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Food choice and feeding by male and female Common Treecreepers (*Certhia familiaris*) during the nestling period

Jukka Suhonen[1] & Markku Kuitunen[2]

[1]Department of Biology, University of Jyväskylä, Konnevesi Research Station, SF-44300 Konnevesi, Finland
[2]Department of Biology, University of Jyväskylä, Yliopistonkatu 9, SF-40100 Jyväskylä, Finland

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Decreased intensity of interspecific competition may be expected to lead to increased variation within the population, especially in the form of sexual dimorphism. As the Common Treecreeper is the only species belonging to the so-called trunk-foraging guild in the coniferous study area in Central Finland, apart from the more strongly billed woodpeckers, its foraging behaviour and/or sites could be expected to differ between the sexes. Moreover, the sexual dimorphism in this species is considerable.

About 99% of the food items used by the Common Treecreepers were arthropods. Aphids were the most frequent, but spiders were most important by weight (65%). This pattern did not change with the nestling age. Taxonomically the nestling food was diverse.

The average food load contained 14.2 items (24.2 mg) and did not differ between the sexes. The number of food items per load decreased with increasing mean prey weight. The content of the load differed slightly between the sexes. Load weight increased with the age of the nestling in females, but not in males. These results suggest that the sexes may differ in their foraging sites.

1. Introduction

Sexual dimorphism in avian species could be expected to be a consequence of an adaptation to differentiated foraging behaviour (e.g. Selander 1966, Gosler 1987), indicating differences in resource partitioning (e.g. Hespenheide 1973), which may be advantageous because they will reduce competition between the sexes (Selander 1966, Wallace 1974, Hogstad 1978, Ebenman 1986, but see Hedrick & Temeles 1989). Sexual differences in morphology and foraging behaviour can be expected to increase if the habitat used during the breeding period is relatively unproductive. Furthermore, such differences should be pronounced, if interspecific competition does not occur or is weak (Ebenman 1986). However, sexual dimorphism in general is a more complicated phenomenon (e.g. Slatkin 1984, Shine 1989), since it is also under the influence of sexual selection. Species belonging to the bark-foraging guild are often sex-dimorphic in bill length and form (e.g. Selander & Giller 1963, Ligon 1968, Jackson 1970, Willson 1970, Kisiel 1972, Hogstad 1976, 1977, 1978). The extinct New Zealand Huia *Heteralocha acutirostris* (see

Burton 1974), which belonged to this guild, was the most dramatic example of sexual dimorphism in bill form.

The microhabitat used by the Common Treecreeper (later: Treecreeper) is the surface of coniferous tree trunks and branches, which is poor in arthropods (Kuitunen 1989). As a result the home range of the Treecreeper is relatively large in Finland (about 3 hectares, Kuitunen & Helle 1988, Kuitunen 1989, Suhonen & Kuitunen unpubl.); other birds of similar size have smaller home ranges. Time budget studies have shown that the Treecreeper uses most of its available time for foraging and feeding (Kuitunen & Suhonen 1989). It mostly forages for predatory spiders and small insects (e.g. Dementiev et al. 1970, Kuitunen & Törmälä 1983, Otvos & Stark 1985, Skylyarenko & Morozow 1987). The only other species belonging to the so-called trunk-foraging guild in the study area are woodpeckers, which have a much larger bill. The sexual dimorphism in the Treecreeper is considerable, especially in bill length (Mead 1975, M. Kuitunen unpubl.).

The main questions posed in this study are:

1) Do the adult birds change the composition and weight of the food load during the breeding season?
2) Does the food vary with the number of nestlings?
3) Does the food delivered to the nestlings differ quantitatively and/or qualitatively between males and females?

2. Study area, material and methods

The field work was carried out in Central Finland near the Konnevesi Research Station (62°37′N, 26°20′E) during the years 1985–1988. Mixed coniferous (*Picea abies* and *Pinus sylvestris*) forests of Cajander's *Myrtillus* and *Oxalis-Myrtillus* types abound. In 1983 we set up 50 specially designed nest-boxes (Kuitunen 1985) in the study area.

