consisted of a 10 cm by 10 cm glass plate wrapped in a plastic film. The upper surface of the film was covered by HYVIS sticky glue. The traps were exposed on the third or fourth day of each eight day period starting on 2 March, and they were collected 48±2 h later. Five traps were analysed in both areas for this study.

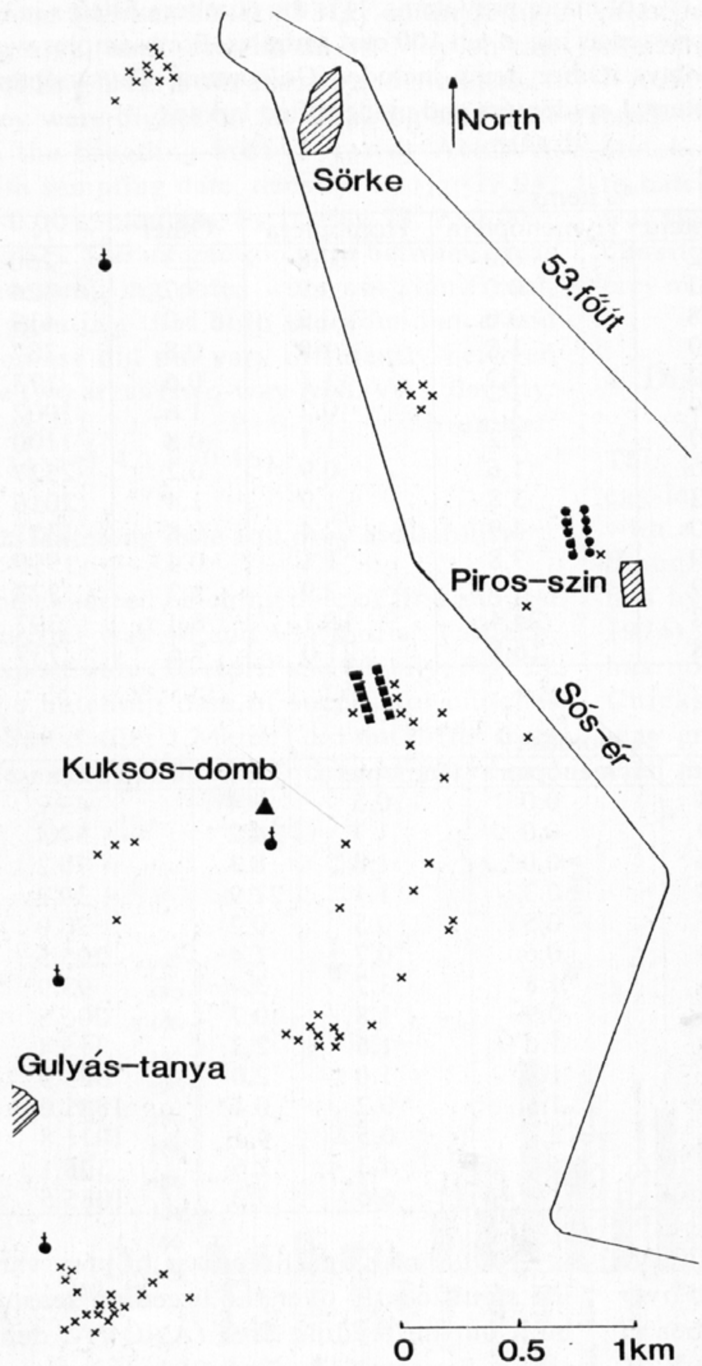


Fig. 1. The study area ('Miklapuszta') in 1991. Arthropod traps are marked by black dots in foraging area and by black squares in the breeding area. Clutches are marked by x (N=66), the shepherd's huts by shaded areas and the wells ('gémeskut') by black dots with cross. The position of the highest point ('Kuksos-domb') is marked by black triangle.

Following collection the length of each prey item was measured from the head to the posterior end. The average number of arthropods in ten traps were used to estimate prey density (no. of items/100 $cm^2$). Dry mass was estimated from the length of arthropods using the equation provided in Rogers *et al.* (1976). Dry masses of arthropods were weighted by the number of arthropods per trap, and the weighted means were used as the index of biomass (mg/100 $cm^2$). Since Kentish Plovers fed both on breeding and feeding areas we took the mean density and dry mass of these samples as representative of average food supply.

