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NORSK ENTOMOLOGISK FORENING

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Some Morphological Differences between *Proisotoma minuta* (Tullberg, 1871) and *P. clavipila* (Axelson, 1903) (Collembola, Isotomidae)

ARNE FJELLBERG

Fjellberg, A. 1973. Some Morphological Differences between *Proisotoma minuta* (Tullberg, 1871) and *P. clavipila* (Axelson, 1903) (Collembola, Isotomidae). *Norsk ent. Tidsskr.* 20, 273-274.

Specimens of *P. clavipila* found under bark on dead *Betula odorata* in Norway and Sweden are compared with material of *P. minuta* from compost heaps and flower pots from Norway and Tenerife. Besides the clavated apical hairs of tibiotarsus, the smaller and more roundish PAO, and the higher number of setae on corpus tenaculi, *P. clavipila* differs from *P. minuta* in having a richer ventral clothing on meso- and meta-thorax. The author considers the two forms to be different species.

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Axelson (1903) described *Isotoma clavipila* based on a single specimen found under a piece of wood near Wiborg in Finland. In 1912 he considered *I. clavipila* to be a variety of *Proisotoma minuta* (Tullberg). Folsom (1937), Stach (1947), and Palissa (1960) share this opinion, but it seems that they had not examined the form themselves. According to the original description of Axelson (1903), *P. clavipila* differs from *P. minuta* in having clavated apical hairs at tibiotarsus, more than one seta on corpus tenaculi, and smaller, more roundish post-antennal organ. But these characters are variable; Linnaniemi (1912) found *minuta* with 4 setae on corpus tenaculi, and Folsom (1937) noticed N. American *minuta* with one seta on corpus tenaculi and clavated tibiotarsal hairs.

I have found numerous specimens of a form corresponding to *P. clavipila* in colonies under rotten bark on birch (*Betula odorata*) at localities in Eastern Norway, Western Norway, and Swedish Lapland, and have compared them with specimens of *P. minuta* from compost heaps and flower pots from Norway and Tenerife. My *P. clavipila* specimens have at least one distinctly clavated apical hair at each tibiotarsus. I have sometimes observed a second hair at T II and

T III. The *P. minuta* specimens have simple hairs. *P. minuta* has normally only one seta on corpus tenaculi, while adults of *P. clavipila* have 3 or 4 setae. To judge from literature both these characters are variable and cannot be used to separate single specimens of the two forms.

I have also observed other characters that seem to be constant and different between the two forms (Fig. 1). *P. clavipila* has 2 or 3 setae at each side of linea ventralis on mesothorax. *P. minuta* has no seta here. I have found a similar group of setae ventrally on metathorax. Adults of *P. clavipila* have from 6 to 9 setae at each side (fewer in juveniles); the most frequent number is 7. All specimens of *P. minuta* that I have seen have only one seta in this position. The ventral clothing of abdomen II is also different. *P. clavipila* has a group of 2 setae in the median area, while *P. minuta* usually has 4 setae that may stay in a transverse line or in a more irregular position. My specimens of *P. clavipila* have a smaller, more roundish post-antennal organ than *P. minuta*. The length (height) of PAO is about 1.5 times the diameter of the nearest ocellus, while the same measurements on *P. minuta* are about 2.5 times.

The morphological difference between *P. mi-*

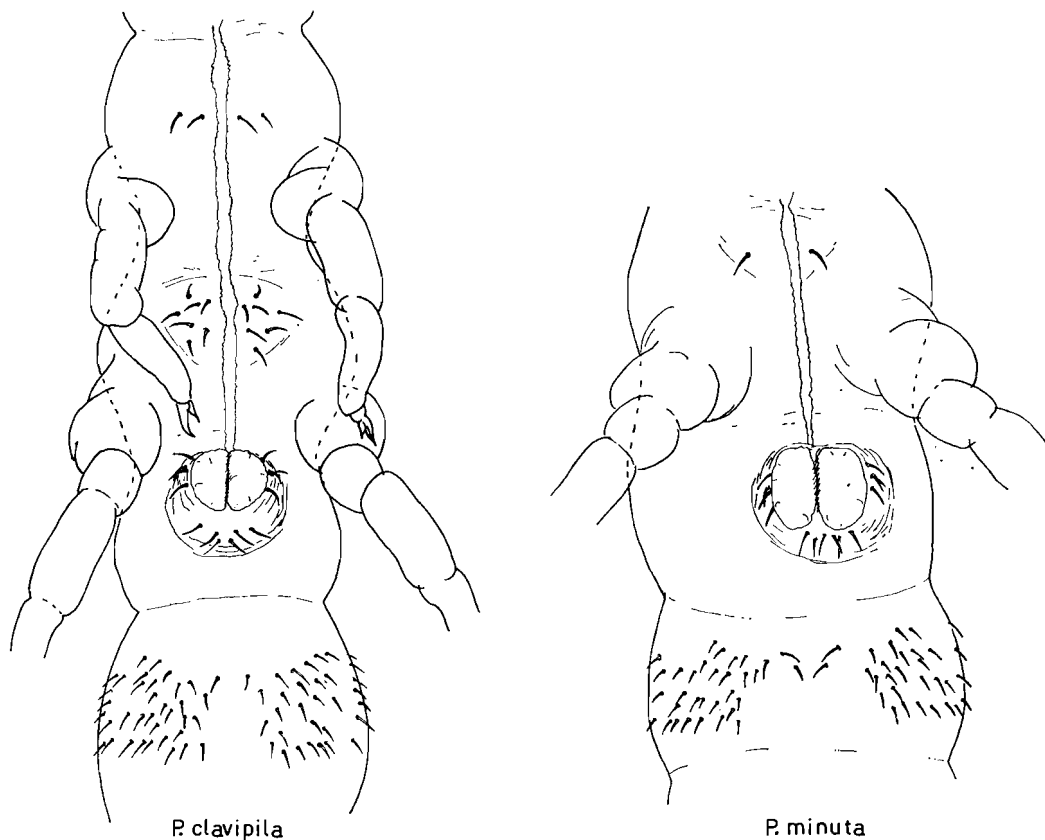


Fig. 1. Ventral clothing on thorax II—abdomen II of *Proisotoma clavipila* and on thorax III—abdomen II of *D. minuta*.

nuta and the Scandinavian *P. clavipila* is so great that it seems justified to regard the two forms as different species. This view is strengthened by the observed difference in habitat. *P. clavipila* seems to be a corticole species, whereas *P. minuta* is most frequently found in compost heaps and humus rich soil.

During the present study I have collected and examined the following material:

P. clavipila. Norway. Hordaland: Bruvik. Trengereidfjord, 11 March 1973. Under bark on rotten birch. 1 specimen. Hordaland: Fana. Hålandsdal, 14 May 1972. Under bark on rotten birch. 8 specimens. Buskerud: Krødsherad. Nore-sund, 19 Febr. 1973. Under bark on rotten birch. 3 specimens. Sweden. Torne Tappmark: Abisko. 23 June 1972. Under bark on rotten birch. 6 specimens.

P. minuta. Norway. Hordaland: Bergen. Botanical Garden, 5 Febr. 1972. Compost heap, litter. 12 specimens. Vestfold: Tjøme. Kjære, 23 Dec. 1972. In flower pots in house. 2 specimens. Tenerife. Puerto de la Cruz, 13 April 1972. Plant debris in banana plantation. 4 specimens.

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Araneae and Opiliones in Light Traps at Målsjøen, Sør-Trøndelag

JOHN O. SOLEM & ERLING HAUGE

Solem, J. O. & Hauge, E. 1973. Araneae and Opiliones in Light Traps at Målsjøen, Sør-Trøndelag. *Norsk ent. Tidsskr.* 20, 275-279.

The present study gives data on Araneae and Opiliones, captured in light traps operated in the area of Målsjøen (63° 14' N, 10° 26' E), just outside Trondheim, Norway. The trapping period was from 26 May to 9 November 1971. 28 species of Araneae and 2 species of Opiliones were captured. *Bolyphantes alticeps* (Sundev.), *Helophora insignis* Blw., and *Drapetisca socialis* (Sundev.) together make up approximately 67% of all adult specimens. *Gnathonarium dentatum* (Wid.) is reported new to Norway.

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During investigations of the insect fauna in the area Målsjøen, Klæbu, Sør-Trøndelag (63° 14' N, 10° 26' E), two light traps (light tubes Philips TLA 20W/05) were operated from 26 May until 9 November 1971. In these traps Araneae and Opiliones were regularly found in late summer and autumn. The traps were situated close to the ground on the shore of lake Målsjøen. One of the traps was fastened to a trunk of spruce (*Picea abies*), and this was the trap that collected most of the Araneae and Opiliones (Fig. 1). The traps were facing lake Målsjøen, and were surrounded by coniferous forest, shrubs of grey alder (*Alnus incana*), birch (*Betula pubescens*), bilberry (*Vaccinium myrtillus*), ling (*Calluna vulgaris*), common reed (*Phragmites communis*), and various mosses.

The present method of capturing Araneae and Opiliones is a rather unconventional one, and the whole collection is a by-product of an insect investigation.

However, an astonishingly high number of spider species (28), though less than 7% of the known spider fauna in Norway, were caught in these light traps, and some of the species are

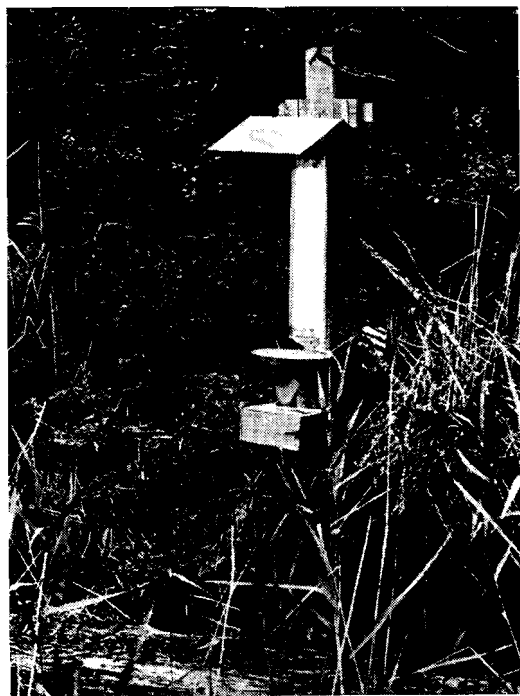


Fig. 1. The position of the light trap that captured most of the Araneae and Opiliones.

quite rare in Norway. An additional point is that the collections were made regularly throughout the whole summer, and thus gave information concerning aspects of the life cycle of some of the species involved. The conservation liquid was ethylen-glycol.

