Seasonal development of the woodland earwig (*Chelidurella acanthopygia* Géné) in Denmark (Dermaptera)

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The developmental phenology and the seasonal activity pattern of *Ch. acanthopygia* in a Danish beech stand were studied. In 1969-1971 and 1987-1989 about 7000 woodland earwigs were collected. Based on head width and number of antennal segments the majority of the earwigs collected were divided into four nymphal instars and adults. The seasonal activity pattern of the developmental stages in the main layers of the beech forest ecosystem is presented. All first and second instar nymphs were collected in June-August and June-September respectively, whereas third and fourth instar nymphs as well as adults were recorded all the year round. A considerable part of the nymphs in the Danish *Ch. acanthopygia* population did not moult into adults during the first summer and autumn, even after a warm summer. Many hibernated as third or fourth instar nymphs apparently moulting into adults during the next spring. In Denmark the development of the woodland earwig is partly biennial. The seasonal development of the Danish *Ch. acanthopygia* population is compared with that of a German one (Schwarzwald) and the phenology of this species and *F. auricularia* in Denmark and Germany is discussed.

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Introduction

In insects, intraspecific variation in seasonal development within the geographical range of a species or from year to year in a given site is often observed. This also applies to earwigs, e.g. the common earwig (*Forficula auricularia* L.) (Günther & Herter, 1974). The duration of the development of *F. auricularia* from egg to adult in a number of sites was calculated (Herter, 1965, 1965a; Günther & Herter, op.cit.): In Madeira 3 months, in Corsica 7 months, in North Germany 9-10 months and in Jämtland, Sweden and the Tyrolese Alps 17 months. At Berlin the duration of the earwig development (egg to adult) varied from year to year, viz from 8-9 months in 1962-1963 to 10-11 months in 1959-1960, obviously depending on the mean air temperatures of spring and summer months (Günther & Herter, op. cit.).

The woodland earwig (*Chelidurella acanthopygia* Géné) is a typical Central European and partly North European species, which is often found in dry and warm habitats (Holst, 1970; Günther & Herter, 1974). In a site in the northern Schwarzwald, Germany, the seasonal development of the woodland earwig was unstable; after a warm summer an annual life cycle was observed, however after a cool summer some of the nymphs hibernated, completing the development during the second year (Franke, 1985). He suggested that a biennial life cycle might be the rule in mountainous regions and in northern Europe near the climatic limits of the species' range.

In Fennoscandia, *Ch. acanthopygia* is very common and widely distributed in South and Central Sweden, towards the north reaching Dalarna, Hålsingland and southern Norway (Holst, 1970; Aagaard 1972; Proschwitz, 1983; Borisch, 1989). In Denmark, the woodland earwig is recorded from several sites mainly in the eastern and southern parts of the country (Holst, op. cit.), primarily being associated with deciduous forest. In a mixed forest in eastern Jutland the species was very abundant in a beech stand (Nielsen, 1974, 1974a, 1974b, 1975, 1975a, 1987). In this site several thousand woodland earwigs representing all developmental stages were collected; sampling was done nearly all the year round for four years. Based on this material the developmental phenology of *Ch. acanthopygia* in a site in the northern part of its range was studied; this paper reports on the results. Further observations on the seasonal activity pattern of the woodland earwig in the main strata of the beech forest ecosystem are presented.

Site

The investigations were carried out 1969-1971 and 1987-1989 in the mixed coastal forest Hestehaven near Rønde, about 25 km NNE of Århus, eastern Jutland, Denmark. The research site is 3 ha of pure beech, the vegetation subsystem consisting of three strata, viz an overstory layer of beech (i.e. trees > 20 m, about 105 years old), an understory layer of beech (i.e. trees < 20 m), and a field layer comprising herbs and natural reproduction of ash (maximum height about 0.5 m). The association of plant species in the herb layer is the one typical of a common beech mull. The litter horizon is rather sharply separated from the surface soil; there is no significant accumulation of litter on the soil surface from year to year.

