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Winter activity of earwigs with special focus on the phenology of *Chelidura guentheri* (Galvagni, 1994) (Dermaptera: Forficulidae)

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Abstract. Winter activity of earwigs has not been intensively studied until now. This study provides the first systematic data on winter activity of *Chelidura guentheri* (Dermaptera: Forficulidae) and its habitat preferences during this period. Most of the specimens were collected during two winter seasons; 2000/2001 and 2001/2002. To detect Dermaptera activity on the ground and under snow cover pitfall traps were used, and to collect earwigs active on the snow surface Moerick's traps were used. Three species of Dermaptera were collected during winter, also from under the snow: *Chelidura guentheri, Forficula auricularia* and *Apterygida media*. In the collected material, *C. guentheri* predominated, while the two other species were noted occasionally. The highest winter activity of earwigs was noted in beech forests, while the lowest was recorded in riparian forests. The results show that earwigs can be a significant element of subnivean invertebrate activity, but they appear on the snow surface only accidentally. The most abundant earwig was an omnivorous species, which may play a role in subnivean food chains.

Key words: Dermaptera, earwig, winter phenology, habitat preferences, subnivean fauna, supranivean fauna.

Introduction

Most invertebrates are inactive during the winter and spend this time in diapause as eggs, larvae or pupae, less often as an adult stage (Leather et al. 1993). However, some poikilothermic organisms can stay active in winter. Their activity during low temperatures is usually dependent on a snow cover with a high insulation capacity. The soil and litter temperature can remain around zero even if the air temperature is rather low (Aitchison 1974, 2001). Thus the occurrence of snow cover during the winter period plays an important role in the biology and ecology of many different invertebrate groups. Certain specialized species have been observed mating and laying eggs during this period (Soszyńska & Durska 2002, Hågvar 2010).

During the last years, global climate change has become an important scientific topic (Loarie et al. 2009). Its influence on animals, except some vertebrate groups, has been poorly studied and hard to predict. Huntley (2007) presented the statement that the easiest detectable and earliest responses on climate change is an adjustment of species phenology. Loarie et al. (2009) suggested there would be rearrangement of the current distribution of climatic conditions in this century. This is likely to impact upon the winter active invertebrates, which are strongly dependent on weather and snow cover. The winter active fauna may be well suited for observing changes in their annual cycles of activities. In fact, depletion of snow cover in some regions can make the study of this fauna extremely difficult.

The winter period is unfavorable for most invertebrates because of low temperatures and limited available food resources. However, winter activity of certain insects and spiders, both on the snow (supranivean fauna) and under snow (subnivean fauna) is a well known phenomenon. Concerning subnivean activity, spiders (Araneida), springtails (Collembola), beetles (Coleoptera) and flies (Diptera) are the best studied groups (Renken 1956, Ackefors 1964, Näsmark 1964, Merriam et al. 1983, Itämies & Lindgren 1989, Łęgowski & Łoziński 1995, Aitchison 2001, Hågvar & Hågvar 2011, Jaskuła & Soszyńska-Maj 2011). The typical supranivean fauna includes mainly scorpionflies (Mecoptera) and flies (Diptera), but many other invertebrates can be observed active on the snow surface, e.g. spiders (Araneae), springtails (Collembola), beetles (Coleoptera), stoneflies (Plecoptera), bugs (Hemiptera), and even moths (Lepidoptera) (Hågvar 1995, 2000, 2007, 2010, Soszyńska & Durska 2002, Hågvar & Greve 2003, Soszyńska 2004, Soszyńska-Maj 2008, Hågvar & Aakra 2006, Soszyńska-Maj & Buszko 2011).

