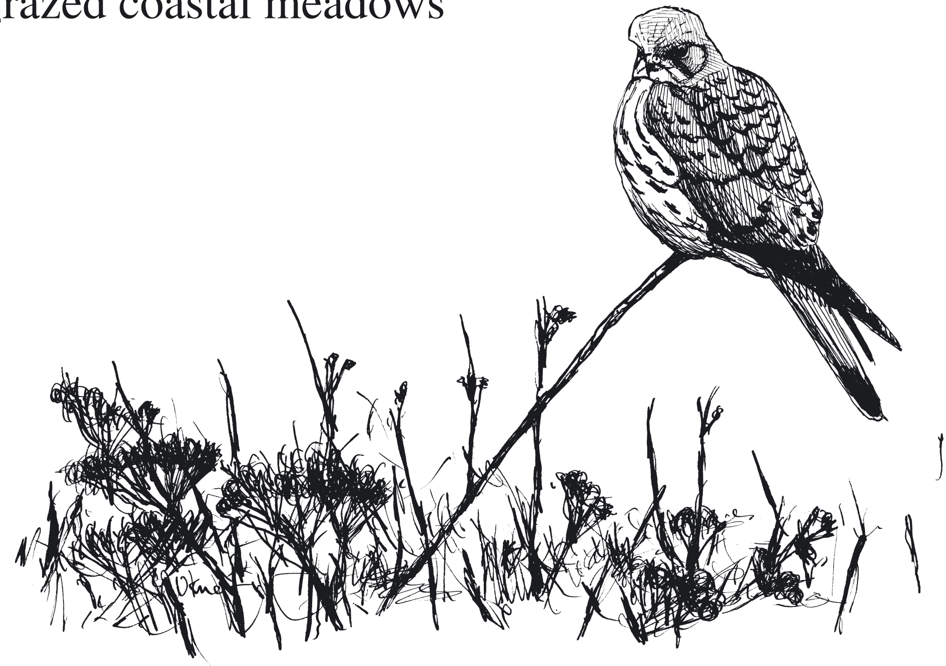
Diet of Kestrels *Falco tinnunculus* on grazed coastal meadows



NIELS M. SCHMIDT, HANNE HÜBERTZ and HENRIK OLSEN

(Med et dansk resumé: Fødesammensætning hos Tårnfalk Falco tinnunculus *på afgræssede strandenge)*

Introduction

Throughout its range, Kestrels *Falco tinnunculus* consume a wide variety of prey species, such as arthropods, lizards, birds, bats, and other small mammals (Cramp & Simmons 1980, Negro et al. 1992, Van Zyl 1994, Aparicio 2000). The diet of Kestrels in Europe, and particularly in northern Europe, is generally dominated by vole species (Korpimäki 1985, Korpimäki & Norrdahl 1991), though insects are frequently consumed too (Yalden & Walburton 1979).

The Kestrel is the most common bird of prey in Europe (Génsbøl 1987), and inhabits a wide variety of open habitats, including open cultivated land and more extensively utilised areas like meadows (Génsbøl 1987, Jørgensen 1998a,b). On such areas livestock grazing is common, and grazing is an important tool in today's nature management. Grazing is known to affect the abundance and distribution of a large number of organisms (reviewed by Milchunas et al. 1998), such as plants (e.g. Smith & Rushton 1994), macro-arthropods (e.g. Lavigne et al. 1972), birds (e.g. Fuller & Gough 1999), and small mammals (Grant et al. 1982, Hayward et al. 1997). Hence, changes induced by grazing upon the lower trophic levels may be traceable up the food chain to apex predators.

The aim of the present study is to describe and contrast the diet composition of Kestrels with prey availability in coastal meadows exposed to three different grazing intensities, and thus, to assess the indirect influence of livestock grazing on Kestrel foraging opportunities.

Material and methods

Kestrel pellets were collected in autumn 1999 at a bird watch tower used by Kestrels as a perch site, located in the centre of the Klydesø reserve (55°36'N, 12°32'E) on Amager, Denmark. The approximately 4 km^2 reserve is part of a 25 km^2 area reclaimed from the sea in 1945. The area was used as a military target range until 1984, when the entire area was left as a nature area. In the attempt to prevent the deterioration of the Klydesø reserve as a breeding ground for waders by the overgrowth of the coastal meadows with shrubs, and especially the tall bush grass *Calamagrostis epigeios*, livestock grazing was introduced in large parts of the area in 1991.

Small-mammal availability was assessed from quarterly live-trappings conducted in connection with another study (Schmidt et al. 2000), and more trapping details are given therein. Traps were placed in pens subject to one of three different grazing intensities: *high* (1.8 steer per hectare), *low* (0.7 steer per hectare), and an ungrazed *control*. On each treatment (10 ha) we used two replicate square grids of 36 Ugglan traps, placed 10 m apart. Ugglan Lemming and Ugglan Special alternated between lines. Traps were filled with hay and rolled oats, and were left open on the grids for 24 hours prior to the trapping sessions. We trapped for three days and nights every three months. Traps were checked once a day, in the early morning.