Materials and methods

The main layers of the beech forest ecosystem, except the overstory beech canopy, were included in the sampling programme. About 7000 woodland earwigs were collected in Hestehaven during the periods 1969-1971 and 1987-1989 by the following methods:

About 2850 woodland earwigs extracted from litter samples collected March 1970-June 1971 or caught by means of pitfall traps operated from September 1969 to August 1971 were kindly placed at my disposal by S. Toft, University of Aarhus; for details, see Toft (1976). Further about 200 woodland earwigs extracted from litter samples collected at random fortnightly from April 1987 to April 1988 and about 900 specimens from pitfall traps operated from April 1987 to July 1988 and again from March to July 1989 were included in the investigation.

Arboreal earwigs were sampled by: 1) Standardized weekly beating of understory beeches by means of wooden clubs, May-October 1969-1971 (N = about 2175; Nielsen 1975a); 2) Trapping of ascending canopy insects on beech stems by means of arboreal photoeclectors attended weekly, April-December 1970-1972 (N = about 275; Nielsen, 1974b); 3) Trapping of insects on beech stems by means of trap-bands, taken down

Instar	Pitfall traps 1969-1971 1987-1989	Litter samples 1970-1971 1987-1988	Beech canopy 1969	Total
Nymphs				
1. instar	281	40	0	321
2. instar	340	29	37	406
3. instar	342	226	304	872
4. instar	292	52	54	398
Adults	2158	205	319	2682
	3413	552	714	4679

Table 1. Number of woodland earwigs (*Chelidurella acanthopygia* Géné) recorded from a beech stand in Hestehaven, Denmark. Sampling methods, year and instar indicated.

*Tabel 1. Antal skovørentviste (*Chelidurella acanthopygia *Géné) indsamlet i en bøgebevoksning i Hestehaven, Danmark. Indsamlingsmetode, år og udviklingsstadier angivet.*

regularly during the autumn and winter 1969 and 1970 (N = about 600; Nielsen, 1974a).

Based on maximum head width and number of antennal segments 4679 specimens were divided into nymphal instars and adults (Table 1). The measurements were made by means of an eye-piece micrometer (Wild stereo microscope).

The remaining specimens (N = about 2300) were not grouped according to instars, thus only illustrating the seasonal and spatial distribution of the species in the beech forest ecosystem.

Results

Maximum head width of 150 woodland earwigs from the forest floor was measured, average head width (± SD) calculated, and number of antennal segments counted; all specimens with damaged antennae were disregarded. Adults and four nymphal instars occurred (Table 2). Among the largest males several specimens of *Ch. acanthopygia* f. *spinigera* were found, characterized by a very well developed forceps carrying two small dorsal projections near the base (Harz, 1960; Franke, 1985).

Based on these measurements the majority of woodland earwigs collected in Hestehaven were divided into developmental stages (Table 1, Fig. 1). In the material extracted from litter samples and collected in pitfall traps adults and all nymphal instars were recorded: All first instar nymphs were collected in June-August, distinctly peaking in July, second instar nymphs were recorded in June-September, primarily in July, and third and fourth instar nymphs were observed all the year round, occurring during winter as well as in spring and early summer of the next year. The number of third instar nymphs peaked in July-September.

Adult woodland earwigs were recorded in the forest floor all the year round. In June-August the number of adults recorded was relatively low, no doubt reflecting the gap separating the declining old adult generation and the appearing new one in September-October.

During the winter woodland earwigs were recorded from the forest floor, for instance in December-February 1970-1971 several specimens were collected by means of pitfall traps, viz N_3 = 18, N_4 = 58 and adults = 274 (Fig. 1) or extracted from litter samples

Instar	Width of head mm			Nos of antennal segments	N
	Range	Average ± SD			
Nymphs					
1. instar	0.88-0.92	0.90±0.02	(0.90±0.03)	8 (8)	9 (4)
2. instar	0.96-1.08	1.03±0.04	(1.06±0.03)	10 (10)	19 (47)
3. instar	1.16-1.36	1.28±0.04	(1.31±0.04)	11 (11)	53(141)
4. instar	1.52-1.72	1.61±0.05	(1.63±0.09)	12 (12)	12 (25)
♂*)		1.95±0.08	(1.88±0.09)	13 (13)	15 (34)
♂ *spinigera*			(2.10±0.10)		(32)
♀		1.92±0.07	(1.95±0.09)	13 (13)	42 (56)
Adults	1.72-2.08	1.93±0.07		13 (13)	57