Chelidura guentheri (Galvagni, 1994) (Dermaptera: Forficulidae) is one of seven earwig species reported from Poland (Liana 2007, Jaskuła et al. 2011). This taxon was recently described after detailed revision of genus *Cheridurella* (=*Chelidura*)

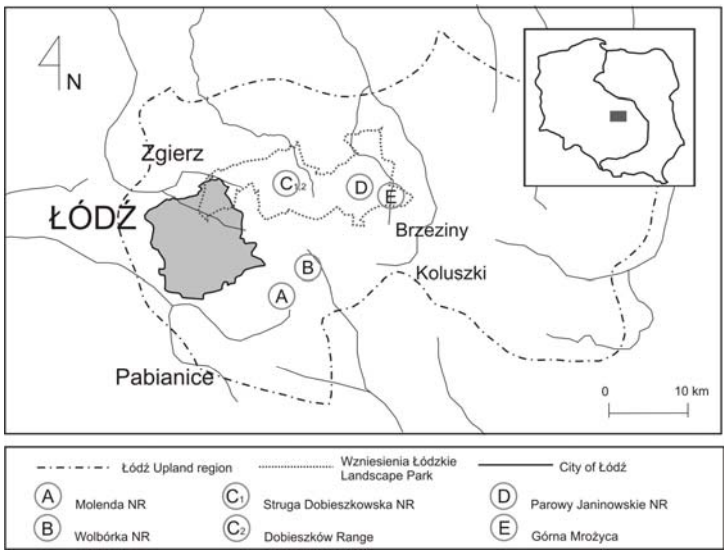

Figure 1. Study area with study sites marked: A,B,C_1,D – pitfall traps in two winter periods (2000/2001 and 2001/2002), C_2, E - pitfall traps and Moerick`s traps in winter period 2005/2006.

(Galvagni 1994, 1997). Its ecology and phenology is poorly known. Typically only wide-distributed and common Dermaptera species or taxa of economical importance have been studied in detail (Behura 1956, Lamb & Wellington 1975, Good 1982, Vancassel & Quris 1994, Kočárek 1998). Most data on phenology and ecology of European Dermaptera reported in the literature were collected during the vegetation season (Kočárek 1998). Winter activity of earwigs has not been intensively studied until now. Only Renken (1956) and Łęgowski and Łoziński (1995) recorded these insects as active during the winter period and Soszyńska-Maj (2008) reported one species active on the snow surface.

The aim of this study was to present the first systematic data on winter activity of Dermaptera. It includes the phenology of the recently described *Chelidura guentheri,* as well as its habitat preferences during this period.

Material and Methods

The study area is localized in the Łódź district, Central Poland (Fig. 1). Regular studies were conducted in four nature reserves: Struga Dobieszkowska [UTM: DC04] – natural part of Młynówka river valley, with springs, overgrown by riparian forest (*Circaeo-Alnetum*) and dry-ground forest (*Tilio-Carpinetum*); Parowy Janinowskie [UTM: DC04] – beech wood (*Luzulo pilosae-Fagetum*) with numerous old beech (*Fagus sylvatica*); Molenda [UTM: CC92] – mixed coniferous forest with fir (*Abies alba*), beech (*Fagus sylvatica*) and spruce (*Picea abies*); Wolbórka [UTM: CC92] – riparian forest (*Circeo-Alnetum*) in Wolbórka river valley. Two first sites as well as Górna Mrożyca [UTM: DC14] – marshy alder carr (*Ribeso nigri-Alnetum*) and Dobieszków Range [UTM: DC04] – dry-ground forest (*Tilio-Carpinetum*) are localized in the Wzniesienia Łódzkie Landscape Park (Rąkowski et al. 2006).

The main part of the material was collected using pitfall traps to catch earwigs active on the ground, even under snow cover, during two winter seasons 2000/2001 and 2001/2002 in four nature reserves. The investigation was a part of a large study of winter active invertebrates of the Łódź Upland region. In every site, 10 traps were located in homogeneous habitat, with 4-5 m distance between them as proposed by Breymeyer (1961). Construction of the traps followed the methodology of Aitchison (1974). They consisted of outer cup with a diameter of 85 mm and inner removable cup with small amount of ethylene glycol to preserve the animals**.** Roofs supported by three legs protected traps against snow and rain. They were checked every two weeks from the end of November to the beginning of April. Every time the inner cup with collected material was replaced by a new one. If snow cover was present, a hole was carefully dug through the snow without disturbing the subnivean space around the trap. Afterwards, the trap was covered again by the roof. When the snow was present, the snow cover was replaced.