The samples of nestling food were collected when the adult birds were ringed from late May to early July. A plastic bag was attached to one of the two entrances to the nest-box. When an adult Treecreeper went into a nest-box, the ringer rushed from a hide and flushed the bird into the plastic bag. The bird dropped the food from its bill into the bag, from which it was collected (for more details see Kuitunen & Törmälä 1983).

The samples were taken from 16 females and 27 males. We have 35 samples from May, three from June and five from July, the distribution agreeing well with that of the breeding attempts (Table 1). The food loads were preserved in 70% ethanol. The 43 samples contained 611 food items altogether, which were measured to the nearest 0.1 mm (body length) and weighed with a microbalance after drying in an oven (60°C) for 24 hours. To compensate for lipid losses during preservation in alcohol 20% was added to weights. The arthropods were mainly identified to family level. We also measured all the captured birds. Wing length was measured with a ruler to the nearest 1.0 mm (maximum method; see Svensson 1984) and the weight was recorded with a spring balance to the nearest 0.1 g. Bill length was measured to the skull in some of the birds (N = 9).

The diversity of the load was measured with the Shannon index, $H' = -\sum p_i \ln p_i$, where p_i = proportion of taxon i in the load. The compositional similarity of the loads carried by females and males was studied using detrended

Table 1. The number of food loads collected from adult male and female Treecreepers in Konnevesi, Central Finland, during 1985–1988. Number of food items given in brackets.

	1985	1986	1987	1988	Total
Male	14 (109)	5 (95)	–	8 (226)	27 (430)
Female	10 (80)	3 (18)	1 (15)	2 (68)	16 (181)
Total	24 (189)	8 (113)	1 (15)	10 (294)	43 (611)

correspondence analysis (without transformation, Hill & Gauch 1980). Daily mean temperatures were obtained from the Tikkakoski meteorological station, about 50 km west of the study area.

3. Results

3.1. Nestling food

The nestling food consisted almost exclusively of arthropods. Of the 611 food items contained by the 43 samples, only one was of plant origin, namely a spruce seed. The most numerous food items were aphids (about 30%), whilst the most significant contribution in terms of weight and energy was made by spiders and harvestmen (65%). One single spider species, *Araneus omoedus*, comprised nearly one-third (by weight) of the food provided for the Treecreeper nestlings (Table 2).

We divided the food samples into three categories by nestling age (1 = <5, 2 = 6–10 and 3 = >10 days). In all age classes two-thirds of the weight was contributed by spiders and harvestmen.

The food given to the Treecreeper nestlings seemed to vary from one year to another. In 1988 the adult birds provided large quantities of aphids, while in 1986 the most numerous food items were spiders and harvestmen. In every year, however, spiders and harvestmen accontainted for more than 60% of the weight.

The length of the food items (Fig. 1) ranged from 1 to 15 mm, the largest being moth larvae. Two-thirds of the food items were shorter than 3 mm. The mean length of the prey (means of loads) taken by females (5.4 mm) was a little greater than males (4.6 mm), but the difference was not significant (Table 3).

The dry weight of the food items averaged 1.7 mg (SD = 4.0) and ranged from 0.01 to 45.3 mg. The greatest proportion of the weight of the nestling food consisted of items measuring 7–9 mm, most of which were spiders. Prey length did not change with nestling age (r = 0.10, n = 43, P = 0.52), nor did the mean prey weight in the loads (r = 0.02, n = 43, P = 0.91).

3.2. Food load diversity

The loads of arthropods brought to the nestlings were very diverse. The number of food items in a load averaged 14.2 (SD = 15.1, range 1–64 items); there was no difference between females and males (Table 3). The most diverse load consisted of eleven taxa; there was no difference in the average number of taxa in a load between females and males. Load diversity (measured by the Shannon index) did not differ between sexes. However, when the prey items were divided into three categories (1 = sessile or slow-moving, 2 = flying or jumping and 3 = running), there was a difference in the load diversity between females and males. Diversity was greater in the loads of the males (0.67±0.34) than in those of the females (0.45±0.34; z = –2.05, P = 0.04). In other words, the loads of the males contained more items from the different movement categories.