RESULTS

Araneae

The collection comprises 146 adult specimens of spiders and 82 juveniles. The 28 species found are classified by families in Table I, in which the number of specimens collected is also given.

Fig. 2 gives data on the number of species and specimens trapped each month the traps were operated. Very few specimens were captured until the last part of July; the number of species and specimens trapped increased until October, when the maximum of 15 species and 69 specimens was collected. The data presented indicate an increasing activity in autumn, partly because most of the species living in the higher strata have their densest adult population in late summer and towards the autumn (as have many of the ground-living species), and partly also because of an increasing gossamer activity. However, as several species were trapped regularly for longer periods, real activity in higher strata of the vegetation is probably the cause.

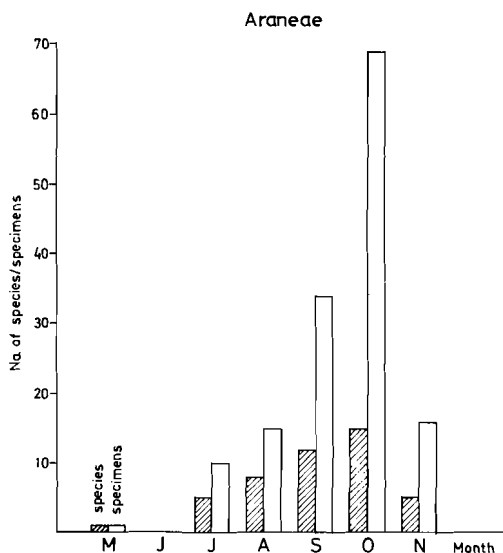


Fig. 2. Number of species and specimens of Araneae trapped in the different months.

Table I. Species and number of specimens of Araneae captured in the light traps

Linyphiidae	
<i>Gnathonarium dentatum</i> (Wid.)	1 ♀
<i>Gonatum rubellum</i> (Blw.)	3 ♀♀
<i>Oedothorax retusus</i> (Westr.)	1 ♀
<i>Savignia frontata</i> (Blw.)	1 ♀
<i>Centromerus silvaticus</i> (Blw.)	1 ♂
<i>Macrargus rufus</i> (Wid.)	1 ♀
<i>Drapetisca socialis</i> (Sundev.)	19 ♂♂ + 17 ♀♀
<i>Stemonyphantes lineatus</i> (L.)	1 ♂
<i>Bolyphantes alticeps</i> (Sundev.)	20 ♂♂ + 6 ♀♀
<i>Bolyphantes index</i> (Thor.)	1 ♀
<i>Lepthyphantes alacris</i> (Blw.)	2 ♀♀
<i>Lepthyphantes menzei</i> (Kulcz.)	1 ♂
<i>Helophora insignis</i> Blw.	15 ♂♂ + 20 ♀♀
<i>Pityophantes phrygianus</i> C. L. Koch.	1 ♂
<i>Trachynella nudipalpis</i> (Westr.)	1 ♂
Linyphiidae indet. juv.	16 specimens
Tetragnathidae	
<i>Tetragnatha dearmata</i> Thor.	4 ♂♂
<i>Tetragnatha extensa</i> (L.)	1 ♂
<i>Pachygnatha clercki</i> Sundev.	2 ♂♂
<i>Tetragnatha</i> spp. juv.	4 specimens
Argiophidae	
<i>Zygiella stroemi</i> (Thor.)	1 ♂
<i>Araneus</i> spp. juv.	3 specimens
Theridiidae	
<i>Steatoda bipunctata</i> (L.)	1 ♂
Lycosidae	
<i>Trochosa terricola</i> (Thor.)	1 ♀
<i>Pirata piraticus</i> (Clerck.)	2 ♀♀
<i>Pardosa lugubris</i> (Walck.)	3 ♀♀
<i>Pardosa prativaga</i> (L. Koch.)	1 ♀
<i>Pardosa</i> (?) juv.	50 specimens
Thomisidae	
<i>Xysticus ulmi</i> (Hahn.)	1 ♂
<i>Xysticus cristatus</i> (Clerck.)	1 ♂ + 2 ♀♀
<i>Xysticus</i> spp. juv.	2 specimens
Clubionidae	
<i>Clubiona trivialis</i> C. L. Koch.	6 ♂♂
<i>Clubiona germanica</i> Thos.	8 ♂♂
<i>Clubiona</i> spp. juv.	7 specimens
Salticidae indet. juv.	1 specimen

When studying Table I, it should be noted that there is (apart from the 50 juvenile Lycosidae) an astonishingly low percentage of juvenile specimens in the collection as a whole, and that

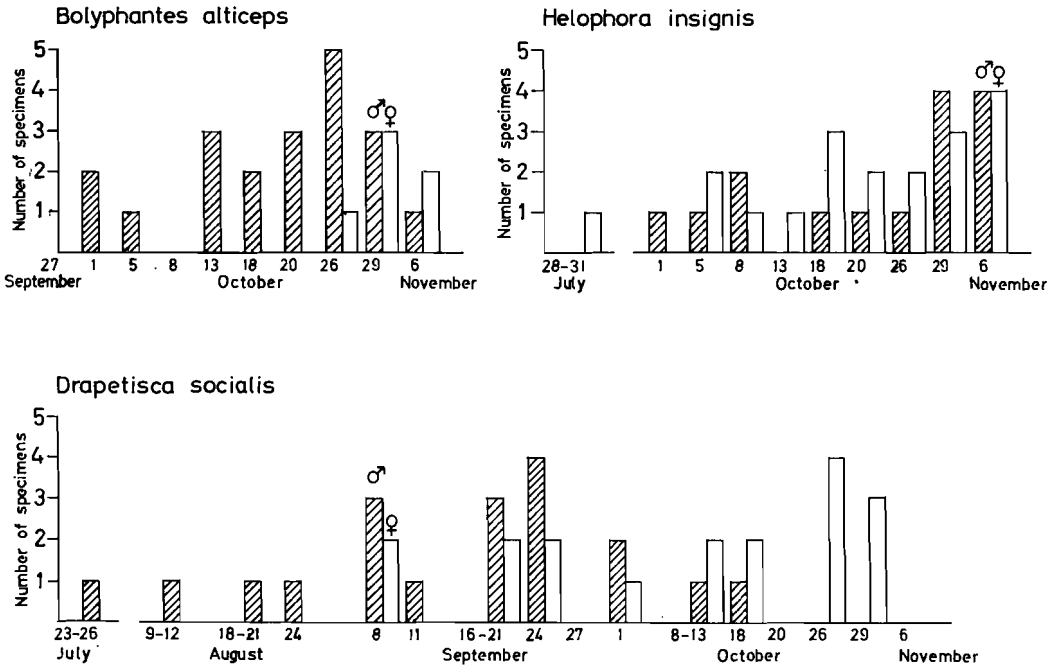


Fig. 3. The number of males and females of *Bolyphantes alticeps*, *Helophora insignis*, and *Drapetisca socialis* trapped on different dates.

the peak of species and specimens in October (Fig. 2) is mostly due to an increase in adult specimens. The 50 juvenile Lycosidae (Table I) are all newly hatched.

Of the species taken in the traps, *Bolyphantes alticeps* (Sundev.), *Helophora insignis* Blw., and *Drapetisca socialis* (Sundev.) together make up approximately 67% of all adult specimens. It is not very surprising that these three species dominate in the material. *B. alticeps* is fairly common in higher vegetation such as spruce (and junipers), while *D. socialis* lives, often in great concentrations, on tree trunks. The finding of the last mentioned species is hitherto one of the most northern records in Norway. Storm (1898) reports it from Mostadmarka near Trondheim, and Hauge (1972) reports it from Byneset near Trondheim, and from Nærøy. *H. insignis* is also a species inhabiting bushes and lower plants. The species has hitherto been reported as far north as Grong, Nord-Trøndelag (Hauge 1972). It is also known from Sogn (Strand 1902, Kauri 1966), and from Hallingdal (Strand 1899). In addition one ♀ has been found in a birch

forest, 28 August 1967, in the Skjomen fjord, Nn: Ankenes (Hauge, unpublished). It may be noted that the males of *B. alticeps* and *D. socialis* appeared earlier than the females, while this is not the case with *H. insignis* (Fig. 3). The captures of *D. socialis* also seem to indicate that the females make up a greater percentage of the capture in October than in September, 67% and 35%, respectively. The phenomenon that the females predominate over the males at the end of the activity period of the adults is known from various species of Plecoptera and Trichoptera (Benedetto 1970, Mendl & Müller 1970, Müller & Ulfstrand 1970), and should in the present study perhaps indicate a higher longevity among the adult females than among the males, as pointed out by Buche (1966).

Concerning the other species, a few words should be said about some of them:

Gnathonarium dentatum (Wid.) (1 ♀ 18-20 October) is to be considered as new to Norway, and the locality seems to be typical for this species, citing Wiehle (1960): 'am Ufer der Seen und Grösseren Teichen an sumpfigen Flussofern

wird man die Art der Bodenbedeckung selten vergebens suchen, wenn dass Belände unbeschattet ist (Tretzel: Photobiont-hygrobiont)'.

Tetragnatha dearmata Thor. (3 ♂♂ 23–26 July, 1 ♂ 18–21 August). The species is previously recorded only once in Norway: Hol in Hallingdal (Strand 1899 as *T. punctipes* Westr. (see Tullgren 1947)).