Additional records were collected from the winter of 2005-2006 in two study sites: Dobieszków Range and Górna Mrożyca. In addition to pitfall traps, Moerick's traps – usually known as yellow traps – were used to check the snow surface activity (Moericke 1949). Pitfall

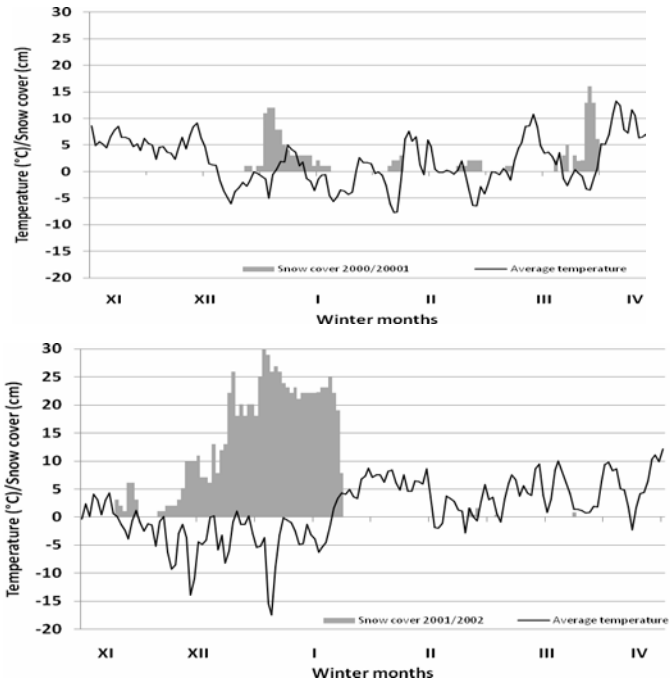

Figure 2. Average ambient temperature (°C) and snow depth (cm) during the two winters of 2000/2001 and 2001/2002.

traps were constructed as mentioned above, while yellow traps were put on the ground (10 traps in every site). After larger snow falls, Moerick's traps were removed from under the snow and placed on the snow cover.

Detailed data of soil temperature and depth of the snow were measured every time traps were emptied. Meteorological data came from the local weather station placed in the neighbourhood area of the sampling sites; this is presented in Figure 2.

To estimate habitat associations and phenology of *C. guentheri* only material from two winter seasons 2000/2001 and 2001/2002 was used.

Results

Altogether, 951 specimens of three Dermaptera species were collected during three winter seasons. *Chelidura guentheri* clearly predominated (920 indv., 96,7%). Two other species, *Forficula auricularia* and *Apterygida media* were caught occasionally – respectively 26 (2,7%) and 5 individuals (0,6%). Only males of *A. media* were found, in *F. auricularia* males predominated (86,4%) (Table 1). All three species were active on the ground, both without snow cover and under the snow. *Chelidura guentheri* was trapped in all types of habitats, *F. auricularia* was caught in dry-ground forest, mix forest and marshy alder carr, while *A. media* was collected only in marshy alder carr.

Winter phenology of *C. guentheri*

In the dominant species, *C. guentheri*, females (87,7%), males (11,5%) and larvae (0,8%) were found. A total of 812 individuals were collected (737♀♀ 75♂♂), 350 specimens in 2000/2001 (325♀♀ 25♂♂), and 462 specimens in 2001/2002 (412♀♀ 50♂♂). Specimens collected in winter 2005/2006 (108 individuals) were not included in phenological analysis as they were caught using a different, incomparable sampling method. Both sexes of *C. guentheri* were active during the whole winter periods, from the beginning of December to the beginning of April. In January and February they were active under snow (Fig. 3). The lowest activity was observed in December-January (from none to 31 individuals per sample). In both winters the activity was low in January, but increased in February, and still more after snow melt in March and April. During the whole study period, the activity of females was higher than males. Detailed results of the activity of *C. guentheri* in the two winter

Table 1. Records of *F. auricularia* and *A. media* in three winter seasons in pitfall traps, 1/XI –means first half of November, 2/XII – second half of December.