3.3. Load size

The load weights ranged from 0.8 to 77.6 mg (mean 24.2 ± 15.0). The numbers of food items per load decreased with increasing mean prey weight of a load (r = –0.75, df = 41, P < 0.001; Fig. 2). A heavy item often occurred alone in the loads, while light items occurred in quantity in the same load. For example, aphids with a mean dry weight of 0.3 mg, were often represented by about 20 animals in a load. By contrast, the heavy spider species *Araneus omoedus* (mean dry weight 16.5 mg) almost always occurred alone (Table 2). The weight of the load did not change with nestling age (r = 0.06, n = 43, P = 0.69) or with the number of nestlings in the brood (ANOVA F = 1.2, df_1 = 2, df_2 = 40, P = 0.33), nor did it differ between sexes (Table 3). The load weights carried by the female increased with nestling age (r = 0.59, n = 16, P = 0.02), however, though not the load weights carried by the male (r = 0.12, n = 27, P = 0.55; Fig. 3). Mean daily temperature did not affect load weight (r = –0.16, n = 43, P = 0.30).

Table 2. Composition of food brought to the nestlings by male and female Treecreepers in Konnevesi, Central Finland. N% = percentage of items, W% = percentage of weight, C% = percentage of loads, W = mean weight of taxa, E = ecological group: S = slow-moving or sessile, F = flying, R = running or jumping. Asterisk indicates that difference between males and females is statistically significant (Fisher's exact probability test) at the 0.05 level.

	Male			Female				
Taxa	N%	W%	C%	N%	W%	C%	W	E
Seed	0.2	0.6	4	–	–	–	4.5	S
Stylommatophora	0.2	0.3	4	0.6	0.9	6	2.6	S
Phalangida	0.5	0.3	7	2.2	2.9	13	2.0	R
Dictynidae	0.2	0.1	4	–	–	–	0.4	R
Clubionidae	1.9	6.2	26	3.9	12.1	31	5.6	R
Thomisidae	6.3	25.0	37	0.6	2.4	6	6.5	R*
Salticidae	0.5	0.5	7	–	–	–	1.9	R
Agelenidae	11.9	3.1	37	1.1	0.1	6	0.4	R*
Theridiidae	3.5	1.1	19	–	–	–	0.5	R
Tetragnathidae	0.5	2.3	7	–	–	–	7.9	R
Araneidae	1.2	0.5	11	1.1	1.3	13	1.1	R
Araneus omoedus	2.3	23.1	30	4.4	39.9	50	16.5	R
Linyphiidae	8.8	4.4	48	10.5	2.1	38	0.7	R
Entomobryoidae	1.6	0.1	7	0.6	0.0	6	0.1	R
Psyllipsocidae	0.5	0.4	7	–	–	–	1.3	F
Caeciliidae	0.2	0.0	4	12.7	3.6	11	0.5	F
Reuterellidae	0.7	0.4	7	–	–	–	0.9	F
Lygaeidae	0.5	0.8	7	0.6	0.4	6	2.2	F
Miridae	0.2	0.1	4	0.6	0.5	6	1.2	F
Heteroptera nymphs	0.2	0.0	4	1.1	0.1	6	0.6	R
Cercopidae	0.2	0.5	4	–	–	–	3.6	F
Cicadellidae	1.9	0.5	4	0.6	0.5	6	0.6	F
Cicadellidae nymphs	3.5	0.9	11	2.2	0.8	11	0.5	F
Aphidioidae	25.6	4.1	19	39.2	6.1	25	0.3	S
Sisyridae	0.2	0.1	4	–	–	–	1.0	F
Hemerobiidae	0.5	0.3	7	–	–	–	0.9	F
Geometridae	0.7	1.8	7	–	–	–	4.1	F
Lepidoptera larvae	0.7	6.7	7	–	–	–	15.5	S
Tipulidae	0.2	0.4	4	–	–	–	2.6	F
Culicidae	0.5	0.1	7	–	–	–	0.4	F
Chironomidae	5.3	1.0	15	7.2	2.0	11	0.4	F
Mycetophilidae	4.2	1.7	22	0.6	0.1	6	0.6	F
Sciaridae	2.6	0.7	22	0.6	0.0	6	0.4	F
Rhagionidae	–	–	–	0.6	5.0	6	17.1	F
Phoridae	3.0	1.8	22	–	–	–	1.0	F*
Sarcophagidae	0.5	3.3	4	–	–	–	11.4	F
Muscidae	0.2	0.3	4	1.1	2.1	11	3.1	F
Diptera larvae	0.9	2.3	11	5.0	13.2	11	4.7	S
Thethredinidae	0.2	0.6	4	–	–	–	4.0	F
Ichneumonidae	0.2	0.2	4	–	–	–	1.1	F
Proctrotrupoidae	0.2	0.0	4	–	–	–	0.2	F
Hymenoptera larvae	0.5	0.2	7	–	–	–	0.8	S
Anobiidae	–	–	–	1.1	0.4	11	0.8	F
Coleoptera larvae	5.6	1.8	30	0.6	0.2	6	0.5	S
Pupa	0.7	1.5	11	1.7	3.3	17	3.6	S
Total	430	100.0	27	181	100.0	16		