Clubiona germanica Thor. 1 ♂ 15–18 August, 1 ♂ 27–30 August, 2 ♂♂ 5–8 September, 1 ♂ 27 September–1 October, 1 ♂ 8–13 October, 2 ♂♂ 18–20 October). In Norway previously known only from Sande, Vestfold (Strand 1900).

Xysticus ulmi (Hahn). (1 ♂ 1–5 July). Known from Namdalen (Collett 1876), Mostadmarka near Trondheim (Storm 1898) (see also Tambs-Lyche 1942), and from Syd-Varanger (Waler 1970).

Opiliones

Only two species of Opiliones were captured, *Mitopus morio* (Fabr.) and *Platybunus triangularis* (Herbst), 420 and 9 specimens, respectively. The times of capture and the number of specimens trapped on the different dates are shown in Fig. 4.

P. triangularis was captured in the last part of July and in August, a period which seems to be somewhat delayed when compared with the findings in other countries where the adults occur in May-June (Thydsen Meinertz 1962).

M. morio is an autumn species, going by the abundance of adult specimens, and it shows a very rapid increase in the number of captured

specimens from the last part of September until the first days of November (Fig. 4).

DISCUSSION

It was unexpected that so many species and specimens of Araneae and Opiliones should be caught in the light traps. The use of light traps for collecting insects is a well-known and widely used method, but nevertheless, we have not heard of Araneae and Opiliones being collected by light traps. The present collection of Araneae and Opiliones was mostly captured in one trap, which is shown in Fig. 1. The trap was situated close to the ground, and the collecting jar was below the top level of the highest vegetation surrounding the trap. The light itself as an attracting source will here be left undiscussed, since we do not have much knowledge about how spiders are affected by it. It seems most likely that the large catches of spiders were due to one trap being situated close to the ground, and that the effect was more or less like that of a Barber trap. This is also confirmed by the fact that *Bolyphantes* (Sundev.), *Helophora insignis* Blw., and *Drapetisca socialis* (Sundev.), which live in higher vegetation or tree trunks, make up approximately 67% of the adult spiders trapped, and that they occurred regularly in the traps for longer periods (Fig. 3).

The large numbers of *Mitopus morio* captured in October (Fig. 4) show a high activity in this month, and may also indicate that the light is an attracting agent.

The collection is obviously not representative of the Arachnoid fauna in the area of Målsjøen, but it might be fairly representative of the Arachnoid fauna occurring high up in the vegetation, bushes etc.

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The field investigations were financially supported by the Norwegian Research Council for Science and the Humanities. Our thanks are also due to Mr. Kaare Aagaard for sorting the light-trap material, and to Professor Hans Kauri for reading the manuscript.

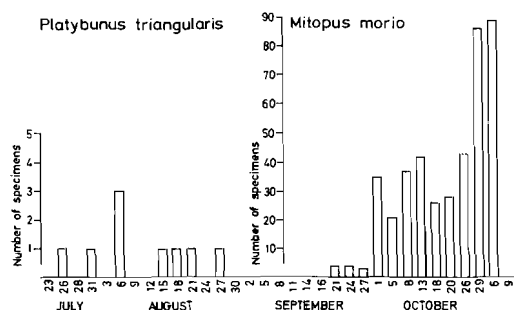


Fig. 4. The number of specimens of two species of Opiliones captured on different dates.

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Further Notes on Distribution and Bionomics of *Atomaria sahlbergi* Sjöberg (Col., Cryptophagidae) in Central Europe

PETR NOHEL

Nohel, P. 1973. Further Notes on the Distribution and Bionomics of *Atomaria sahlbergi* Sjöberg (Col., Cryptophagidae) in Central Europe. *Norsk ent. Tidskr.* 20, 281-284.

The cryptophagid beetle *Atomaria sahlbergi* Sjöberg, whose presence in Central Europe has only very recently been discovered, is reported here to occur in the Slovak East Carpathians (the Poloninské Karpaty Mts.). Additional data concerning the bionomics of this species are given, and an attempt is made to explain its present-day Central European occurrence as surviving from the Late Glacial period.

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The presence in Central Europe of *Atomaria sahlbergi* Sjöberg has only very recently been discovered (Nohel 1973). This species formerly considered as Nordic in its distribution has been reported to occur in the Silesian Beskydy Mts. It is thus of interest to note the most recent N. E. Slovakia records, which represent a considerable extension of the hitherto known range of *A. sahlbergi*.

MATERIAL

Amongst the material of the Atomariinae collected by the writer in Czechoslovakia, 1971–1972, and kindly identified by Dr. Colin Johnson, there were additional specimens of *A. sahlbergi*, taken at the following localities (Fig. 1):

Czechoslovakia: Czech Silesia: the Silesian Beskydy Mts. The Mionší primeval forest state nature reserve, 27 Sept. 1971, two specimens. Northeastern Slovakia: the Poloninské Karpaty Mts.: The Stučica montane primeval forest state nature reserve, 27 June 1971, two specimens. Same locality 7 Nov. 1971, four specimens. Same locality 4 Sept. 1972, three specimens.



Fig. 1. General location map of the Stučica montane primeval forest state nature reserve.

BIOLOGICAL OBSERVATIONS

The Mionší specimens were extracted from mouldy heaps of dry fir wood litter mixed in

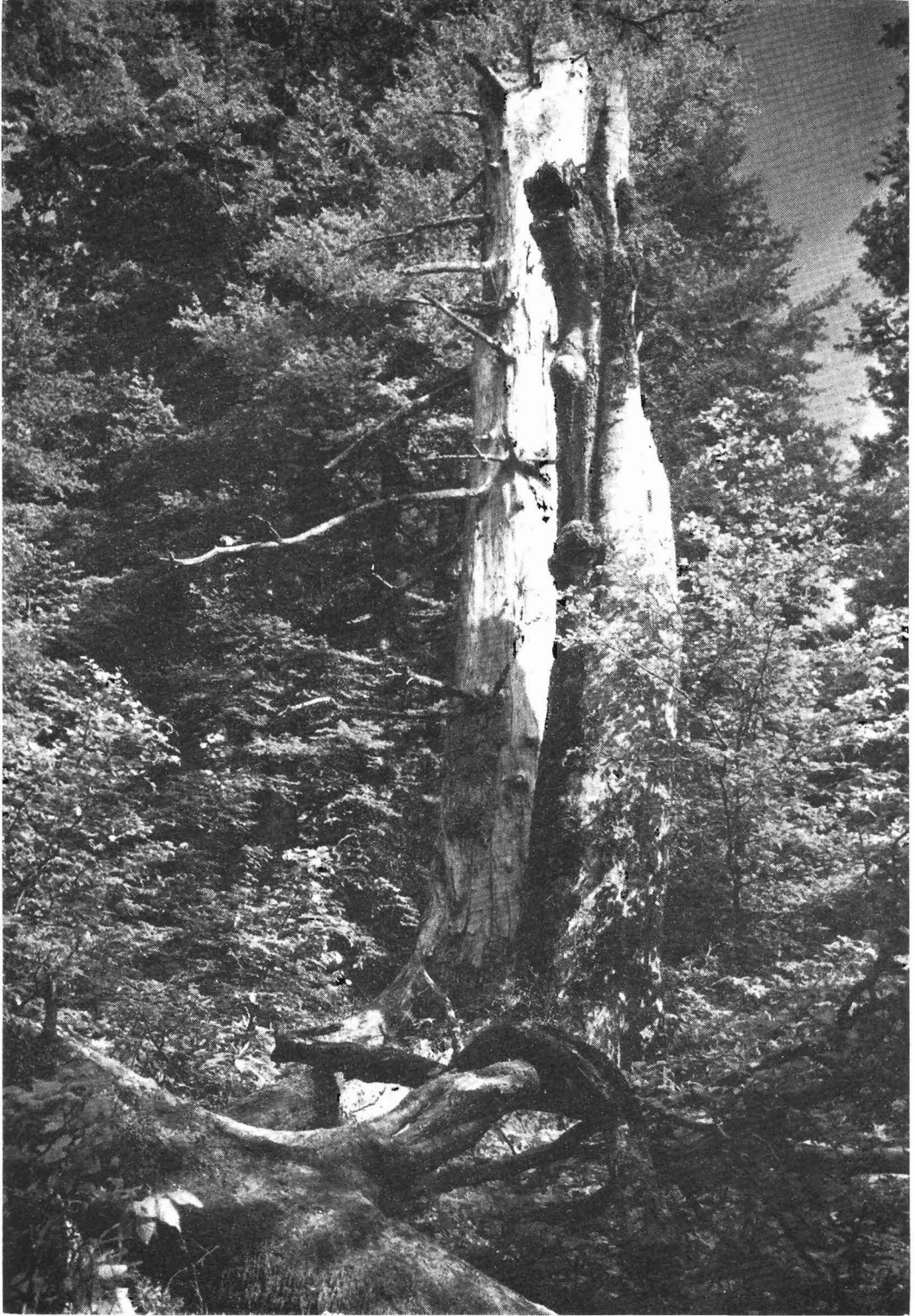


Fig. 2. Habitat of *Atomaria sahlbergi* Sjöberg. The Stužica state nature reserve, the Poloninské Karpaty Mts. Photo by Dr. Rudolf Janda.