### 2.3. Statistical analyses

Logarithmic transformations were applied to each variable tested by ANOVA. F values with degrees of freedom are indicated (main effect or interaction, residual). Non-normal variables were tested by Mann-Whitney U tests, Kruskal-Wallis tests and by Spearman-rank correlation. Mean±SE and two-tailed probabilities are given.

## 3. Results

### 3.1. Composition, density and biomass of prey

Collembola, Diptera, Homoptera and Hymenoptera were the most common items in the prey samples, representing 63.6%, 26.9%, 5.1% and 3.0% of items, respectively by number, and 6.6%,

Tab. 2. Composition (%) and biomass (%) of major prey items. N is the number of items in ten 100 $cm^2$ samples. Total biomass is expressed as mg in ten 100 $cm^2$ samples. Prey samples were collected by sticky glue traps for 2 days. Other items included Coleoptera, Thysanoptera, Araneida, Psocoptera, Acarina, Hemiptera, Lepidoptera and unidentified larvae.

a. Composition

| | % items | | | | | |
|---|---|---|---|---|---|---|
| Date of sampling | Collembola | Diptera | Hymenoptera | Homoptera | Other | N |
| 25 March | 92.7 | 4.2 | 0.0 | 0.8 | 2.3 | 260 |
| 2 April | 91.1 | 4.3 | 0.0 | 0.9 | 3.7 | 326 |
| 10 April | 93.3 | 4.8 | 0.0 | 0.9 | 1.0 | 419 |
| 19 April | 90.7 | 4.9 | 1.8 | 1.8 | 0.8 | 387 |
| 26 April | 84.4 | 8.7 | 5.2 | 1.1 | 0.6 | 173 |
| 4 May | 84.1 | 7.9 | 5.7 | 0.7 | 1.6 | 1002 |
| 12 May | 84.9 | 8.0 | 5.2 | 1.1 | 0.8 | 1100 |
| 20 May | 92.3 | 5.0 | 1.6 | 0.9 | 0.2 | 2527 |
| 28 May | 78.6 | 14.3 | 3.8 | 1.9 | 1.4 | 2016 |
| 5 June | 57.9 | 34.0 | 4.9 | 2.4 | 0.8 | 1351 |
| 14 June | 29.8 | 64.9 | 3.8 | 1.1 | 0.4 | 1999 |
| 21 June | 24.6 | 62.9 | 7.3 | 2.9 | 2.3 | 1373 |
| 29 June | 4.3 | 46.8 | 24.4 | 18.1 | 6.4 | 393 |
| 7 July | 11.8 | 42.8 | 16.8 | 21.0 | 7.6 | 737 |

b. Biomass

| | % biomass | | | | | |
|---|---|---|---|---|---|---|
| Date of sampling | Collembola | Diptera | Hymenoptera | Homoptera | Other | Total biomass |
| 25 March | 89.7 | 6.4 | 0.0 | 0.5 | 3.4 | 43.2 |
| 2 April | 50.1 | 14.0 | 0.0 | 1.7 | 34.2 | 34.4 |
| 10 April | 72.5 | 17.4 | 0.0 | 1.8 | 8.3 | 70.2 |
| 19 April | 36.9 | 39.8 | 0.3 | 1.1 | 21.9 | 39.2 |
| 26 April | 25.7 | 73.1 | 0.5 | 0.5 | 0.2 | 20.0 |
| 4 May | 15.5 | 81.8 | 0.6 | 0.7 | 1.4 | 205.5 |
| 12 May | 33.5 | 57.6 | 1.8 | 3.7 | 3.4 | 93.9 |
| 20 May | 37.0 | 59.6 | 0.9 | 1.8 | 0.7 | 206.5 |
| 28 May | 21.7 | 72.9 | 1.6 | 1.6 | 2.2 | 315.4 |
| 5 June | 2.8 | 92.3 | 1.9 | 1.0 | 2.0 | 523.0 |
| 14 June | 1.1 | 97.0 | 1.6 | 0.2 | 0.1 | 1881.0 |
| 21 June | 1.1 | 91.6 | 2.7 | 0.5 | 4.1 | 1011.8 |
| 29 June | 0.3 | 67.4 | 25.4 | 4.3 | 2.6 | 308.1 |
| 7 July | 0.3 | 88.3 | 1.6 | 6.6 | 3.2 | 1085.5 |

