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Available insect prey in bark patches selected by the Three-toed Woodpecker *Picoides tridactylus* prior to reproduction

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The diet composition of the Three-toed Woodpecker (*Picoides tridactylus*) before the onset of egg laying was investigated in eastern Finland. This was carried out in 1997 and 1998 by collecting bark samples from woodpecker territories in six old-growth and two burnt forest patches during the two month period preceding the start of reproductive activities. Bark samples (10 × 15 cm) were removed from the immediate vicinity of a freshly exploited area, either directly after a foraging bird left the tree or from trees recently exploited. A total of 55 bark samples were collected, from which 33 were found after direct foraging observation. Recently dead spruce comprised 89% of foraging substrates. Including adult, larva and pupa development stages, 3236 potential insect prey were collected and identified. Among them, Scolytids, or bark beetles, represented 96.9% of the insect prey. This proportion did not differ between territories, sexes and years. Some 78.5% of adult bark beetles found were classified as mature spruce forest interior specialists.

1. Introduction

Food availability prior to the onset of breeding activities is one of the most important factors for reproductive success in birds (Martin 1987, Daan et al. 1988). For example, considerable within population variation in reproduction timing, clutch size, egg quality and extent of parental care has been empirically and experimentally shown to be optimally related to environmental quality (e.g., Högstedt 1980, Martin 1987, Hakkarainen & Korpimäki 1994, Perrins 1996, Tolonen & Korpimäki 1996). Breeding time may especially affect the current reproductive success in single-brooded species, as suggested by a general seasonal decrease in their juvenile survival (e.g., Perrins 1965, Daan et al. 1988, Barba et al. 1995). As a result, understanding the consequences of fluctuations in the natural food supply on the population dynamics of any species requires knowledge of its basic diet preferences during the breeding season.

The medium-sized (60–70g) Three-toed Woodpecker is the only woodpecker found both in the New World and in the Old World (Winkler et al. 1995). It inhabits mature boreal or montane coniferous forests with a distribution closely coinciding with that of spruce species (Baldwin 1968, Bock & Bock 1974, Virkkala 1991, Virkkala et al. 1994). Local concentrations in recently disturbed forest areas, i.e. in burned (Blackford 1955, Koplin 1969, Sorvari 1994), flooded (Yeager 1955), storm-felled (Virkkala et al. 1991) and/or insect-infested forest areas (Yeager 1955, Knight 1958, Baldwin 1960, Baldwin 1968, Koplin & Baldwin 1970, Koplin 1972, Massey & Wygant 1973, Crockett & Hansley 1978) have

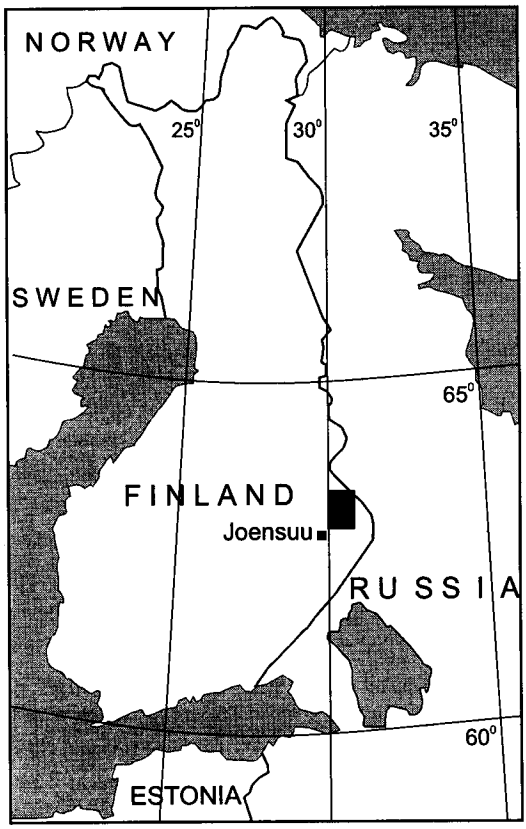

Fig. 1. Location of the study area (dark rectangle).

also been reported. Recent abundance estimates show the decline of the species in Fennoscandia (Virkkala 1987, Virkkala 1991, Nilsson et al. 1992, Stenberg & Hogstad 1992).