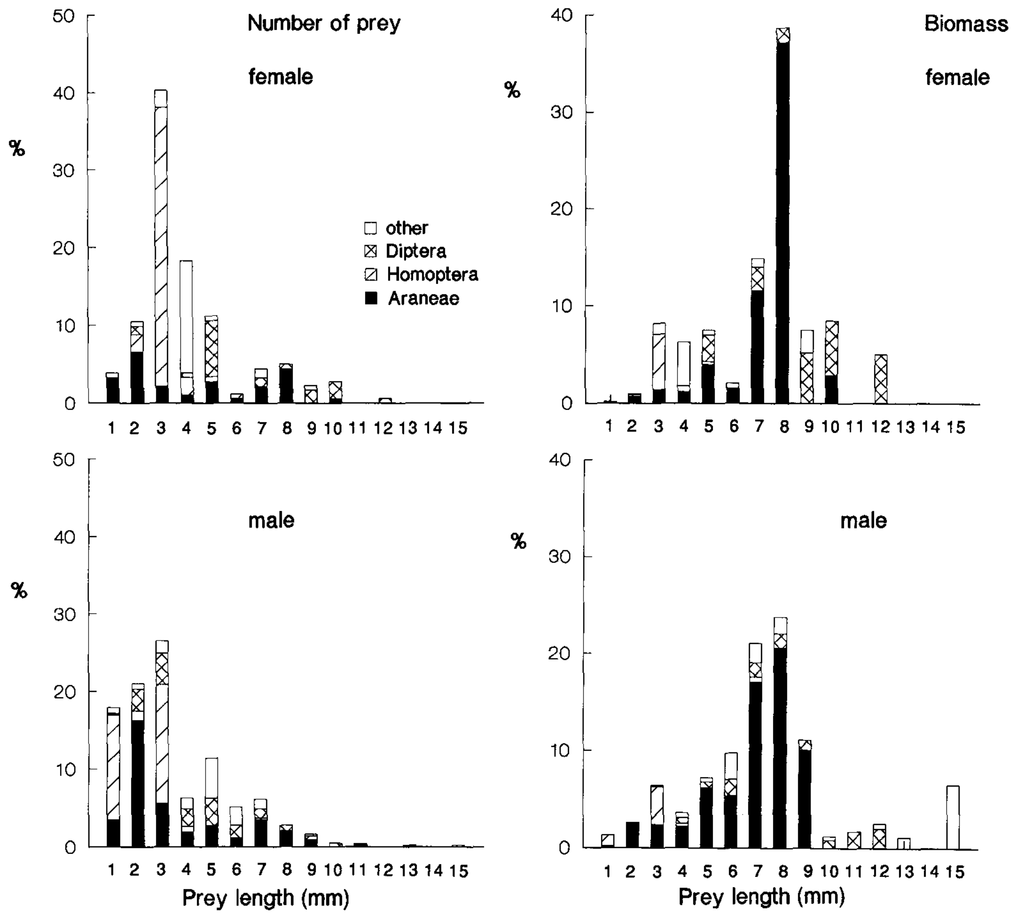

Fig. 1. Percentage distribution of prey items (by weight and frequency, females and males separately) in relation to prey length in Central Finland.