with decomposed fir needles, accumulated at roots of a giant fir trunk growing on a steep northern slope, 700 m. a.s.l. The *Stužica* specimens, on the other hand, were collected by sieving quite dry and mouldy leaf litter and wood debris mixed in with partially decomposed grass roots. The litter was accumulated just under uprooted decaying beech log nearby the margin of the *Kyčera* alpine meadow, 700 m a.s.l. General view of this habitat is shown in Fig. 2. Such a vast bulk of mycelia of moulds and lower fungi grew through the litter heaps that at several places the mass of mycelia predominated over other organic material. The microhabitat was quite dry as the lying log sheltered it against rain. Nevertheless, exposed parts of the log were suitably damp to permit the occurrence of many species of lower fungi (Pezizales, Myxomycetes), which were seen to overgrow the more humid portions of the wood surface, being also abundant under remains of the bark. It is worth mentioning that the Coleoptera associated with damp wood included species that were never associated with the respective dry leaf litter – for example, various species of the genera *Abraeus*, *Plegaderus*, *Agathidium*, *Anisotoma*, *Rhizophagus*, *Sphaerosoma*, and *Mycetina*. The coleopterous fauna intimately associated with the peculiar microhabitat of dry heaps of mycelia was extremely rich both in species and in the number of specimens. It consisted also of many species that are indeed rare – to name all of them would be inappropriate since such a list is long. Yet, some of them certainly deserve mention as they no doubt indicate the richness of the fauna: Scydmaenidae: *Cephennium slovenicum*, *Microscydmus minimus*, *Euthia* sp.; Staphylinidae s.lat.: *Phyllodrepa pygmaea*, *Phyllodrepa melanocephala*, *Othius crassus*, *Conosoma bipunctatum*, *Leptusa koronensis*, *Stenus obscuripes*; Pselaphidae: *Euplectus bescidicus*, *Euplectus punctatus*, *Euplectus fauveli*, *Trimium carpathicum*, *Bryaxis ruthenus*; Anisotomidae: *Agathidium discoideum*, *Liodes nitida sedlicaensis*; Lathridiidae: *Enicmus brevicollis*; Micropeplidae: *Micropeplus latus*; Cryptophagidae: *Cryptophagus silesiacus*, *Atomaria affinis*, *Atomaria bescidica*, *Atomaria diluta*, *Atomaria alpina*; Trogoxetidae: *Zimioma grossum*;

DISCUSSION

Like all the three *Beskydy* specimens of *A. sahlbergi* mentioned previously (Nohel 1973), the additional two *Mionší* specimens were associated with fir debris. This would seem to indicate that in the Silesian *Beskydy* Mts. *A. sahlbergi* is definitely associated with the peculiar type of microhabitat that originates by accumulating fir-wood debris and needles under suitable environmental conditions, i.e. when the humidity of the habitat is reduced to a minimum, thus permitting the occurrence of special mycoflora with which many Coleoptera seem to be associated (Nohel 1973). In the *Stužica*, however, all *A. sahlbergi* specimens were found in debris of beech origin. Nonetheless, the humidity of that microhabitat was also very low. Observations made by the writer both at the *Mionší* and *Stužica* seem to indicate that *A. sahlbergi*, as well as several other related species, is ecologically associated with mycelia of some moulds or lower fungi, growing in suitably dry habitats. The same seems to be true for some other Coleoptera also associated with microhabitats mentioned above. For example, at the respective place in the *Stužica* primeval forest, there was a marked reduction in the richness of the coleopterous fauna even in the moderately damp leaf litter and wood debris situated very closely to the dry microhabitat where *A. sahlbergi* and other interesting beetles occurred. Generally speaking, it seems that suitably dry habitats are seldom encountered even in the otherwise rich milieu of the montane primeval forests. Perhaps this might explain the fact that the occurrence of *A. sahlbergi* in Central Europe was previously unrecorded. Also, the obvious rarity of some other Coleoptera associated with the afore-mentioned habitats could well be explained by the actual rarity of those habitats.

ZOOGEOGRAPHICAL IMPLICATIONS

The present N. E. Slovakian records represent a considerable eastward extension of the known range of *A. sahlbergi*. Since the environmental and climatic conditions in both the *Beskydy* montane primeval forests and in the same forests

of the Poloninské Karpaty Mts. are essentially the same, or at least very alike, it appears that the speculations concerning the origin of the occurrence of *A. sahlbergi* in the Silesian Beskydy Mts. (Nohel 1973) might well be extended to this species' occurrence in the Poloninské Karpaty Mts. There again, *A. sahlbergi*'s presence is most probably due to its surviving during the Late Würm retreat stages and the subsequent warm interstadial. It is clear that *A. sahlbergi* must also occur in montane primeval forests surrounding the Slovak Stužica, namely in the Puszcza Stużycza primeval forest on the Polish side of the Poloninské Karpaty Mts. (in Poland called the Bieszczady Mts.), and in the Stužickij Zapovednik primeval forest on the eastern side of these mountains, which now belongs to the Soviet Ukraine. In addition, it is extremely likely that *A. sahlbergi* occurs in those remains

of montane primeval forests where the climatic and environmental conditions permitted its survival. Consequently, the occurrence of *A. sahlbergi* elsewhere in the northern parts of the Carpathians may be anticipated.

ACKNOWLEDGEMENTS

I am grateful to Dr. Colin Johnson for identification of the *Atomaria* specimens which formed a basis for this paper.

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Received 16 April 1973

Anurida frigida. A New Species of Collembola (Hypogastruridae) from Swedish Lapland

ARNE FJELLBERG

Fjellberg, A. 1973. *Anurida frigida*. A New Species of Collembola (Hypogastruridae) from Swedish Lapland. *Norsk ent. Tidsskr.* 20, 285–287.

The new species was found under moss and stones by melt-water brooks in a high alpine locality (1600 m a.s.l.). It is related to the species *A. thalassophila* Bagnall, but differs from it in the shape of post-antennal organ, the dorsal chaetotaxy of prothorax, and the body granulation.

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HOLOTYPE

Female, 1.3 mm, labelled: 'Sweden. Torne Lappmark. Abisko, 20 June 1973. Nissuntjärro, 1600 m a.s.l. Under moss. A. Fjellberg leg.' The specimen is conserved in alcohol and deposited at the Zoological Museum, Department of Entomology, Bergen, Norway.

PARATYPES

65 specimens from the same sample as the holotype deposited as follows: 10 specimens in alcohol and 2 ♀♀ mounted on slides at the British Museum (Natural History), London; 48 specimens in alcohol and 5 ♀♀ on slides in my own collection. With the holotype in Bergen are also deposited 10 paratypes (8 in alcohol, 2 ♀♀ on slides) collected by me 28 June 1972 at the same site as the holotype.

DESCRIPTION

Colour whitish. No eyes. Body slender with clothing of rather thin setae (Fig. 1). Macrosetae of the last abdominal tergites finely ciliated. Thorax I with a dorsal, transverse row of 4 setae between the lateral macrosetae. Ventral tubus with 4+4 setae, the one pair inserted basally, behind the apical pair. Median area of abdominal sternite IV with 3–6 minute setae between the surrounding normal hairs. Cuticular granulation nearly uniform on the whole body,

only a little coarser on abdominal tergites V and VI. Post-antennal organ with about 15 irregular vesicles in circular arrangement (Fig. 4). Antenna IV with 7 more or less hammer-shaped sensorial hairs (Fig. 3). Apical organ with 3 lobes. Maxilla with 4-toothed ungulum and 3 ciliated lamellae, of which one extends beyond apex of ungulum. Mandibles with 6 teeth, the basal one largest. Claws without teeth. Body size reaches 1.35 mm. No males have been seen yet.

AFFINITIES

The new species is closely related to *A. thalassophila* Bagnall, of which I possess material from the vicinity of Bergen, Western Norway. It differs from *A. thalassophila* by having only 4 setae in the dorsal, transverse row of thorax I (*A. thalassophila* has 6, see Fig. 2). The vesicles of PAO are irregular, while they are of regular shape in *A. thalassophila* (Fig. 4). The abdominal setae are not so spiny as in *A. thalassophila*, and the body granulation is finer and nearly uniform on the abdominal tergites V–VI. On *A. thalassophila* this granulation is distinctly coarser in the middle part of tergites V–VI. The sensorial hairs on antenna IV are not so bent as in *A. thalassophila*, and a little more hammer-shaped (Fig. 3). The maxilla and mandible of the two species seem to be identical (for illustrations see Lawrence & Goto 1968, Figs. 36–41).

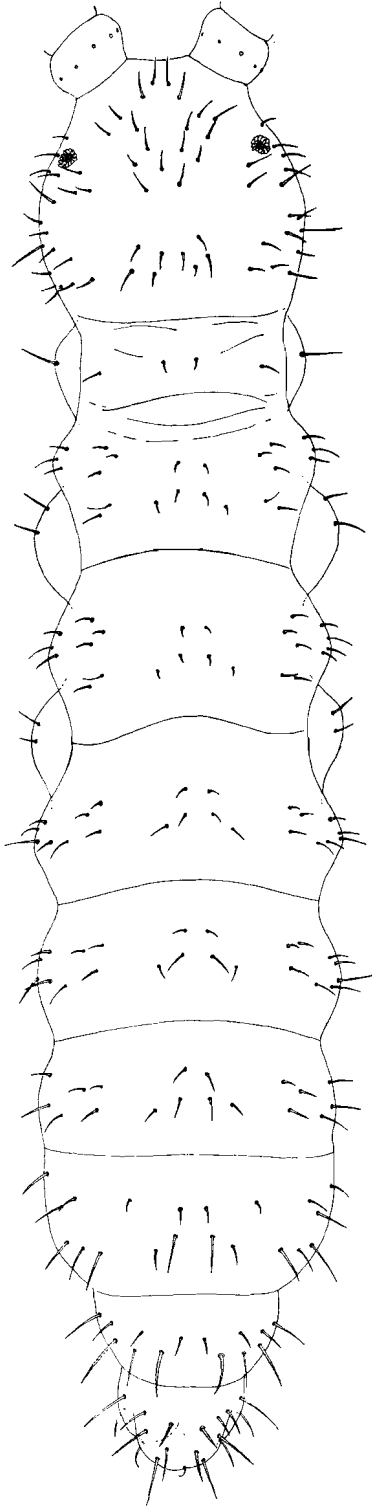


Fig. 1. Dorsal chaetotaxy of *A. frigida*.

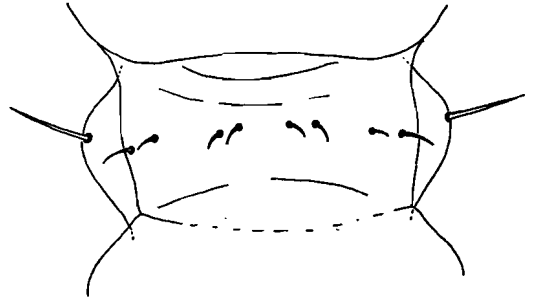


Fig. 2. Dorsal chaetotaxy of prothorax of *A. thalassophila*.