86.1%, 3.0% and 2.0% by biomass (Table 2). Composition of prey items varied over the breeding season (Tab. 2). Number of Diptera, Homoptera and Hymenoptera increased over the breeding season (Diptera: $r_S=0.751$, $P<0.001$, N=140; Homoptera: $r_S=0.700$, $P<0.001$, N=140; Hymenoptera: $r_S=0.671$, $P<0.001$, N=140) and the number of Collembola decreased ($r_S=-0.169$, P=0.023, N=140).

Total density and biomass of prey varied significantly over the breeding season both on the feeding area (ANOVA, density: $F_{13,56}=9.32$, $P<0.001$; biomass: $F_{13,56}=22.20$, $P<0.001$) and on the breeding area (ANOVA, density: $F_{13,56}=6.27$, $P<0.001$; biomass: $F_{13,56}=10.79$, $P<0.001$). Prey density varied 15 fold, and prey biomass 85 fold over the whole season. The peak density of arthropods occurred between 20-22 of May on the foraging area, and between 28-30 May on the breeding area. Both density and biomass of prey were higher on the foraging area than on the breeding area (two-way ANOVA with sampling date, density: $F_{1,112}=37.94$, $P<0.001$; biomass: $F_{1,112}=69.73$, $P<0.001$; Fig. 2). The interaction term between areas and sampling dates were not significant, suggesting that both the abundance and biomass did not vary differently between the two areas (two-way ANOVAs, density: $F_{13,56}=1.30$, $P=0.22$; biomass: $F_{13,112}=1.42$, $P=0.16$).

### 3.2. Hatching date and prey availability

The expected hatching date of first and last clutches was 46 and 134 d after 1 March, respectively (16 April and 13 July; Fig. 2). The hatching date of successful clutches (95±9 d after 1 March) did not differ from the expected hatching date of failed and manipulated clutches (93±4 d after 1 March) (Mann-Whitney U test, z=0.12, P=0.90), therefore they were pooled for each eight-day periods. The number of clutches which hatched or were expected to hatch on consecutive eight day periods was significantly correlated with both prey density ($r_s=0.647$, P=0.006, N=14), and prey mass ($r_s=0.560$, P=0.019, N=14) (Fig. 3).

## 4. Discussion

This study has shown that females time egg-laying so that hatching date coincides with a high level of prey abundance. Although previous studies have discussed this hypothesis (Holmes 1966, Nettleship 1974), as far as we know, this relationship has not been shown for any shorebird. Chicks hatched when food is abundant may grow faster, and may survive better, than those hatched during less favourable