Table 2. Width of head (range and average ± SD) and number of antennal segments recorded in each developmental instar of the woodland earwig (*Chelidurella acanthopygia* Géné), Hestehaven, Denmark. Number of earwigs (N) measured presented. Corresponding results recorded in a German population of *Ch. acanthopygia* in brackets (after Franke 1985); *) including f. *spinigera.*

*Tabel 2. Bredde af hovedkapsel (variationsbredde og gennemsnit ± SD) og antallet af følehornsled registreret hos udviklingsstadierne af skovørentvisten (*Chelidurella acanthopygia *Géné), Hestehaven, Danmark. Antallet (N) af ørentviste målt angivet. Tilsvarende resultater fra en tysk population af skovørentviste angivet i parentes (efter Franke, 1985); *) inklusiv f.* spinigera.

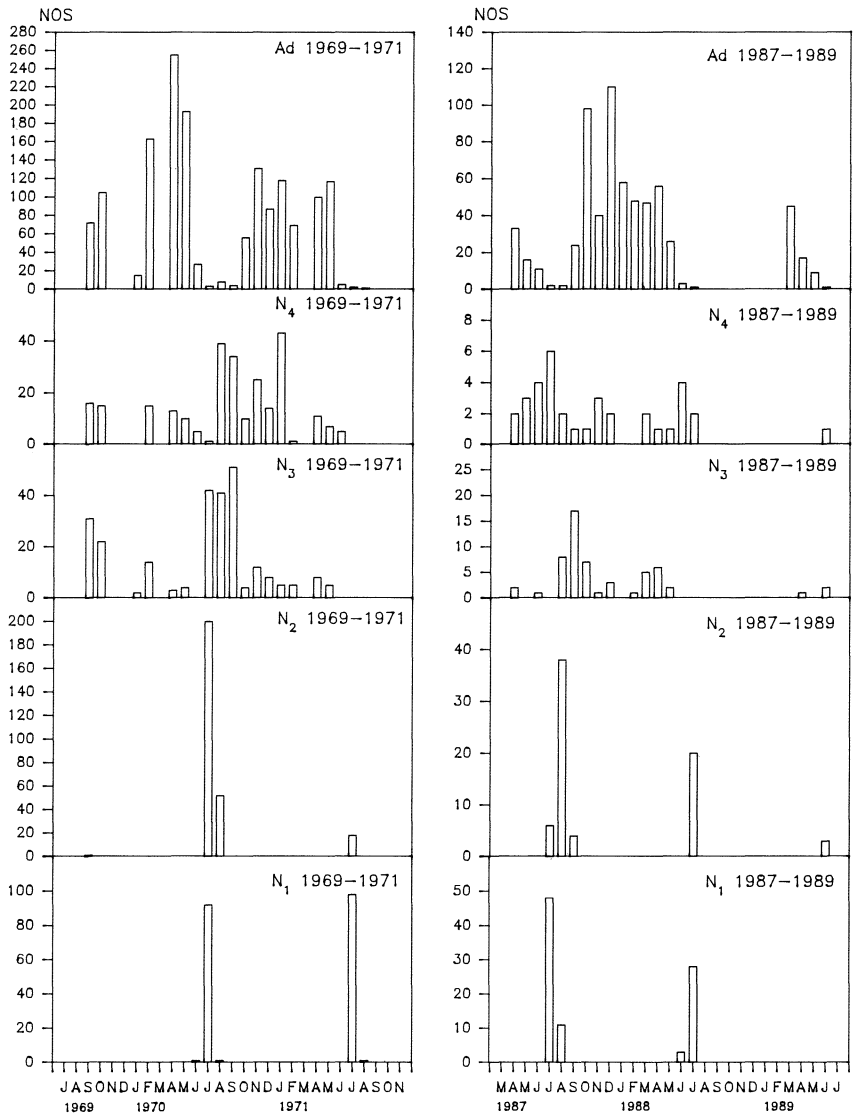

Fig. 1. Seasonal distribution of nymphs (N_1-N_4) and adults of the woodland earwig (*Chelidurella acanthopygia*) collected in pitfall traps in the forest Hestehaven, Denmark 1969-1971 (N = 2514) and 1987-1989 (N = 899). No sampling was done August 1988-February 1989. Note different scales of ordinate axes.