The aim of this study was to examine whether the Three-toed Woodpecker behaves rather like a generalist or like a specialist predator during the late winter and early spring time, before breeding onset.

2. Material and methods

The study was conducted within the municipalities of Eno, Lieksa and Ilomantsi, province of north carelia, in eastern Finland, in 1997 and 1998 (63°N, 31°E) (Fig.1). The study area consisted of a patchwork of six old-growth coniferous and two burnt forest areas (10–162 ha). Each patch was inhabited by a single pair of Three-toed Woodpeckers. The surrounding matrix consisted mainly of younger managed tree stands, generally dominated by Scots Pine (*Pinus sylvestris*), creating a sharp edge transition around the bird territory.

The Three-toed Woodpecker typically restricts its winter and spring foraging activities to the bark layer of the selected trees (P. Fayt, unpubl.). During the two month period from 20 March to 20 May, preceding the onset of egg laying, potential prey of the foraging woodpecker were investigated by bark removal. The composition of the insect community in samples was then supposed to reflect the diet of the Three-toed Woodpecker. Bark samples (10 × 15 cm) were picked off the immediate vicinity of a freshly exploited area, in the lower part of standing tree trunks (i.e. between 1 and 3 m high). This method assumes a limited small-scale variation in distribution and composition of insect preys inside the tree bark on a similar level from the ground. Woodpeckers were searched for all over their territories, including interior and edge parts, and located by careful listening for their foraging sounds while scaling the bark. Samples were then directly collected after visual observation, once the bird had left the tree. Sex of the bird, tree species and tree condition (alive, decaying, dead) were noted. To complement these samples, additional samples were taken from trees where only fresh foraging tracks could be found. The presence of small bark pieces surrounding the base of the trunk, visible on the snow, is reliable evidence of recent Three-toed Woodpecker foraging.

A total of 55 bark samples were collected from eight woodpecker territories, with 28 and 27 samples in 1997 and 1998, respectively. Among them, 33 were found after direct observation of foraging behaviour, with 15 and 18 samples from eight males and seven females, respectively.

Insects found were identified, counted and named according to Silfverberg's (1992) nomenclature proposal.

3. Results

The adult, larva and pupa development stages of the Scolytids, or bark beetles, combined represented 96.9% of potential insect prey found (n = 3236) (Table 1). Samples were taken from six dif-

ferent territories in both years, with a similar availability of bark beetles (Kruskal-Wallis test 1997: $H_5 = 2.369$, NS; 1998: $H_5 = 3.192$, NS) and insects belonging to other families (Kruskal-Wallis test 1997: $H_5 = 5.679$, NS; 1998: $H_5 = 6.225$, NS) from selected trees. The proportion of insects belonging to the Scolytidae and other insect families did not differ between years ($\chi^2 = 3.249$, df = 1, NS) and between sexes ($\chi^2 = 0.003$, df = 1, NS). Based on adult beetles, 78.5% of individuals (body size: 1.3–2.9 mm, $n = 1262$) were classified as mature spruce forest interior specialists (Table 2).

In total, 49 (89%) out of the 55 bark samples originated from recently dead spruces *Picea abies*, while 3 (5.4%), 2 (3.6%) and 1 (1.8%) were collected from freshly dead pines *Pinus sylvestris*, dead birches *Betula* spp. and decaying spruce, respectively.