All grazing treatments were located within 300-500 m from the bird watch tower where the pellets were collected.

Due to the small number of mammals trapped during each trapping session, we here use the total number of individuals of each species caught during 1998-2000 on each treatment as an index of the availability and species composition of small mammals. Previous trappings in the reserve during 1992-96 (Jensen & Frandsen 1998) resulted in species compositions in line with those obtained in the present study.

Since we did not know the size of the prey consumed by Kestrels, we used the number of individuals rather than biomass in our analyses.

Kestrel pellets were carefully broken up under microscope (20×). Prey was identified using teeth, skull and fur remains or, in the case of non-mammal remains, other hard parts.

Results

A total of 96 small mammals were recovered from the 104 Kestrel pellets examined. Owing to the high rate of digestion by Kestrels (Yalden & Yalden 1985), prey could only be identified as 'mammals' in 20 of the pellets. Field voles *Microtus agrestis* occurred most frequently (91% of pellets) and constituted 82% of the prey individuals recovered (Fig. 1). Common shrew *Sorex araneus* and pygmy shrew *S. minutus* were found

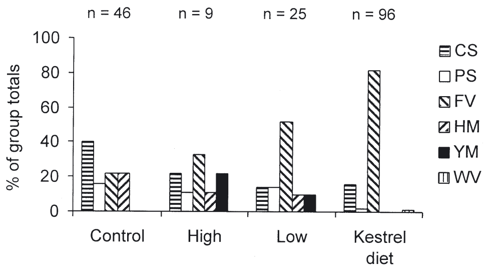


Fig. 1. Small mammal species composition on three grazing treatments and in the diet of Kestrels. Abbreviations: CS common shrew, PS pygmy shrew, FV field vole, HM harvest mouse, YM yellow-necked mouse, WV water vole. Numbers above bars indicate sample size.
Artssammensætning af småpattedyr på tre græsningsintensiteter og i tårnfalkegylp. Anvendte forkortelser er: CS almindelig spidsmus, PS dværgspidsmus, FV nordmarkmus, HM dværgmus, YM halsbåndmus, WV mosegris. Tal over søjlerne angiver størrelsen af stikprøven.

in 16% and 2% of the pellets, respectively, and constituted 16% and 2% of the prey individuals recovered. One pellet contained the remains of a young water vole *Arvicola terrestris*. The elytra of a beetle were recovered from one pellet.

The abundance of small mammals varied among the three grazing intensities. The total number trapped was highest on *control* (n = 47) and lowest on *high* (n = 9), whereas an intermediary number (n = 25) was trapped on *low* (Fig. 1).

The species composition of small mammals was dominated by field vole and common shrew in all trapping sessions. Before subjecting the species frequencies to chi-square tests, we lumped harvest mouse *Micromys minutus*, yellow-necked mouse *Apodemus flavicollis* and water vole into one group, thereby avoiding too small frequencies. The species composition varied significantly among grazing treatments (Fig. 1) ($\chi^2 = 28.0$, df = 6, P = 0.0001), and in pairwise chi-square tests *control* differed significantly from both *low* and *high* ($\chi^2 = 27.6$, df = 3, P << 0.001, and $\chi^2 = 14.8$, df = 3, P = 0.002, respectively). No difference was found between *high* and *low* ($\chi^2 = 1.30$, df = 3, P = 0.73). Kestrel diet composition showed a preference for field voles (Fig. 1) and differed significantly from the species composition found on all three grazing intensities, as shown by pairwise chi-square tests (χ^2 between 24.4 and 81.0, df = 3, P << 0.001).

Female Kestrel. Photo: John Larsen.
På det inddæmmede areal på Vestamager foretrak Tårnfalkene nordmarkmus, som der var flest af på moderat græssede arealer.

Discussion

The present study documented a dominance of field voles in terms of individuals in the Kestrel pellets and, when compared to the species composition of small mammals on the three grazing treatments, a preference for this species was suggested irrespective of grazing intensity. Conversely, common shrews, and especially pygmy shrews, were consumed less frequently than expected from their apparent availability. Neither harvest mouse nor yellow-necked mouse were found in the pellets although both species occurred on the meadows in the autumn. The absence of yellow-necked mouse from the pellets is probably connected with the nocturnal habits of this species (e.g. Corp et al. 1997), but may also be attributed to the small sample size. Due to the trapping set-up, we were unable to estimate the availability of water voles, but their low frequency of occurrence in pellets suggests that this species is unimportant as Kestrel prey in the study area.

A preference for *Microtus* voles as found in this study has previously been reported by Village (1982), Korpimäki (1985, 1986), and Korpimäki & Norrdahl (1991), who also found the number of Kestrel breeding pairs to be positively correlated with vole abundance. In this respect it is noteworthy that no common voles *M. arvalis* were found in the Klydesø reserve.

The three grazing treatments applied in the present study influenced both the overall availability and the species composition of small mammals. The *high* grazing intensity treatment resulted in a very low prey availability of which, furthermore, one third could be attributed to transient yellow-necked mice in the autumn. The ungrazed *control* held the largest number of small mammals, while the number was intermediary on the *low* treatment. Hence, it seems likely that livestock grazing influences the foraging opportunities of Kestrels and, possibly, their numbers and breeding success.