*Fig. 1. Årstidsmæssige fordeling af nymfer (N_1-N_4) og voksne af skovørentvisten (*Chelidurella acanthopygia*) indsamlet med fangglas i Hestehaven, Danmark, 1969-1971 (N = 2514) og 1987-1989 (N = 899). Indsamlingen var afbrudt august 1988-februar 1989. Bemærk forskellig inddeling af ordinatakserne.*

(N_3 = 43, N_4 = 5, adults = 28).

A considerable arboreal activity of *Ch. acanthopygia* was also observed in the site. In April a peak was observed in the catch of *Ch. acanthopygia* in arboreal photoeclectors, reflecting a considerable activity of ascending earwigs on the beech stems (Fig. 2). In August-September the above-ground activity increased in intensity, which is clearly demonstrated by an increasing number of *Ch. acanthopygia* trapped in arboreal photoeclectors – even after autumn litter fall – or

beaten from understory beeches, especially in September (Fig. 2). In the beech canopy only N_2, N_3, N_4 and adults were recorded (Table 1).

Discussion

The size class distribution of head width measurements and the number of antennal segments recorded in *Ch. acanthopygia* from Hestehaven indicate the presence of 4 nymphal instars (Table 2), being in accordance with the statements of Lhoste (1942) and Franke (1985). Average head width and the number of antennal segments recorded in adults and the four nymphal instars from Denmark are very close to - or identical with - those found in the German population studied by Franke (op. cit.) (Table 2). Presumably the four nymphal instars observed represent N_1-N_4 (cf. Lhoste, op. cit.; Franke, op. cit.). However Günther & Herter (1974) state that the original numbers of nymphal instars in earwigs, e.g. *F. auricularia,* are 5, the first moult occurring during the eclosion of the nymph from the egg. If so the first free-living instar is N_2. If the same is true in *Ch. acanthopygia,* the instars recorded in this investigation actually represent N_2-N_5.

In Hestehaven the first free-living nymphal instar was recorded in June-August, peaking in July. In Germany (Schwarzwald) this instar was observed in June; the woodland earwig oviposites in March-April (Franke, 1985) and the embryonic development lasts 5-6 weeks (Harz, 1960). In Denmark, the oviposition of *Ch. acanthopygia* most likely takes place in May-June. This is supported by 3 records of female woodland earwigs attending eggs in early June in the research site. In Sweden (Gothenburg), Gunnarsson (1980) made similar observations in late June; in one case (June 19) he observed eggs and a few newly hatched nymphs, indicating that the embryonic development was nearly completed. However it should be mentioned that dissection of 14 female woodland earwigs collected in early

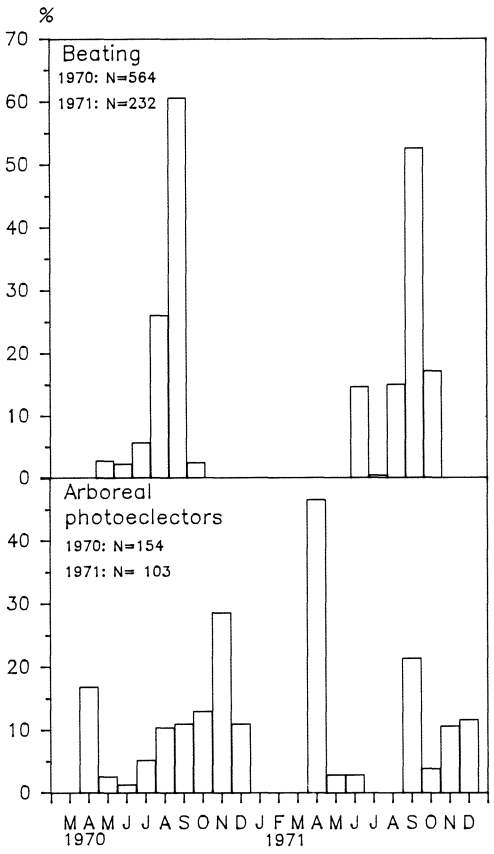

Fig. 2. Relative seasonal abundance of woodland earwigs (*Chelidurella acanthopygia*) recorded from beech in the forest Hestehaven, Denmark, 1970-1971. Below: Earwigs recorded from beech stems by means of arboreal photoeclectors. Above: Earwigs recorded from beech canopy by beating trees with clubs (N = number of specimens recorded).