4. Discussion

The current findings strongly suggest a close trophic relationship between the Three-toed Woodpecker and bark beetles prior to the bird's reproduction season. While there is no earlier evidence for such a highly specialised diet at that particular time of the year, this is in agreement with other results from stomach and dropping analyses of Three-toed Woodpeckers originating from the northern Palaearctic (Neufeldt 1958, Sevastyanov 1959, Dement'ev 1966, Hogstad 1970, Pechacek & Krištín 1993) and Nearctic (Baldwin 1968, Koplin & Baldwin 1970, Koplin 1972, Massey & Wygant 1973). The importance of bark beetles, and especially spruce beetles, in the woodpecker's diet has nevertheless been shown to be dynamic, depending on the level of beetle infestation and the time of the year. The Three-toed Woodpecker consumes more prey as prey density increases, although predatory effectiveness in pan-epidemic infestations seems to be constrained by an upper limit in the predator density (Baldwin 1960, Baldwin 1968, Koplin & Baldwin 1970, Koplin 1972, Massey & Wygant 1973). Correspondingly, bark beetle consumption seems to be reduced during the summer months and/or the nestling period (Baldwin 1968, Pechacek & Krištín 1996, P. Fayt, unpubl.).

Patterns in the spatial distribution of bark beetle communities on tree trunks and its main determinants have been paid considerable attention by forest ecologists. Besides the possibility of niche segregation between competitive species (e.g., Schlyter & Anderbrant 1993), additional tree host and site factors have been evaluated as affecting the

Table 1. Family composition of potential insect prey (Coleoptera) found in 55 bark samples selected by *Picoides tridactylus* between 20 March and 20 May 1997 and 1998.

Composition	Total number	Percentage ($n = 3236$)
Adult		
Scolytidae	1262	39.02
Staphylinidae	15	0.46
Cucujidae	6	0.18
Latridiidae	6	0.18
Anobidae	2	0.06
Bostrichidae	1	0.03
Rhizophagidae	1	0.03
Colydiidae	1	0.03
Curculionidae	1	0.03
Larva		
Scolytidae	1861	57.51
Others	67	2.07
Pupa		
Scolytidae	13	0.40

Table 2. Scolytid species assemblage, based on adult beetles, found in 55 bark samples selected by *Picoides tridactylus* between 20 March and 20 May 1997 and 1998.

Composition	Total number	Percentage ($n = 1262$)
Polygraphus sp. (*poligraphus* and *subopacus*)	590	46.75
Crypturgus subcribrosus	304	24.09
Pityogenes chalcographus	197	15.61
Cryphalus saltuarius	85	6.73
Hylurgops palliatus	51	4.04
Xylechinus pilosus	12	0.95
Tomicus piniperda	8	0.63
Carphoborus rossicus	6	0.47
Ips amitinus	3	0.24
Pityophthorus micrographus	3	0.24
Dryocoetes autographus	1	0.08
Pityogenes quadridens	1	0.08
Trypodendron lineatum	1	0.08

community distribution at the tree and stand levels (e.g., Chararas 1962, Jakuš 1995, 1998, Peltonen et al. 1998). Among them, tree dimension and bark position from the ground level are worth considering. This raises the question whether the present results offer a representative overview of the woodpecker's potential diet in late winter and early spring as bark samples were removed rather close, i.e. up to 3 m, to the forest floor. This may especially be true as Three-toed Woodpeckers have been observed to forage as high as 20 m in the winter time (Hogstad 1976, 1978). Previous studies based on stomach and dropping analyses of the Three-toed Woodpecker support, however, the current data set. In addition, both sexes have been most frequently recorded foraging at heights of 1–3 m above ground level in winter (Hogstad 1991). Furthermore, the environmental conditions of trees, particularly insolation, have been shown to strongly affect the distribution patterns of bark beetles (Jakuš 1998). Shady dying or freshly dead standing spruces, the main foraging substrates in this study, enclosed within mature forest stands offer more homogenous environmental conditions than downed or edge trees (Chararas 1962). This, in turn, explains a more even distribution of different beetle species along their trunks compared with the abrupt gradation found on uprooted trees (Jakuš 1998). If so, it may be reasonable to propose that the forest beetle assemblage found in this work is a representative sample of insect fauna inhabiting bark patches selected by foraging Three-toed Woodpeckers during the study period.