Table 3. Sexual differences in the size and food content of loads carried by adult Treecreepers to their nestlings in Central Finland.

	Male n = 27		Female n = 16		Total n = 43		Range	z	P
	Mean	SD	Mean	SD	Mean	SD			
Load weight (mg)	25.9	17	21.3	10	24.2	15	0.8–77.6	–0.54	0.59
Number of food items/load	15.9	15	11.3	15	14.2	15	1.0–64.0	–1.34	0.18
Mean weight of food items (mg)	3.7	4	4.5	4.5	4.0	4.2	0.3–18.6	1.11	0.27
Mean length of food items (mm)	4.6	2	5.4	2.2	4.9	2.1	1.5–10.1	–1.03	0.30
Number of taxa/load	5.1	3.2	3.4	1.8	4.5	2.8	1.0–11.0	–1.31	0.19
Load diversity	1.2	0.6	0.8	0.6	1.0	0.6	0.0– 2.2	–1.76	0.08
Moving habit diversity	0.7	0.3	0.4	0.3	0.6	0.4	0.0– 1.1	–2.05	0.04

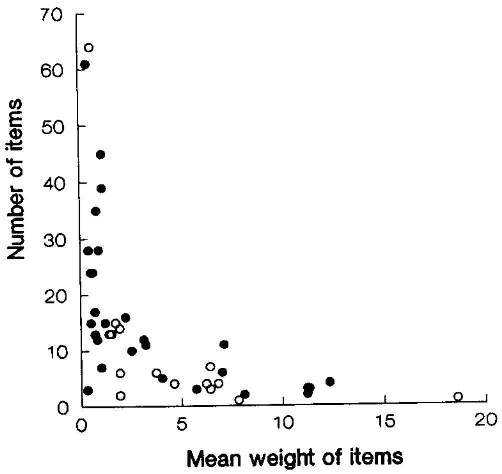

Fig. 2. Relationship between number of food items (I) and mean weight (W)(mg) of food items in a load. Filled circle = male adult Treecreeper, circle = female. $\ln(I) = 2.72 - 0.70 \ln(W)$. $r = -0.75$, $R^2 = 0.56$, $P < 0.001$.

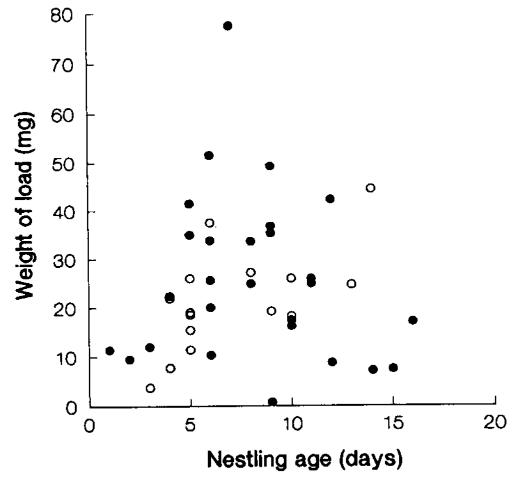

Fig. 3. The weight of the load (mg) in relation to nestling age (days). Filled circle = male adult Treecreeper, circle = female.

3.4. Load similarity between sexes

Taxonomical similarities among the samples were studied using detrended correspondence analysis (without transformation of data, Gaugh & Hill 1980) (Fig. 4). The first axis in the ordination (eigenvalue 0.85) revealed weak correlations with the number of prey items per load ($r = 0.37$ $n = 43$, $P < 0.016$). The second axis of ordination (eigenvalue 0.65) showed correlations with adult Treecreeper weight ($r = -0.54$, $n = 43$, $P < 0.01$) and wing length ($r = 0.34$, $n = 43$, $P = 0.025$). Both the weight and the wing length depend on the sex of the Treecreeper; the males are usually bigger than the females (Table 4).