Fig. 2. Relativ månedlig hyppighed af skovørentviste (Chelidurella acanthopygia) *indsamlet på bøg i Hestehaven, Danmark 1970-1971. Nederst: Skovørentviste registreret på bøgestammer ved hjælp af fangtragte. Øverst: Ørentviste registreret i bøgekronerne ved bankning af underetage-bøge med køller (N = antal indsamlede individer).*

November 1969 in Hestehaven revealed mature eggs in the ovaries and living spermatozoa in the spermatheca of all specimens.

The duration of the life cycle of *Ch. acanthopygia* in Hestehaven, Denmark, differs from that recorded in Schwarzwald, Germa-

ny by Franke (1985). In the four years a considerable part of the Danish *Ch. acanthopygia* population did not moult into adults during the first summer and autumn but hibernated as N_3 or N_4, moulting into the adult during the next year. Even after the favourable summer of 1969, this developmental pattern was observed. This year the mean air temperature of July and August represented the highest positive deviation from the mean of these months in the period of investigation, viz + 1.7° (data from the official meteorological station Tirstrup, about 25 km from Hestehaven).

Thus in Denmark the development of the woodland earwig is partly biennial, viz a life cycle comparable to the one observed after cool summers in the German site 800 km further south (Franke, 1985). Thus the seasonal pattern of development, which constitutes an exception in Schwarzwald, appears to be a rule under Danish climatic conditions.

Presumably woodland earwigs hibernating as nymphs in Denmark moult into adults during the next spring, reproducing in May-June. This is supported by the record of N_1 in June-August and N_2 in June-September only, suggesting a rather well-defined reproductive period (Fig. 1).

All nymphal instars as well as adult earwigs are active in the forest floor. In the material from pitfall traps the latter instar contributed about 63% but only 37% of the individuals extracted from litter samples (Table 1). Comparable trends were observed in woodland earwigs from the forest floor in Schwarzwald, Germany, viz 86% and 28% respectively (Franke, 1985). According to Franke (op. cit.) adult *Ch. acanthopygia* are more active on the surface of the forest floor than are nymphs, which are mainly associated with deep-seated litter layers. Consequently pitfall traps are a suitable collecting method for trapping adult earwigs, but less suitable when nymphs are concerned (Franke, op. cit.).

The first nymphal instar was only recorded in the forest floor and no arboreal activity was observed (Table 1). This distribution pattern reflects the parental care shown by earwigs, being maintained up to the 2. nymphal instar (Harz, 1960). After this period the nymphs also exploit the tree layers.

During the winter *Ch. acanthopygia* (adults, N_3 and N_4) is active in the forest floor – at least in mild weather or in the air space below the snow. During spring the activity of the woodland earwig in the forest floor continues, however arboreal activity is also recorded (Fig. 2). In spring, late summer and autumn the earwig is abundant in beech canopy as well as on stems, which are important connecting links between the forest floor and the canopy. In the latter period woodland earwigs are numerous on the beech stems during the night feeding on epiphytic growths (Nielsen, 1987). Nicolai (1985) also observed *Ch. acanthopygia* in high densities on beech stems during the night. The extent of arboreal activity of *Ch. acanthopygia* in the woodland site in Schwarzwald investigated by Franke (1985) is not yet clarified.

In the Danish woodland site *Ch. acanthopygia* was recorded from beech stems until December 1970; arboreal photoeclectors were not operated in January-March 1971 (Fig. 2). However artificial hibernation sites in the form of corrugated cardboard bands put out on beech stems were not utilized to any appreciable extent (Nielsen, 1974a). In December-February woodland earwigs were recorded in pitfall traps (Fig. 1) and extracted from litter samples; no doubt the majority of the earwigs spend the winter in the forest floor. Apparently the smooth bark of beech stems is inadequate as an arboreal hibernation site for *Ch. acanthopygia.* In a mixed deciduous forest in Germany *Ch. acanthopygia* used bark crevices of oak stems as hibernation sites (Büchs, 1988).