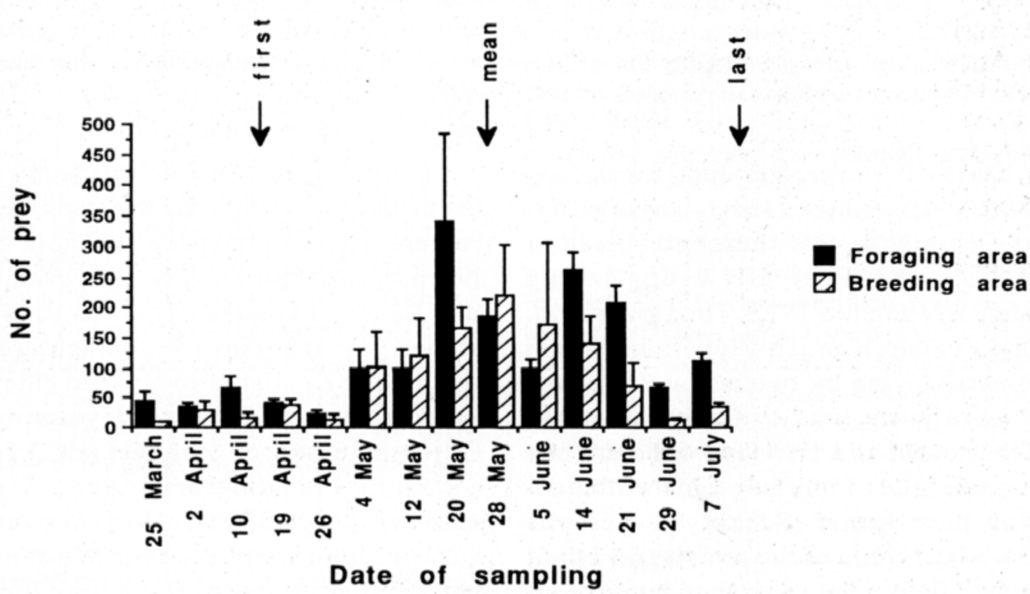


Fig. 2. Density of preys (no. of items/100 cm$^2$ of trap) on the foraging and breeding area (mean±SE). Five traps were used on both areas. Prey density was higher on the foraging area than on breeding one (two way ANOVA with sampling date, $F_{1,112}=37.94$, $P<0.001$). The expected hatching date of first and last clutch of the breeding season as well as the mean expected hatching date of all clutches are indicated.

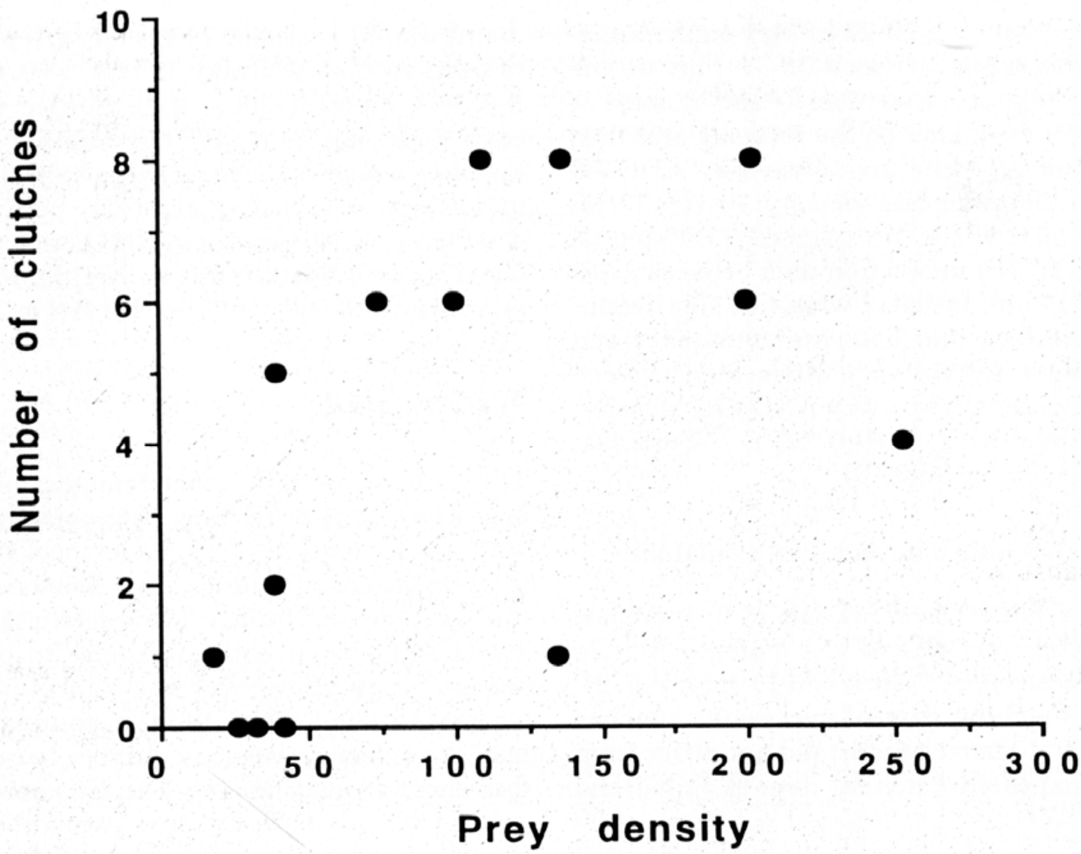


Fig. 3. Relation between prey density (no. of items/100 $cm^2$ of trap) and number of clutches hatched or expected to hatch over eight day periods ($r_S$=0.647, P=0.006).