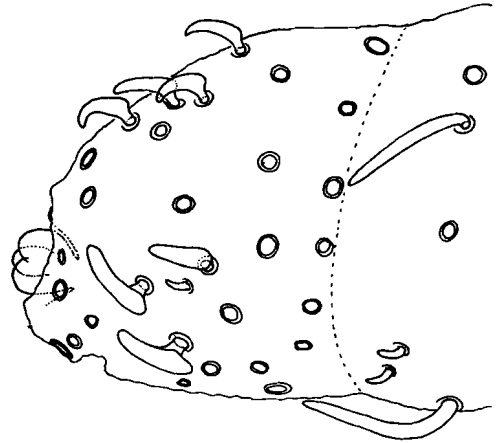


Fig. 3. Sensory hairs of antenna III and IV of *A. frigida*.

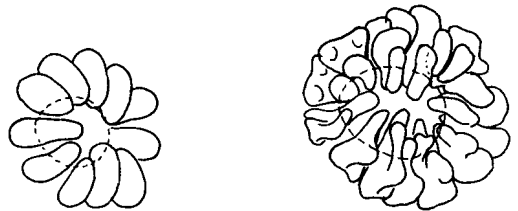


Fig. 4. Post-antennal organ of *A. thalassophila* (left) and *A. frigida* (right).

HABITATS

A. frigida was discovered in 1972 and 1973 under moss on stones at high levels (1600 m) on the Nissuntjärro mountain at Abisko, Swedish Lappland. Greatest numbers were seen under moss that was soaked by ice-cold melt water from snow drifts. They could easily be collected from the surface of pools which formed when stones lying in small brooks of melt water were turned up. The species was here accompanied by *Anurida alpina* Agrell, *Agrenia bidenticulata* (Tullberg), *Folsomia microchaeta* Agrell, *F. agrelli* Gisin, *Pseudisotoma sensibilis* (Tullberg), *Proisotoma subarctica* Gisin, and a possibly undescribed species of *Vertagopus*. I looked in vain for the

species at lower levels (1200 m) of the mountain. The only *Anurida* species occurring here was *A. forsslundi* Gisin.

It is remarkable that the nearest relatives of this apparently high alpine animal live under stones at the coasts, though it should be noted that both live at very moist places where periodically they may be submersed by flooding melt water or high tide.

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Received 16 July 1973



Taxonomical Notes on *Parasemidalis fuscipennis* (Reuter) (Neuroptera, Coniopterygidae)

JOHN O. SOLEM & KAARE AAGAARD

Solem, J.O. & Aagaard, K. 1973. Taxonomical Notes on *Parasemidalis fuscipennis* (Reuter) (Neuroptera, Coniopterygidae). *Norsk ent. Tidsskr.* 20, 289–290.

Taxonomical notes on *Parasemidalis fuscipennis* (Reuter) are given. Two males collected in an area just outside Trondheim, Norway, differed from the description of the species. The diagnostic character of the present specimens are intermediate to those earlier known of *P. fuscipennis* and the unnamed species *Parasemidalis* sp. 1. The specimens may belong to a geographically isolated population, but a clinal variation is another explanation for the difference.

J.O. Solem & K. Aagaard, *The Royal Norwegian Society of Sciences and Letters, The Museum, Erling Skakkes gt. 47b, N-7000 Trondheim, Norway.*

In an insect collection from the area of Målsjøen, Klæbu, Norway (63°14' N, 10°26' E), three males of the genus *Parasemidalis* were found. The collecting was carried out by light traps (light tubes Philips TLA 20W/05), and the two specimens dealt with in the present report were captured on the dates 18–22 June 1971 and 16–20 June 1972. The genitalia of the third specimen is unfortunately lost, but the specimen was identified as *P. fuscipennis* (Aagaard & Solem 1972).

As *P. fuscipennis* (Reuter) is the only species known from Norway and northern Europe, it was natural to compare the specimens with the description of *P. fuscipennis*. However, the diagnostic characters differed from the description and drawings of Meinander (1972), and the two males were sent to, and kindly examined by Dr. Martin Meinander, Helsinki. His opinion was that the specimens belonged to the species *P. fuscipennis*.

Since the present specimens differ from the description of *P. fuscipennis* given by Meinander (1972), we think our specimens are noteworthy. Following the nomenclature used by Meinander (1972), the specific species-characters of the males are confined to the genital structures, named hypandrium. In caudal view, the hypandrium on the specimens captured at Målsjøen has an incision (Fig. 1F), but if we follow the

description and the key to the species of the genus *Parasemidalis* in Meinander (1972, pp. 281–282), he states for *P. fuscipennis*: 'Hypandrium of male in caudal view without any incision' (Fig. 1B), while for the unnamed species *Parasemidalis* sp. 1 he states (pp. 281, 283): 'Hypandrium of the male in caudal view with a deep rather narrow incision' (Fig. 1D). In a letter to the first author, Meinander mentions that there was a slight incision on the hypandrium of the *P. fuscipennis* specimens examined by him, but as the incision was very slight, he did not pay much attention to it.

P. fuscipennis has a widespread distribution on the European continent, and is elsewhere recorded from Britain, Finland, Sweden, and Norway (Aagaard & Solem 1972, Meinander 1972). *Parasemidalis* sp. 1 is only recorded from the Canary Islands (Meinander 1972). In the whole distribution area, *P. fuscipennis* seems to be scarce, and is everywhere collected with only a few individuals. This handicaps studies of the range of variations of the diagnostic characters of the species.

According to Meinander (1972), *P. fuscipennis* is apparently confined to coniferous trees; if so, its location at Målsjøen is on the periphery of the European area suitable for the species. The diagnostic features may differ because the specimens belong to a geographically isolated popula-

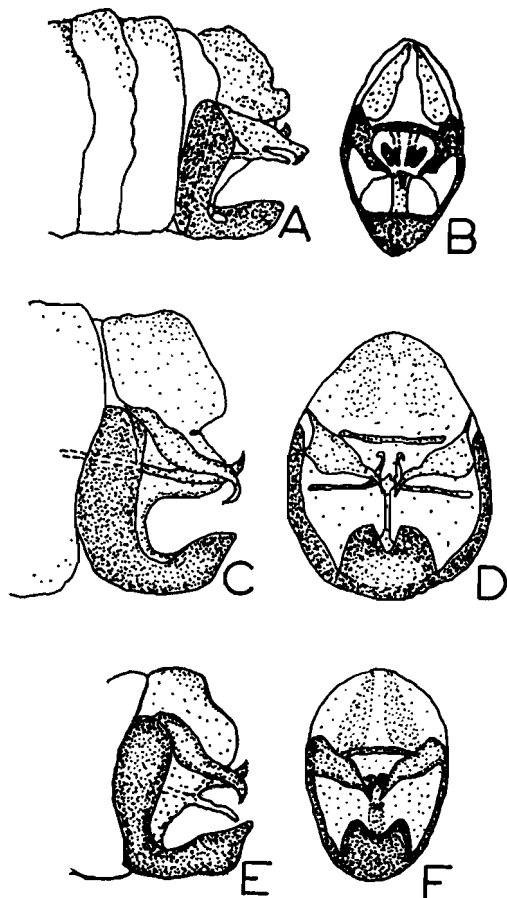


Fig. 1. Male genitalia in lateral (A, C, and E) and caudal (B, D, and F) view. A and B -- *Parasemidalis fuscipennis*; C and D -- *Parasemidalis* sp. 1; E and F -- *P. fuscipennis* from Målsjøen Norway. A, B, C, and D after Meinander (1972).

tion; a clinal variation is another possible explanation.

The finding of the *P. fuscipennis* specimens in the area of Målsjøen raises doubts as to the validity of the diagnostic characters used to separate the species in the group that Meinander (1972) calls 'species group *P. fuscipennis*', and which includes the two species *P. fuscipennis* and *Parasemidalis* sp. 1.

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Received 25 June 1973

The Breeding Biology of *Polydesmus angustus* Latzel (Diplopoda, Polydesmidae)

BARUNDEB BANERJEE

Banerjee, B. 1973. The Breeding Biology of *Polydesmus angustus* Latzel. *Norsk. ent. Tidsskr.* 20, 291–294.

April to July is the breeding period of *Polydesmus angustus* Latzel in the oak woodlands. Mating, nesting, and oviposition are at their peaks during this period and each behaviour pattern is described. The number of eggs laid vary under different environmental conditions. Eggs are deposited in special nests constructed by the female with worked-up soil from the gut. Different instars construct their own moulting chambers with bits of soil and humus.

The life cycle of *P. angustus* is completed in about 115 days in the laboratory against 200 days under field conditions. The difference reflected the responses of different instars to their immediate environment.

Barundeb Banerjee, Tocklai Experimental Station, Jorhat 8, Assam, India.

Polydesmus angustus Latzel is a common millipede of the British oak woodlands (Blower 1958) and in some parts of continental Europe (Meidell 1967). Its bionomics and seasonal cycle have been discussed by Blower (1955) and Banerjee (1967b) respectively. This paper gives an account of its life cycle and certain behaviour associated with breeding.

MATERIAL AND METHOD

Field studies were made in the oak woodlands in and around the Royal Holloway College (London) grounds; a description of the study area is given by Banerjee (1967a). Nests of *P. angustus* were common on the moss cushions during April–July (1961–63), when a number of them were examined every week for eggs and larval instars. Additional data on the abundance of advanced (4th to 7th) instars were obtained from the collections in the pitfall traps set up in the study area (Banerjee 1967b, 1970b). From the succession of instars an estimate of the different instars was made.

Observations on mating, nesting, oviposition, and life cycle phenomena were made in the laboratory, keeping adult millipedes in crystallizing dishes (diameter 10 cm; height 10 cm) filled

with decomposed litter collected from their natural habitats. The litter was kept moist and occasionally fresh litter was added. The receptacles were periodically examined to record the behaviour of the diplopods and the appearance of different instars.