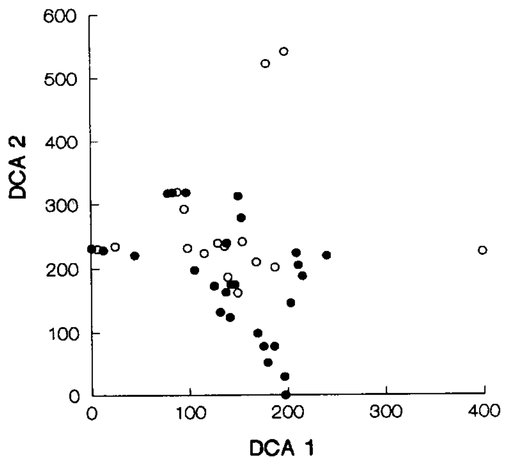

Fig. 4. The structure of the load in the DCA ordination (first and second axis). Filled circle = male adult Treecreeper, circle = female.

The values of the second axis differed between females and males ($t = -2.83$, $df = 41$, $P = 0.007$). Differences in the loads between female and male samples indicated differences in the food items carried to the nestlings. Thomisid and Agelenid spiders and Phorid flies were more frequent in male than in female loads (Table 2).

4. Discussion

In composition and load weight, the food given to Treecreeper nestlings in Central Finland both in composition and load weight closely resembled that reported from southern Finland (Kuitunen & Törmälä 1983) and the Soviet Union (Sklyarenko & Morozov 1987). In all three studies the proportion of spiders and harvestmen was more than two-thirds by dry weight and about one-third by frequency. It is noteworthy that one spider species, viz. *Araneus omoedus*, made up nearly 30% of the nestling food weight in Central Finland. This species is common on spruce (Palmgren 1974) and according to suction samples it is the largest food item available on the spruce trunks (Kuitunen 1989). The year-to-year variation in the composition of the food given to Treecreeper nestlings indicated that this species is opportunistic with respect to its food exploitation pattern. Similarly, Kuitunen (1989) showed that the diet of the nestlings did not differ in composition from random samples. The only exception was that Treecreepers used disproportionately large food items compared to the range available.

Adult Treecreepers are typical multiple prey forager, often bringing many food items in the same load to their nestlings (Kuitunen & Törmälä 1983). Our data showed that the load contained either a few large or numerous small items. This observation agrees with the theory of central place foraging (e.g. Orians & Pearson 1979).

The only major differences between sexes in the Treecreeper were

1) the fewer taxonomical differences in the food brought to nestlings by female and
2) the increase of the food load with nestling age in females but not in males.

The first difference suggests that females are more specialized on sessile and slowly moving items than are males. This difference is probably due to differences in food searching sites between males and females; such differences have been observed to be fairly common among members fo bark-foraging guild. For example in the Three-toed Woodpecker *Picoides tridactylus*, the heavier male forages more often on tree trunks than the female, the overlap between sexes was smaller in summer than in winter (Hogstad 1977, see also experiments with *P. pubescens*, Peters & Grubb 1983). The sexual dimorphism is greater in the Three-toed Woodpecker than in *Dendrocopos* spp. The correlation between sexual dimorphism and sexual differences in foraging behaviour in woodpeckers has been interpreted as an adaptation to mitigate intraspecific competition for food, particularly during periods of food shortage (Selander 1966, Wallace 1974, Hogstad 1978).

In other species, such as the Coal Tit *Parus ater* the female forages in winter in the outer part of tree canopy and the heavier male in the inner part (Gustafsson 1988). It seems that bill form in particular has evolved in response to the foraging sites and food supply. In the Great tit *Parus major*, the bill form has even been observed to vary annually, in parallel to the changing food (Gossler 1987).