conditions. However, our study did not exclude the alternative 'early laying' hypothesis which is that shorebirds breed as soon as conditions allow egg-laying (Hilden & Vuolanto 1972, Thompson *et al.* 1986). Female Kentish Plovers may gain from early laying by two ways. First, they may have more time to lay replacement clutch should the first one fail, or they have more time to find a new mate after deserting their brood (Székely & Lessells 1993). Since some of the females laid their eggs well before the peak abundance of insects, these females may have timed their egg-laying to gain some advantage other than from the greatest abundance of food for their precocial chicks.

A possible criticism of this study is that the arthropods caught by the traps were not representative of the prey available to, and taken by, Kentish Plovers. However, this is not likely, because other studies have shown, by analyses of stomach contents that inland Kentish Plovers feed chiefly on insects such as Diptera, Hymenoptera, Coleoptera and on Araneidae (Cramp & Simmons 1983, Sterbetz 1988). We also observed that Kentish Plovers feed on Collembola (unpubl. obs.). We therefore believe that the prey sampled by the traps corresponded to the true prey availability and included the main prey taken by Kentish Plover.

In Hungary Kentish Plovers breed in

two types of habitat: in alkaline grasslands or in the bottom of dried fish-ponds (Székely 1992). The common features of these sites are that they provide bare ground with low vegetation cover for breeding, and that they appear to be insect-rich. Plovers breeding at fish-pond areas feed on the water's edge, while grassland breeders prefer to forage on areas grazed by sheep. Kentish Plovers most often fed on three areas in Miklapuszta, and all of these areas were typically trampled four times a day by sheep flocks. The management implication of this study is, then, to point out the importance between sheep-grazing and breeding of Kentish Plover. Because Kentish Plovers seem to depend on extensive sheep-farming in Miklapuszta, the population is vulnerable to minor changes in sheep-farming techniques. It is not known which types of insects attract Kentish Plover to grasslands grazed by sheep. These might be a particular group of insects e.g. Diptera developing in sheep dung, or merely the average insect density. Whether the relationship between sheep grazing and presence of Kentish Plover proposed here is correct is not known, but it certainly deserves further investigation.

In conclusion, this study found high variation in both prey density and biomass over the breeding season. Both density and biomass of prey were positively correlated with the expected number of hatching clutches. We propose that sheep have an important role in breeding of Kentish Plovers in Hungary, perhaps by providing breeding place (e.g. dung) for their insect prey.

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## Összefoglalás

**A széki lile *Charadrius alexandrinus* táplálékkínálata egy közép-magyarországi szikespusztán**

A széki lile potenciális táplálékkínálatát vizsgáltuk 1991-ben ragadós rovarcsapdák segítségével Miklapusztán. Kéttípusú területen csapdáztunk: táplálkozó- és fészkelőterületen. Collembola (64%) és Diptera (27%) volt a legnagyobb egyedszámú az 14063 ízeltlábú közül, habár Diptera képviselte a legnagyobb száraz biomasszát (86%). Az ízeltlábúak csúcsidőszaka május végén volt a táplálkozó- és a fészkelőterületen egyaránt. Az ízeltlábúak denzitása és száraz biomasszája nagyobb volt a táplálkozóterületen, mint a fészkelőterületen. A lerakott fészekaljak száma pozitívan korrelált a kelés idejére várható ízeltlábúak denzitásával ($r_s$=0.65) és száraz biomasszájával ($r_s$=0.56). A vizsgálat következtetése, hogy a táplálékdenzitás fontos szerepet tölt be a széki lile szaporodásában. A táplálékgazdagság fenntartásában és/vagy specifikus táplálékcsoportok biztosításában kiemelt szerepe van a juhlegeltetésnek. A dolgozat rámutat, hogy az extenzív juhtartási mód megváltoztatásával vagy a juhfalkák számának csökkenésével a széki lile hazai fészkelőállománya veszélybe fog kerülni.