In Denmark the common earwig (*F. auricularia*) moult into the adult during the first summer (Bolwig, 1944; Holst, 1970). However Meinert (1863) observed different nymphal instars in October, stating that in Denmark the seasonal development largely

depends on the climatic conditions during summer. In Germany the postembryonic development of the common earwig is generally terminated before autumn (Harz, 1960). Apparently the same developmental pattern generally occurs in Danish *F. auricularia* in contrast to *C. acanthopygia* in which species only a part of the population moults before hibernation, even after a warm summer. In Denmark the common earwig generally oviposites in spring (Bolwig, 1944), however Meinert (1863) and Nielsen (unpublished) have observed earwigs guarding eggs in early October and early November respectively. In Germany the common earwig oviposites from November to March; at Berlin the majority of the eggs are laid in November (Harz, 1960; Günther & Herter, 1974). No doubt in Danish populations of *F. auricularia* and *Ch. acanthopygia* the oviposition is delayed as compared with the pattern observed in German ones.

Consequently when Danish and German populations of *Ch. acanthopygia* and *F. auricularia* are compared, displacements in life cycle phenology are observed. However detailed investigations in Danish populations on the developmental temperature thresholds of the different instars and the temperature sum necessary for the development are lacking. Further studies on the environmental control of life cycle pathways of earwigs by combinations of photoperiod and temperature (Khaldey, 1977; Danks, 1991) are necessary.

Dansk sammendrag

Skovørentvistens (*Chelidurella acanthopygia* Géné) årstidsmæssige udvikling i Danmark.

Fænologi og varighed af udviklingstid kan variere inden for en insektarts geografiske udbredelsesområde, men også fra år til år på en given lokalitet. Det gælder også for ørentviste. I det foreliggende arbejde blev udviklingstid og sæsonaktivitet i en dansk bestand af skovørentviste (*Chelidurella acanthopygia*) undersøgt og artens livscyklus i Danmark – i den nordligste del af dens udbredelsesområde – og Tyskland (Schwarzwald) sammenlignet.

Undersøgelsen er baseret på ca. 7000 skovørentviste indsamlet 1969-1971 og 1987-1989 i skovbund, på bøgestammer og underetagebøge i Hestehaven, Rønde (EJ); indsamlingerne blev stort set foretaget året rundt. Baseret på måling af hovedkapslens bredde og antallet af antenneled inddeltes hovedparten af materialet i udviklingsstadier; voksne individer samt fire nymfestadier påvistes. Alle nymfer i første og andet stadium indsamledes i henholdsvis juni-august og juni-september, hvilket tyder på en velafgrænset forplantningsperiode. Tredie og fjerde nymfestadium samt voksne skovørentviste registreredes derimod året rundt. En betydelig del af nymferne i den danske skovørentvistebestand udvikledes ikke til voksne i løbet af første sommer og efterår, idet mange overvintrede som nymfer i tredie eller fjerde stadium – selv efter den varmeste sommer i undersøgelsesperioden. Antagelig fuldføres udviklingen det følgende forår. I Danmark synes udviklingen af skovørentviste derfor at være delvis toårig, svarende til det udviklingsmønster, der i Schwarzwald – 800 km længere mod syd – observeres efter kølige somre. Det udviklingsmønster, der repræsenterer undtagelsen i skovørentvistebestande i Schwarzwald, synes at være reglen i danske bestande. Udviklingsstadiernes sæsonaktivitet i skovbund, på bøgestammer og i bøgekroner beskrives. Fænologien hos *Ch. acanthopygia* og den almindelige ørentvist (*Forficula auricularia*) i Danmark og Tyskland diskuteres. I den danske bestand af skovørentviste fandtes en del hanner tilhørende *Ch. acanthopygia* f. *spinigera,* der er karakteriseret ved veludviklede tænger med to små, dorsale fremspring ved basis.

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