Both Three-toed Woodpeckers and bark beetles rely on highly temporary resources distributed throughout the environment in a clustered fashion. With an initial process of host colonisation closely mediated by the physical and physiological conditions of the trees (Chararas 1962, Coulson 1979), the bark beetles life cycle is restricted to the earlier stages of wood decomposition (Heliövaara & Väisänen 1984, Kulikov 1991). Regional stability of the beetle populations will, however, be dependent on the disturbance regime at the stand and landscape level. Therefore, as a food resource, bark beetles are patchily and unpredictably distributed. The same is true for their main avian predator, the Three-toed Woodpecker. As a result, their respective ranging behaviour is subject to intense selective pressure, upon which the species survival is contingent (Coulson 1979).

With only a few species strictly associated with primeval or burnt forests (Heliövaara & Väisänen 1984, Wikars 1994, Martikainen et al. 1996), Scolytids do not seem to have highly specialised requirements regarding their habitat selection apart from the tree host species and condition. Recent studies aiming to determine a possible edge effect in the distribution of bark beetles stress nevertheless the important influence of the forest edge on the distribution patterns of forest insect species (Peltonen et al. 1997, Peltonen & Heliövaara 1998). Many generalised bark beetle species of clear cut areas or pine forests spread over stand borders into mature forest. This contrasts with shady and slowly dying spruce forest species such as *Xylechinus pilosus* (Ratz.), *Polygraphus*-species, *Crypturgus subcribrosus* Egg. and *Cryphalus saltuarius* Weise, which tend to withdraw into the interior parts of forest stands. Forest interior specialists occur so in the family Scolytidae (Martikainen et al. 1996, Peltonen et al. 1997, Peltonen & Heliövaara 1998).

Along with underlining the importance of dying or recently dead spruce trees for foraging Three-toed Woodpeckers, which corroborates previous observations (e.g. Baldwin 1968, Hogstad 1970), the present work emphasises the importance of spruce forest interior bark beetle specialists, i.e. 78.5% of adult bark beetles found, in the woodpecker diet during the spring time. This makes the Three-toed Woodpecker a prime candidate for showing lower foraging efficiency in a fragmented mature spruce forest landscape, if the proportion of interior forest decreases. This finding would consequently validate the usefulness of the species as an appropriate indicator of old-growth conditions while planning the maintenance and restoration of ecologically sustainable boreal forest (Angelstam 1998).

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Selostus: **Hyönteislajien saatavuus keväällä pohjantikan valitsemissa ruokailupuissa**

Kirjoittaja tutki pohjantikan mahdollista ravinnon koostumusta keräämällä kaarnanäytteitä sellaisista puista, joissa pohjantikka oli hiljattain ruokaillut. Tutkimus tehtiin Pohjois-Karjalassa, Enon, Lieksan ja Ilomantsin kuntien alueella maalis–toukokuussa 1997 ja 1998. Näytteitä kerättiin kuudelta vanhan metsän alueelta ja kahdelta metsäpaloalueelta. Yhteensä kaarnanäyte (10 × 15 cm) kerättiin 55 puusta. Eniten pohjantikka oli käyttänyt juuri kuolleita kuusia ruokailupuinaan (89% ruokailuhavainnoista). Kaarnanäytteistä löytyi yhteensä 3236 hyönteistä, jotka ovat pohjantikan mahdollisia ravintokohteita. Kaarnakuoriaiset (Scolytidae) muodostivat 97% yksilöistä. Eri reviirien, vuosien tai sukupuolten välillä ei ollut eroa kaarnakuoriaisten osuudessa. Noin 79% aikuisista kaarnakuoriaisista kuului lajeihin, jotka voidaan lukea varttuneeseen kuusimetsään erikoistuneiksi, reunaa karttaviksi kovakuoriaisiksi. Tulokset osoittavat, kuinka tärkeää hiljattain kuolleiden kuusien saatavuus on pohjantikalle. Toisaalta suuri kuusimetsän sisäosiin erikoistuneiden lajien osuus ravintokohteissa viittaa pohjantikan rooliin mahdollisena vanhan metsän ilmentäjälajina metsämaisematasolla.

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