## References

Baines, D. 1990. The roles of predation, food and agricultural practice in determining the breeding success of the Lapwing (*Vanellus vanellus*) on upland grasslands. – J. Anim. Ecol. 59: 915-929.

Beissinger, S.R. & N.F.R. Snyder. 1987. Mate desertion in the snail kite. – Anim. Behav. 35: 477-487.

Bengtson, S.A. 1971. Variations in clutch-size in ducks in relation to the food supply. – Ibis 113: 523-526.

Bolton, M., Houston, D. & P. Monaghan. 1992. Nutritional constraints on egg formation in the lesser black-backed gull: an experimental study. – J. Anim. Ecol. 61: 521-532.

Davies, N.B. 1991. Mating systems. pp. 263-294. In: Krebs, J.R. & N.B. Davies. (eds) Behavioural Ecology. – Blackwell, Oxford.

Cramp, S. & K.E.L. Simmons. 1983. The Birds of the Western Palearctic. Vol. 3. – Oxford University Press, Oxford.

Emlen, S. T. & L.W. Oring. 1977. Ecology, sexual selection, and the evolution of mating systems. – Science 197: 215-223.

Grant, M.C., Chambers, R.E. & P.E. Evans. 1992. The effects of re-seeding heathland on breeding whimbrel *Numenius phaeopus* in Shetland. II. Habitat use by adults during pre-laying period. – J. Appl. Ecol. 29: 509-515.

Hilden, O. & S. Vuolanto. 1972. Breeding biology of the Red-necked Phalarope *Phalaropus lobatus* in Finland. – Ornis Fennica 49: 57-85.

Holmes, R.T. 1966. Breeding ecology and annual cycle adaptations of the Red-backed Sandpiper (*Calidris alpina*) in Northern Alaska. – Condor 68: 3-46.

Lack, D. 1954. The natural regulation of animal numbers. – Clarendon Press, Oxford.

Lack, D. 1968. Ecological Adaptations for Breeding in Birds. – Chapman & Hall, London.

Lank, D.B., Oring, L.W. & S.J. Maxson. 1985. Mate and nutrient limitation of egg-laying in a polyandrous shorebird. – Ecology 66: 1513-1524.

Lyon, B.E., Montgomerie, R.D. & L.D. Hamilton. 1987. Male parental care and monogamy in snow buntings. – Behav. Ecol. Sociobiol. 20: 377-382.

Maxson, S.J. & L.W. Oring. 1980. Breeding season time and energy budgets of the polyandrous Spotted Sandpiper. – Behaviour 74: 200-263.

Nettleship, D.N. 1974. The breeding of the Knot *Calidris canutus* at Hazen Camp, Ellesmere Island, N.W.T. – Polarforschung 44: 8-26.

Noszály, G. 1992. A széki lile (*Charadrius alexandrinus*) fészekalj- és tojásméretváltozása a fészkelési időszak alatt. – Unpubl. Diploma thesis, Kossuth University, Debrecen.

Rogers, L.E., Hinds, W.T. & R.L. Buschbom. 1976. A general weight vs. length relationship for insects. – Ecology 69: 387-389.

Sterbetz, I. 1988. Observation on the feeding of waders at Kardoskút-Fehertó, SE-Hungary. – Aquila 95: 142-161.

Székely, T. 1992. Reproduction of Kentish Plover *Charadrius alexandrinus* in grasslands and fishponds: the habitat mal-assessment hypothesis. – Aquila 99: 59-68.

Székely, T., Karsai, I. & T.D. Williams. 1994. Determination of clutch-size in the Kentish Plover *Charadrius alexandrinus*. – Ibis 136: 341-348.

Székely, T. & C.M. Lessells. 1993. Mate change by Kentish Plovers *Charadrius alexandrinus*. – Ornis Scandinavica 24: 317-322.

Thompson, D.B.A., Thompson, P.S. & D. Nethersole-Thompson. 1986. Timing of breeding and breeding performance in a population of Greenshanks (*Tringa nebularia*). – J. Anim. Ecol. 55: 181-199.