Differences in prey availability among treatments reflect differences in a number of habitat variables, including differences in predation risk. Being visual hunters, Kestrel hunting success is limited by the vegetation cover, which is probably why small mammals in the study area are mainly trapped in tall, dense vegetation (Schmidt et al. 2000). Increasing grazing intensity results in a decreasing number and size of patches with tall and dense vegetation, and in a decreased vegetation cover in general. Andreassen & Ims (1998) found predation by avian predators to be the main mortality cause for voles in habitats consisting of vegetation patches and showed that the risk of predation was highest in habitats with long inter-patch distances.

This suggests that the described effect of grazing on small-mammal abundance is caused by a differentiated predation pressure. However, Kestrels were often observed foraging on *control* and *low*, but were only rarely seen hunting on the *high* treatment. Differentiated predation pressure is therefore likely to have amplified, but not caused, the differences observed among treatments.

Unfortunately, we do not have data on where the Kestrel prey was actually caught, so we can only speculate on the effect of grazing on Kestrel foraging opportunities. However, grazing has previously been suggested as an important parameter for birds of prey e.g. by Watson & Clarke (2000) who suggested that the abandonment of grazing and the corresponding decrease in prey availability (susliks *Spermophilus* sp.) was an important factor behind the decline of Saker Falcons *Falco cherrug* in Kazakhstan. In the present study, grazing at low intensities may have been the most favourable treatment for Kestrels because *low* treatment had a higher relative frequency of field voles than the other two treatments and at the same time supported a fairly high abundance of potential prey. Moreover, Kestrel hunting success will probably increase with grazing intensity due to the decrease in vegetation cover. Thus, although the ungrazed *control* had the highest prey abundance, the prey may have been less accessible than on the other treatments. In addition, the ungrazed control held the largest fraction of shrews which were avoided by Kestrels. Similarly, most likely Kestrel hunting success was highest on the *high* treatment, but here prey abundance was low.

However, a mosaic of areas with low-intensity grazing and ungrazed areas would probably produce the highest prey availability, since the latter may function as a source of small mammals for the grazed and more easily hunted areas. Unfortunately, low-intensity grazing seems unable to prevent the spread of bush grass on coastal meadows (H. Olsen & M.L. Jørgensen unpubl. data), and future management may therefore have to be based upon intensively grazed pens. This could result in a declining occurrence of Kestrels on the meadows of the Klydesø reserve.

Summary
The diet of Kestrels on a grazed coastal meadow in Denmark was investigated by pellet analysis. Compared to the availability of small mammal species, Kestrels showed a preference for field voles *Microtus agrestis* which made up 80% of the prey numbers. Common shrew *Sorex araneus*, pygmy shrew *S. minutus*, and water vole *Arvicola terrestris* were also found. Three grazing intensities were investigated of which the *high* grazing treatment resulted in low prey densities and the *low* grazing treatment in intermediary prey densities, compared to the ungrazed control areas. The fraction of field voles, however, was largest in areas with grazing of low intensity, and prey on the ungrazed areas may have been less accessible to Kestrels due to an extensive vegetation cover, so grazing at low intensity could be more beneficial for Kestrels than either no grazing or grazing at high intensity.

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Resumé
Fødesammensætning hos Tårnfalk *Falco tinnunculus* **på afgræssede strandenge**

Fødesammensætningen hos Tårnfalk på en afgræsset strandeng i Danmark blev undersøgt ved analyser af byttedyr-rester i gylp. Nordmarkmus *Microtus agrestis* udgjorde ca 80% af de indtagne byttedyr, mens almindelig spidsmus *Sorex araneus*, dværgspidsmus *S. minutus* og mosegris *Arvicola terrestris* udgjorde mindre fraktioner af føden. Sammenlignes Tårnfalkens fødesammensætning med tilgængeligheden af småpattedyr, var der en præference for nordmarkmus. De tre græsningsintensiteter på den undersøgte strandeng resulterede i store forskelle i mængden af byttedyr og til dels også i disses artssammensætning. Den uafgræssede kontrol havde de højeste tætheder af bytteddyr, mens høj græsningsintensitet førte til meget lave tætheder og lav græsningsintensitet til middelstore tætheder. Artssammensætningen på den uafgræssede kontrol var dog domineret af spidsmus, mens nordmarkmus udgjorde den største fraktion på den lave græsningsintensitet. Desuden kan småpattedyr på uafgræssede områder være mere eller mindre utilgængelige for Tårnfalk pga. det tætte vegetationsdække her. Sammenlignet med den høje græsningsintensitet og den uafgræssede kontrol kan den lave græsningsintensitet derfor have tilgodeset Tårnfalkens fouragering bedst.

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Niels M. Schmidt (nms@kvl.dk), Hanne Hübertz, Henrik Olsen

Department of Ecology, Zoology Section,

The Royal Veterinary and Agricultural University,

Thorvaldsensvej 40,

1871 Frederiksberg C, Denmark