Species	Winter months									
	2/XI	1/XII	2/XII	1/I	2/I	1/II	2/II	1/III	2/III	1/IV
F. auricularia	-	12♂3♀	1♂	-	-	3♂	-	-	-	7♂
A. media	1♂	2♂	1♂	1♂	-	-	-	-	-	-

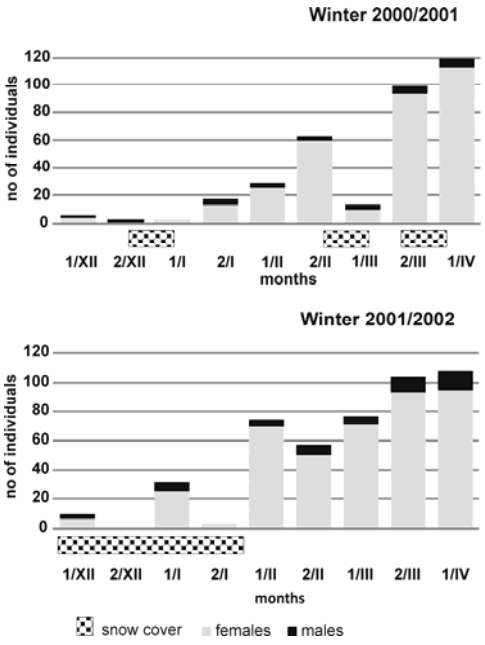

Figure 3. Phenology of *Chelidura guentheri* in Central Poland in two winter periods (2000/2001 and 2001/2002) based on material collected using pitfall traps with snow covered period marked, 1/XI – means first half of November, 2/XII – second half of December.

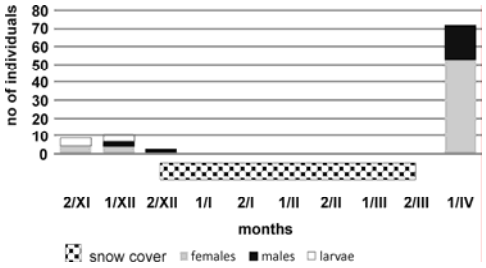

Figure 4. Number of *Chelidura guentheri* in winter period 2005/2006 catched in Moerick`s traps with snow covered period marked, 1/XI – means first half of November, 2/XII – second half of December.

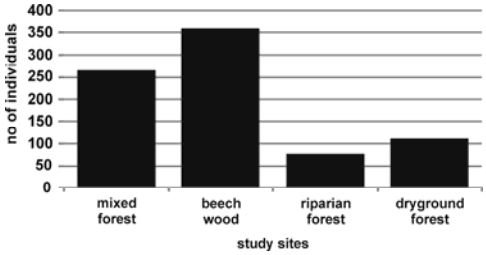

Figure 5. Cumulative abundance of *Chelidura guentheri* in material collected during two winter periods of 2000/2001 and 2001/2002 in four nature reserves in Central Poland.

seasons are presented on Figure 3. *Chelidura guentheri* was the only species collected using Moerick`s traps; all larvae of this earwig were caught with this method. Larvae were collected only at the beginning of December. In our material from Moerick's traps, Dermaptera were absent in samples from periods with snow cover (Fig. 4).

Habitat associations

The highest activity of earwigs was observed in beech wood (Parowy Janinowske NR; 359 indv., 44,2%) and in mixed coniferous forest (Molenda NR; 264 indv. 32,5%), while the lowest number of winter active *C. guentheri* individuals was found in riparian forest (Wolbórka NR; 78 indv., 9,6%) and in dry-ground forest (Struga Dobieszkowska NR; 111 indv., 13,7%) (Fig. 5). The total catch of *C. guentheri* was 4.6 times higher in the driest habitat (beech wood) compared to the most humid habitat (riparian forest).