The second difference, namely, the load increse with nestling age in the female, presumably improves the reproductive output, although the feeding frequency also increases strongly with nestling age (Kuitunen & Suhonen 1989). A similar difference between the sexes has been observed in the Swallow *Hirundo rustica* (Jones 1986). In contrast, in the Wheatear *Oenanthe oenanthe* males tended to carry larger loads than females (Carlson & Moreno 1983, Moreno 1987), which was explained by the larger size of the males. In Swallows the difference in loads between the sexes could not be due to on sexual size dimorphism, because male Swallows have significantly longer keels and a larger size than females (Jones 1986). The difference indicates that the sexes employ different feeding strategies when collecting food for the young, which agrees well with our observations on Treecreepers (also Suhonen & Kuitunen unpubl.).

Table 4. Wing length, body weight and bill length of the male and female Treecreepers measured during the nestling period in Konnevesi, Central Finland.

	Male mean±SD	n	Female mean±SD	n	t	P
Wing (mm)	65.8 ± 1.9	27	62.7 ± 1.4	16	5.54	<0.001
Weight (g)	9.3 ± 0.2	27	9.0 ± 0.3	16	3.78	<0.001
Bill (mm)	18.0 ± 1.2	5	16.1 ± 0.9	4	2.59	<0.04

Resource partitioning within species has received less attention than partitioning between species. The case studies are primarily those in which usually males and females differ morfologically, in characters related to food-gathering, suggesting differences in resource utilization (see Ebenman & Nilsson 1982 and references there).

It is probable that the species belonging to the bark-foraging guild tend to suffer more often from food shortage than an average do other species in other guilds, even during the breeding period. The explanation of the relatively large sex dimorphism in the Treecreeper can therefore probably be attributed to the fact that its nutritional niche is poor in food, although no interspecific competition exist.

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Selostus: **Emolintujen sukupuolen vaikutus puukiipijän poikasten ravintoon**

Puukiipijäemojen poikasilleen tuoman ravintolastin koostumusta tutkittiin Konnevedellä Keski-Suomessa. Ravintonäytteet kerättiin pyydystämällä emolinnut muovipussiin, joka oli kiinnitetty V-mallisen erikoispöntön toiseen lentoaukkoon. Kun lintu meni ruokkimaan poikasiaan, se pelästytettiin pussiin. Emon pussin pohjalle pudottama ravinto määritettiin pääosin heimon tarkuudella, mitattiin ja punnittiin.

Puukiipijän poikasravinnosta (kuivapainosta) kaksi kolmasosaa oli hämähäkkejä, eikä suhde muuttunut poikasten kasvaessa. Ravinnon koostumus vaihteli vuosittan. Suurin osa saaliseläimistä oli pieniä 1–3 mm:n mittaisia hyönteisiä ja hämähäkkejä. Biomassasta muodostivat kuitenkin 7–9 mm:n mittaiset hämähäkit suurimman osuuden (kuva 1). Pelkästään yhden painavan hämähäkkilajin (*Araneus omoedus*) osuus oli noin 30% poikasravinnosta (taul. 2).

Jos yksittäinen ravintolasti sisälsi keveitä saaliseläimiä, niitä oli yleensä runsaasti. Mitä painavampia saaliit keskimäärin olivat sitä vähemmän niitä oli samassa ravintolastissa (kuva 3). Naaraan ravintolastin paino kasvoi poikasten kasvaessa. Koiraan lastin paino ei muuttunut (ku va 4). Koiraan ja naaraan ravintolastin koostumus erosi toisistaan (kuva 5). Koiraan lastissa oli useammin Agelenidae ja Thomisidae -heimojen hämähäkkejä sekä Phoridae-heimon kärpäsiä kuin naaraan poikasilleen kantamassa lastissa. Naaraan ravintolastista ei löytynyt selvästi dominoivaa taksonia (taul. 2). Lajien välisen kilpailun puuttuessa sukupuolten välinen erikoistuminen vähentää lajin sisäistä kilpailua ravinnosta ja tekee mahdolliseksi paremman lisääntymismenestyksen etenkin niukkojen ravintovarojen olosuhteissa.

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