OBSERVATIONS

Nesting sites in the field

Fully formed nests with eggs inside were found during April to July. Around the freshly constructed nests, adults were frequently seen crawling or staying very close. Nests were common on stones, fallen leaves, and wood, particularly in well-shaded damp areas, because they prevented desiccation during hot and dry periods and waterlogging during rain (Blower 1955).

Mating behaviour

Just before mating the male approached the female from behind and then slowly moved along her dorsal surface. By this time the female came beneath the male with her antero-ventral side clasping closely the corresponding part of the male body. The legs of the anterior segments

of the male held the female by the side of her keel. Mating continued uninterrupted for 30 minutes to three hours in different cases, but in some it persisted for about twelve hours at a stretch.

In the laboratory, mating occurred anytime during the day and night in February–March. Many adults trapped in the field during April–July were found in the state of mating.

Nesting behaviour and oviposition

The time gap between mating and oviposition varied from 14 to 25 days. Each female oviposited in a specially constructed nest. Before constructing the nest, the female became restive, moved vigorously along the inner edges of the receptacles, and constantly flickered her antennae. The sites selected for nesting were usually concave.

After the selection of the site, the female started moving slowly and closely around it. As she did so, she left behind her blobs of excrements containing soil particles, which dried up soon after coming in contact with air. These excrements were held together by a sticky substance spread all over the faeces which made them rather muddy. In about 10 to 40 minutes the concave spot was surrounded by a sort of rampart. The female added bits of leaves to the newly constructed nest to camouflage it.

The female then stretched herself across the open surface of the nest and laid eggs, one at a time, inside it. After all the eggs had been laid in about 20 minutes, the female started working on the upper part of the nest to cover the egg mass. This portion was constructed rather slowly. Only the posterior part of the animal made slow movements around the rim of the nest, leaving blobs of excreta in a similar manner as before. The anterior part of the female body rested in the surrounding litter and hardly moved at all. The upper portion was completed in about 60 minutes. The finished nest looked like a chimney with a broad base, tapering gradually at the upper end. The average diameter of the base was 7 mm, the height 10 mm ($N = 30$).

The temperature inside some nests constructed

at a constant temperature of 23° C in the laboratory was recorded with a thermocouple. The data are presented in Fig. 1. The nest temperature was always lower than that of the ambient temperature, but the difference decreased with time from 8° C an hour after construction to 3° C twelve hours later.

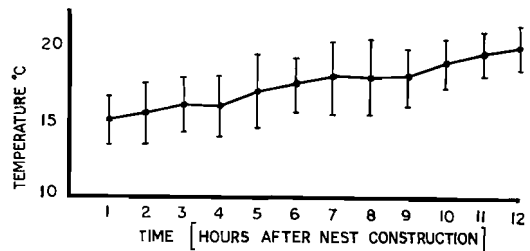


Fig. 1. Temperature fluctuations inside the nests of *Polydesmus angustus*, constructed at a constant temperature of 23° C. Mean of the observations on five nests is shown. Vertical lines are the standard errors of the mean.

The female did not leave the nest immediately after oviposition, but stayed close to it for two to three days. If forcibly removed, she quickly regained her position. Damaged portions of the nests were quickly repaired by her. The male stayed passive during the entire process of nest construction and its removal soon after mating or at any phase of nest construction did not affect the nesting behaviour of the female.

Nature of eggs

Eggs are white, spherical, diameter 0.35 – 0.45 mm. They are rich in yolk and held together by a sticky substance as in other diplopods (Miley 1927, Causey 1943, Davenport et al. 1952). The number of eggs laid by different Polydesmid species under laboratory conditions varied. Miley (1927) recorded 586 eggs and Davenport et al. (1952) 160. The present study shows that under field and laboratory conditions *P. angustus* laid on an average 184 (range 125–246) and 157 (range 135–251) eggs respectively.

Characteristics of different instars

Diagnostic features and measurements of

Table I. Characteristics of different instars of *Polydesmus angustus*. All measurements in mm. Mean \pm S. E. (standard errors) of measurements are given. N = 150 in each instar

Instar	No. of segments	Total body length	Maximum width	No. of paired legs	
				Male	Female
1	7	1.3 \pm 0.23	0.35 \pm 0.09	3	3
2	9	2.1 \pm 0.42	0.54 \pm 0.12	6	6
3	12	3.8 \pm 0.38	0.94 \pm 0.16	11	11
4	15	5.7 \pm 0.96	1.25 \pm 0.18	16	17
5	17	6.7 \pm 0.34	1.83 \pm 0.34	22	23
6	18	12.7 \pm 0.41	2.30 \pm 0.27	26	27
7	19	17.8 \pm 0.57	3.40 \pm 0.23	28	29

* The adult stage is reached at 8th instar with 20 segments

different instars are given in Table I. *P. angustus* moulted seven times before developing into sexually mature adults which then ceased moulting. The distribution of the instars in different months is shown in Fig. 2.

Appearance of first instar, moulting and gonopod development

Although the actual process of hatching could not be observed, newly emerged first instar larvae, as evident from their transparent guts, came up to the nest surface through exit holes at the basal end of the nests. Two to three hours

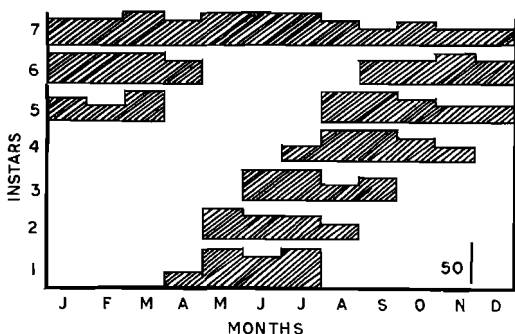


Fig. 2. Annual distribution of different larval instars of *Polydesmus angustus* on oak woodlands, around Royal Holloway College grounds.

after their appearance these larvae started feeding on humus and therefore their guts became dark. Under field conditions, they appeared approximately 45 days after oviposition, but in the laboratory this time was reduced to about 30 days.

Different larval instars constructed their own moulting chambers with bits of humus and soil held together by the secretions of the salivary glands. Moulting chambers of the 5th, 6th, and 7th instars were similar to those constructed by the female for oviposition but less elaborate. After the completion of the moulting chamber each individual crept in and sealed it from inside. More than one individual was common in the same moulting chamber, though individuals belonging to different instars did not occupy the same chamber. If used, moulting chambers were left fairly intact; only 2nd, 3rd, and 4th instar larvae utilized them for moulting. All the instars utilized parts of previous moulting chambers in constructing new chambers.

During moulting the old cuticle splits midventrally and laterally above the articulation of the legs. The animal then crept out of the old skin near the junction of the head with the trunk segments.

Sexual dimorphism began at the 4th instar stage, when in the male a dome-shaped structure appeared in place of the 8th pair of legs. In the succeeding instars this dome became complicated, being longer and three-jointed. In the 7th instar the three joints became considerably larger and the proximal segment sunk into a pit in the sternite. After the final moult the gonopod became more complicated.

Rate of development

Fig. 3 shows the respective duration of the seven larval instars in the field and laboratory. Some variation and overlapping were common because all the individuals belonging to a particular instar did not moult simultaneously. In the laboratory the duration of the life cycle was shorter (115 days) than those exposed to fluctuating conditions in the field (270 days).

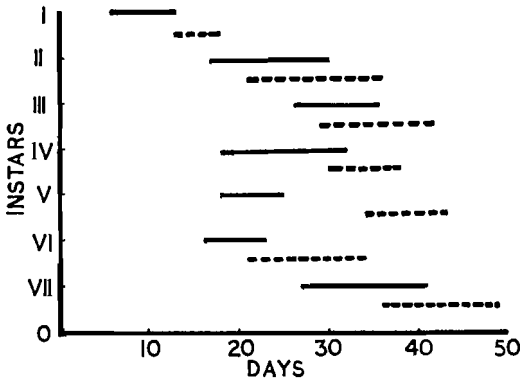


Fig. 3. Duration of the different larval instars of *Polydesmus angustus* on oak litter in the laboratory (continuous line) and under field conditions (dotted line).

DISCUSSION

The appearance of a large number of nests, eggs, and 1st to 3rd instars of *P. angustus* in the field during April to July coincides well with the peak period of its seasonal activity (Banerjee 1967b). This suggests that like the two Iulids, *Cylindroiulus punctatus* (Leach) and *Tachypodoiulus niger* (Leach), the seasonal activity of this species is also at maximum during its breeding season (Banerjee 1967a, b).

The basic plan of development of *P. angustus* is similar to that of the other species of Polydesmoidea (Evans 1910, Voges 1916, Miley 1927 Causey 1943, Eaton 1943, and Davenport et al. 1952). The number of segments added in the successive moults until the adult stage is 2,3,3,2, 1,1,1. The method of segment formation is described by Pflugfelder (1932) and follows the multiplicative mechanism by which a constant ratio is maintained between the rate of segment formation and moulting at a given time (Maynard-Smith 1960).

P. angustus has a fairly long life cycle extending well over 7 months under field conditions. Consequently one generation is produced in a year. The variability in the duration of different instars reflects the interacting effects of the immediate physical and biological factors on their behavioristic and developmental processes (Lyford 1943, Banerjee 1970). This in turn may influence the role of the species in the dynamics of an ecosystem of which it is a part.

ACKNOWLEDGEMENTS

The work reported here forms part of a study on diplopod ecology I made at Royal Holloway College, University, London.

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Syrphidae (Diptera) from Sicily, with a Description of a New *Pipizella* Species

TORE RANDULFF NIELSEN & ERNST TORP PEDERSEN

Nielsen, T. R. & Pedersen, E. Torp 1973. Syrphidae (Diptera) from Sicily, with a Description of a New *Pipizella* Species. *Norsk ent. Tidsskr.* 20, 295–299.

A collection of Syrphid Flies, comprising 29 species, was made by the authors in the Taormina area in April 1973. A new species, *Pipizella siciliana* nov. sp., is described, and comments given on the poorly known *Cheilosia brunipennis* Beck. female.