Discussion

Winter phenology

Our data show that three species of Dermaptera were winter active in the area of the Łódź district, even under snow cover. Among them, *Chelidura guentheri* dominated. The catches of *C. guentheri* increased gradually from November to April with the highest number of individuals from February to April. After the revision of genus *Chelidurella* (=*Chelidura*) (Galvagni 1994) it is not clear which species concerns the data provided by Renken (1956), who was the first who noted this species as *Chelidurella acanthopygia* during winter in a similar

period – from November to March. *Apterigidia media* was not known as winter active before. Moreover, the only statement of snow activity of *C. acanthopygia*, given by Soszyńska-Maj (2008), was due to incorrect identification and should be assigned to *C. guentheri* (unpublished data). Only one species of earwigs found in winter – *F. auricularia* (Renken 1956) is undoubted. In this study, single individuals of *F. auricularia* were recorded in December, February and April. Renken (1956) provided data on this species activity from November to March.

Other Polish data on winter activity of invertebrates are few. Some data deal with phenology of flies and moths recorded on snow (Soszyńska 2004, Soszyńska-Maj & Klasa 2009, Soszyńska-Maj & Buszko 2011). Both Diptera and Lepidoptera were most active on the snow in early winter with a tendency to decrease in number of individuals from autumn to spring. During earlier winter studies, earwigs were found on the snow only once (Soszyńska-Maj 2008, Soszyńska-Maj – unpublished data). In our material from Moerick's traps these insects were absent in samples from the period of snow cover. It proves that Dermaptera are a significant element of subnivean fauna but only accidentally appear on the snow.

Can winter activity be explained by reproductive strategy?

The winter activity of *C. guentheri* can be explained by its reproductive biology. It is closely related to *C. acanthopygia,* which reproduce in the spring, and both males and females and the last two instars larvae overwinter (Kočárek 1998). Similarly, the occurrence of overwintering males can indicate copulation occurring just after winter. Kočárek et al. (2005) suggested that winter period can be used by these insects for intensive migration. The same strategy is characteristic for *A. media*, where probably males overwinter to copulate in early spring (Kočárek 1998).

The reproductive strategy of *F. auricularia* is different from *C. acanthopygia*. According to Kočárek et al. (2005) *F. auricularia* reproduce in autumn and both freshly laid eggs and adults overwinter. The first instar larvae appear in spring. Kočárek (1998) suggested that males are absent in winter catches because they do not survive this period, while females after laying their eggs overwinter to care for nests and young nymphs. However, *F. auricularia* was very accidentally noted in this period, predominantly males were collected in pitfall traps – in early and late winter and in the spring.

Habitat preferences

Chelidura guentheri was most abundant in beech wood in Parowy Janinowskie NR and in mixed coniferous forest in Molenda NR. Only single individuals were caught in riparian forest in Wolbórka NR. *Apterigidia media* were collected only in marshy alder carr (*Ribeso nigri-Alnetum*) confirming their specific environmental requirement. It is a hygrophilous species, collected only at very moist habitats, especially near rivers (Bednarz 1988, Kočárek 1998).

Subnivean feeding and food chains

Certain specialized invertebrates use the winter time for reproduction and migration under the conditions of lower pressure from predators (Soszyńska & Durska 2002, Hågvar & Greve 2003, Hågvar 2010). Furthermore, several groups are actively feeding under snow (Hågvar & Hågvar 2011) forming a winter food chain (Jaskuła & Soszyńska-Maj 2011). Dermaptera have not earlier been an object of winter food chains studies. *Chelidura guentheri*, the dominant species in our studies, is an omnivorous species feeding on both plants and animals. Maybe it can participate in winter food chains, even under snow. Closely related to earwigs, but absent in Europe, is the order Grylloblattodea, which consisted of species preferring low temperatures with the optimum around 4°C. These insects stay active in winter in subnivean space and on the snow cover, being top predators among invertebrates in cold period (Gillot 2005). The relatively high activity of *C. guentheri* under snow in some habitats suggests that these insects could be a food source for insectivorous vertebrates, especially shrews. As recent studies indicate, these omnivorous small mammals prefer to take actively moving prey (Ackefors 1964, Pernetta 1977, Aitchison 1984, 2001, Itämies & Lindgren 1989).

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