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The present paper reports on a collection made by the authors in the Taormina area, eastern Sicily, in 1973. Due to the short visit, from 14 to 20 April, and to extraordinarily bad weather conditions during the stay, the material is rather small, comprising 336 specimens and belonging to 29 species. The fauna of Sicily is, however, rather poorly known, and it is therefore of interest to publish records even of more common species of the area investigated. Three localities were visited:

Taormina. Collecting was made in a short, cultivated valley with scattered houses just north of the city. The valley is dominated by orchards and gardens between steep, sandy cliffs. Altitude 200–250 m a.s.l.

Letoianni (3 kms NNE of Taormina). Cultivated valley with *Citrus*-orchards near the city of Letoianni. Altitude 100 m a.s.l.

3 kms WSW of *Linguaglossa*. Rocky slope with grass and flowering herbs at the foot of Etna vulcano. Altitude 700 m a.s.l.

The material concerned can be found in the collections of the authors. A few species have been collected by only one of us. In that case the initials of the collector will be found in the list. We have also had the opportunity to use a male specimen of the new *Pipizella siciliana* nov.sp., belonging to the collections of Zoological Museum, Copenhagen, in our study. We are grateful to Dr. Leif Lyneborg for the loan of this specimen.

MATERIAL

Paragus albifrons (Fall.) 1817

Taormina 14 April (1♀); 15 April (1♂); 16 April (4♂♂, 2♀♀); 18 April (3♂♂).

P. haemorrhous Meig. 1822 (Syn.: *P. sigillatus* Curtis 1836)

Taormina 14 April (1♀); 15 April (1♂); 16 April (2♂♂, 1♀); 18 April (4♂♂, 1♀); 20 April (3♂♂).

Baccha elongata (Fabr.) 1775

Taormina 16 April (1♀); 18 April (1♂); 19 April (1♀); 20 April (1♀) (TP).

B. obscuripennis Meig. 1822

Taormina 14 April (2♂♂, 1♀); 15 April (3♀♀); 16 April (3♀♀); 18 April (2♀♀); 20 April (3♀♀).

Melanostoma mellinum (L.) 1758

Letoianni 16 April (3♀♀) (TRN).

M. scalare (Fabr.) 1794

Taormina 14 April (8♀♀); 15 April (1♂, 4♀♀); 16 April (3♀♀); 18 April (1♂, 4♀♀); 19 April (1♂); 20 April (1♀); Letoianni 16 April (1♀); 3 kms WSW of Linguaglossa 17 April (1♂).

Platycheirus ambiguus (Fall.) 1817

Taormina 14 April (1♂, 1♀); 15 April (1♂); 16 April (1♂); 19 April (1♀). The species is dis-

tributed over nearly the whole of Europe, from Norway and Sweden in the north, to Spain (e.g. Alicante) and Italy in the south. Schiner (1862, p. 291) recorded it from Botzen (= Bolzano) in the Italian Alps.

P. scutatus (Meig.) 1822

Taormina 14 April (13♂♂, 2♀♀); 15 April (8♂♂, 3♀♀); 16 April (5♂♂, 3♀♀); 18 April (4♀♀); 19 April (5♂♂); 20 April (3♀♀).

Xanthogramma pedissequum (Harr.) 1776

Taormina 15 April (2♂♂); 16 April (1♀); 18 April (1♀); 19 April (1♂); 20 April (2♂♂, 1♀).

Episyrrhus auricollis (Meig.) 1822

Taormina 14 April (8♂♂, 4♀♀); 15 April (3♂♂, 6♀♀); 16 April (1♂, 2♀♀); 18 April (1♂, 1♀); 19 April (10♂♂, 4♀♀); 20 April (2♀♀).

E. balteatus (Deg.) 1776

Taormina 14 April (1♀); 15 April (2♂♂, 1♀); 16 April (1♂, 1♀); 18 April (2♀♀); 19 April (1♂).

Chrysotoxum intermedium Meig. 1822

Taormina 14 April (1♂); 15 April (1♂); 16 April (1♂, 3♀♀); 18 April (2♂♂, 1♀); 19 April (1♂, 2♀♀); 20 April (3♂♂); 3 kms WSW of Linguaglossa 17 April (1♂, 2♀♀).

Metasyrrhus corollae (Fabr.) 1794

Taormina 14 April (1♂, 1♀); 18 April (2♀♀).

Syrphus ribesii (L.) 1758

Taormina 19 April (1♀); 20 April (1♂).

Epistrophe eligans (Harr.) 1776

Taormina 14 April (1♀); 15 April (1♂); 16 April (3♂♂, 1♀); 19 April (1♂); 20 April (1♂).

Sphaerophoria rueppelli (Wied.) 1830

Letojanni 16 April (1♂) (TRN).

S. scripta (L.) 1758

Taormina 14 April (2♀♀); 15 April (1♂); Letojanni 16 April (3♂♂).

Cheiliosia brunnipennis Beck. 1894

3 kms WSW of Linguaglossa 17 April (11♂♂, 1♀).

Belongs to group C according to Sack's (1932) division. Becker (1894) described the male on basis of material from southern Europe (including Sicily) in coll. Osten Sacken, coll. Loew and coll. Schiner-Egger. Szilady (1937–38, p. 141) mentions the species from two localities in present Rumania: Zetelaka (= Zetea, Reg. Mures) and Szaszka (= Sasca, Reg. Banat) (Lehrer & Lehrer 1966, p. 64), and from Albania. He also described very shortly the female, but this does not quite agree with our specimen. We therefore give an additional description of *Cheiliosia brunnipennis* Beck. ♀ below:

Epistoma, frons, and vertex shining aeneous black, dusted only at the sides and below the antennae. Frons somewhat broad, a little widening downwards, and only with lateral channels. The distance from lunulae to front ocellus is nearly the same as width of frons at transverse channel. Epistoma a little more hollowed than in the male, but central knob of the same shape. Eye-margins rather broad with pale hairs. Occiput quite shining on upper part. Eyes with rather short, dark hairs that also cover the lower parts. Antennae with 3rd joint somewhat larger than in the male, about 1 1/4 times as long as deep. It is orange-brown with the tip somewhat darkened. Arista black, less than twice as long as 3rd joint, and distinctly thickened on basal third.

Thorax, abdomen, and venter much more shining and with shorter hairs than in the male.

Femora black with apical 1/8 yellow. All tibiae quite yellow. Front and middle tarsi quite yellow except for the 5th joint. Hind tarsi with metatarsus and the 5th joint black; 2nd–4th joints yellowish, but somewhat darkened above.

Szilady (1937–38) remarks that *C. brunnipennis* might be only a variety of *C. canicularis* Panz. Our specimens, however, are very different from that species; they are more like *C. limbicornis* Strobl, but antennae and epistoma differ distinctly in the two species.

C. griseiventris Loew 1857

Taormina 14 April (3♀♀); 15 April (1♀); 16 April (1♀).

Belongs to group B. It is related to *C. intonsa*

Loew, but has broader frons and face, darker antennae, and eyes with denser pubescence, also in the female. Furthermore it has longer hairs on thorax, scutellum, and abdomen, longer wings, and the venter dulled by dust.

C. griseiventris was described on the basis of material from Italy (including Sicily), and is also known from France, Switzerland and northern Africa.

C. latifacies Loew 1857

Taormina 14 April (2♂♂); 15 April (1♂); 16 April (7♂♂, 1♀), 20 April (2♂♂); 3 kms WSW of Linguaglossa 17 April (1♀).

Belongs to group A. It is a southern and central European species, resembling the Spanish species *C. paralobi* Malski. The paralobes are, however, very different in the two species: about twice as long as deep in *C. latifacies*, and about ten times as long as deep in *C. paralobi*.

C. siciliana Beck. 1894

3 kms WSW of Linguaglossa 17 April (2♀♀) (TP).

Belongs to group D. A rather characteristic species with quite black legs. Becker described male and female on basis of material from Messina (Sicily) in coll. Loew in Berlin. The species seems to be endemic to Sicily.

Sphegina clunipes (Fall.) 1816

Taormina 14 April (1♀), 20 April (1♂).

Neoascia podagrica (Fabr.) 1775

Taormina 14 April (3♂♂, 1♀), 15 April (2♂♂), 16 April (7♂♂, 2♀♀), 18 April (1♂, 5♀♀), 19 April (2♂♂), 20 April (2♂♂).

Eristalis arbustorum (L.) 1758

Taormina 16 April (1♀) (TRN).

E. tenax (L.) 1758

Taormina 14 April (1♂, 2♀♀), 15 April (1♂), 16 April (1♂), 19 April (1♂); 3 kms WSW of Linguaglossa 17 April (2♀♀).

Myiatropa florea (L.) 1758

Taormina 14 April (2♂♂), 15 April (3♂♂), 16 April (1♂, 1♀).

Xylota segnis (L.) 1758

Taormina 14 April (1♀), 16 April (2♂♂, 2♀♀), 18 April (1♀), 20 April (1♂, 1♀).

Syritta pipiens (L.) 1758

Taormina 14 April (1♂, 4♀♀), 15 April (2♂♂), 16 April (2♂♂, 5♀♀), 18 April (5♂♂, 5♀♀).

Pipizella siciliana nov. sp.

Description

Male. Head: vertex, frons and epistoma aeneous black, a little pruinose in a narrow zone at the sides of epistoma, and with rather long hairs. The hairs are especially long and yellowish on frons and vertex, shorter and more whitish at the epistoma. Above and at the sides of antennae are some black hairs. The eye-suture is less than half as long as the vertical triangle and is about as long as the distance between front and hind ocelli. Occiput shining aeneous black on upper half, and with the yellow hairs longest on upper part. Eyes with rather dense and long, light yellowish-brown hairs; they are longest on upper parts of eyes. Angle of approximation in front nearly 90°. Antennae black. 3rd joint nearly as dark as the basal joints, and about 1 3/4 times as long as broad. Arista rather short, only a little longer than 3rd antennal joint.

Thorax: aeneous black with long yellowish hairs, which are especially long on scutellum. Veins of the wings black. Upper marginal cross-vein a little bent, and with the upper angle right-angular. Squamulae white with yellowish fringe. Halteres very light yellowish-brown. Legs predominantly black. Front and middle femora black with the apical 1/8 – 1/10 yellow. t_1 and t_2 yellow on basal 1/6. Metatarsus on p_1 and p_2 yellow, tarsal joints otherwise mainly black. Hind legs nearly quite black, f_3 yellow only very narrowly at apex. The legs with yellowish hairs, that are especially long on the femora, and on middle and apical part of t_3 .

Abdomen: aeneous black with yellowish hairs, longest at the margin and especially on basal corners of tergite 2. Venter shining with long pale hairs. Genitalia, see Fig. 1.

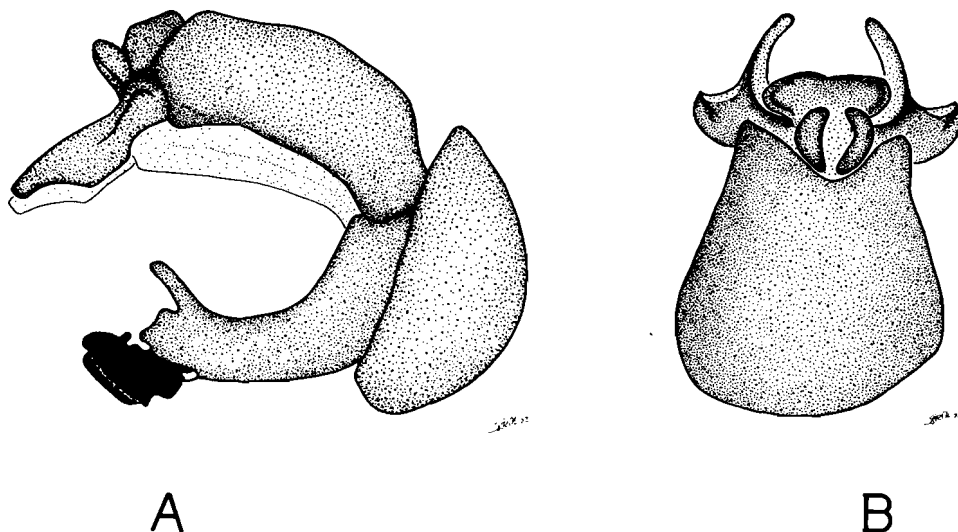


Fig. 1. Male genitalia of *Pipizella siciliana* nov. sp. A: Lateral view. B: ventral view. Orig.

Female. Head: Vertex, frons and epistoma coloured as in the male. Frons widening downwards from vertical triangle towards the antennae; it has a slight but marked transverse depression, with a shallow pit in the middle, above the antennae. Face below the antennae with the sides almost parallel. The hairs are black just in front of vertical triangle and at base of antennae; the hairs otherwise yellow at vertex and on frons, more whitish-yellow on epistoma. Antennae as in the male. Eyes with the pubescence a little shorter than in the male.

Thorax: mesonotum, scutellum and pleurae shining aeneous black, the hairs yellowish but slightly shorter than in the male. Wings lightly greyish or greyish-brown tinged, stigma greyish-brown, the veins brownish-black. Squamulae whitish, the fringe whitish-yellow. Halteres yellowish-white. Legs predominantly black, the knees narrowly yellow and metatarsus of p_1 and p_2 yellow. The hairs as in the male.

Abdomen: tergites coarsely punctate, moderately shining. The hairs short and brownish-yellow on disk except for some short, black hairs at apex of tergite 2 and 3. The hairs otherwise longer and more whitish-yellow at apex of tergite 4 and 5, and at frontal corners of tergite 2. Venter shining with rather long pale hairs.

Type material. Holotype: ♂ specimen dated Italy, Sicily, Taormina, 225 m a.s.l. 14 April

Table I. A comparison between males of some *Pipizella* species

	3rd antennal joint: length divided by its breadth	Front metatarsus
Group A: Length of eyesuture as long as length of vertical triangle		
<i>P. lyneborgi</i> Pedersen 1971	$1\frac{1}{2} \times$	dark
<i>P. maculipennis</i> (Meig.) 1822	$2\frac{1}{4} \times$	yellowish, but darkened above
<i>P. virens</i> (Fabr.) 1805	$1\frac{3}{4}-2 \times$	dark
Group B: Length of eyesuture as long as distance between front and hind ocelli		
<i>P. annulata</i> (Macq.) 1827	$2 \times$	yellow
<i>P. curviflora</i> Stackb. 1960	$2 \times$	yellow
<i>P. siciliana</i> nov.sp.	$1\frac{3}{4} \times$	yellow
<i>P. varipes</i> (Meig.) 1822	$1\frac{3}{4} \times$	dark
Group C: Eyes touching each other in one point		
<i>P. mesasiatica</i> Stackb. 1952	$1\frac{1}{2} \times$	dark
<i>P. mongolorum</i> Stackb. 1952	$1\frac{1}{2} \times$	yellow
<i>P. nigriana</i> (Séguy) 1961	$1\frac{1}{4}-1\frac{1}{2} \times$	yellow

1973. Allotype: ♀ specimen, same locality, 15 April 1973. Paratypes: 1♂ 14 April 1973, 1♂ and 1♀ 16 April 1973, 1♂ 18 April 1973, 1♂ 19 April 1973, 1♂ 20 April 1973, all from same locality; and 1♂ 4 May 1968, Sicily, Troina, Lago di Ancipa, 900 m a.s.l. (leg. S. Langemark, Zool. Mus., Copenhagen). Holotype in coll. E. Torp Pedersen, Jelling. Allotype in coll. Tore R. Nielsen, Sandnes. Paratypes: 3♂♂ in coll. Tore R. Nielsen, 2♂♂ and 1♀ in coll. E. Torp Pedersen and 1♂ in coll. Zool Mus., Copenhagen.

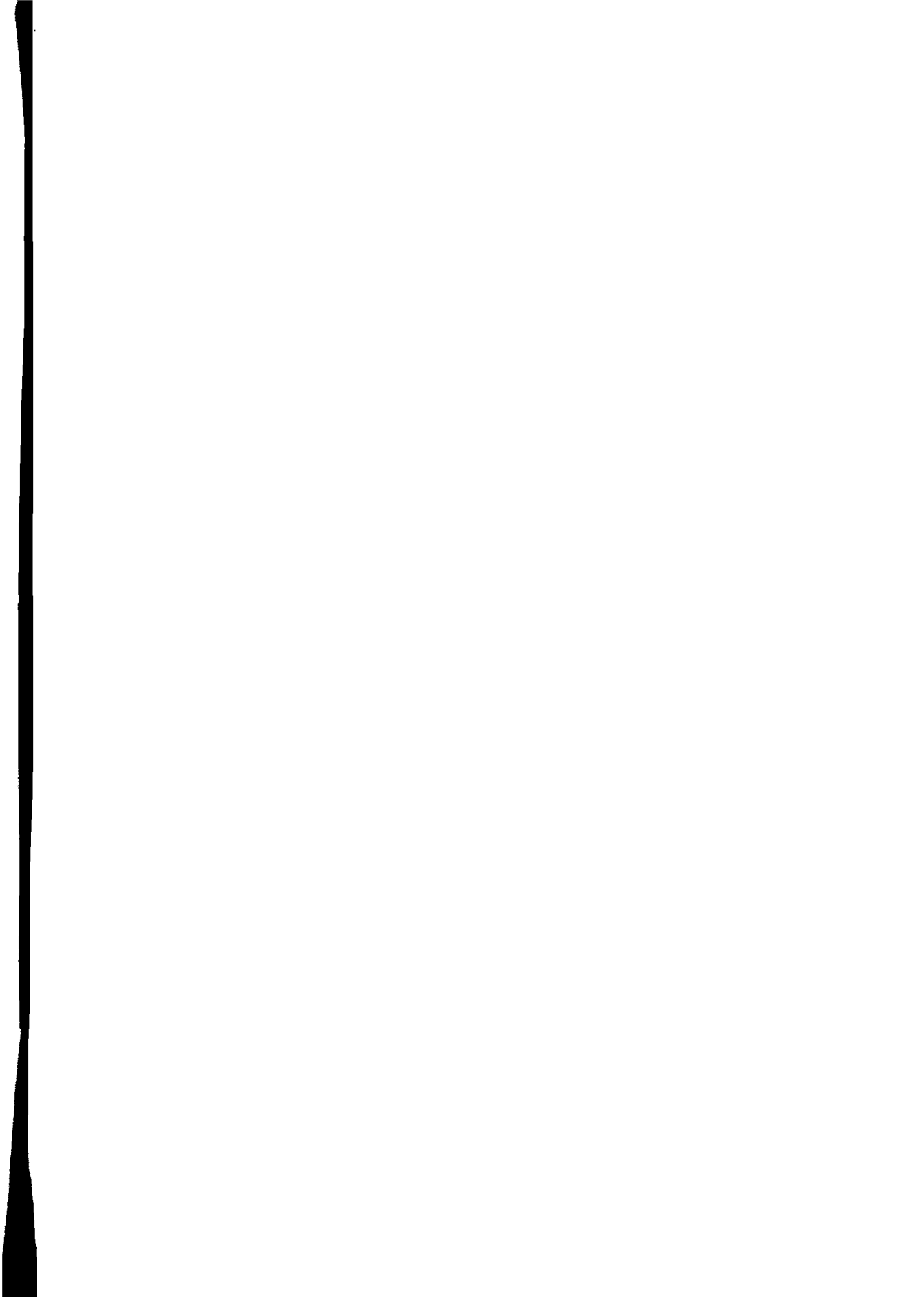
Comparison with other species

Pipizella siciliana nov. sp. has been compared with some related species in Table I. The table should, however, be used together with the genital structures of different species, which give additional and important characters in this genus (Fig. 1).

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Interactions between Pest and Host Plant in an Attack by the Broad Mite, *Hemitarsonemus latus* (Banks) (Acarina, Tarsonemidae), on Passion Fruit, *Passiflora edulis* Sims

GUDMUND TAKSDAL

Taksdal, G. 1973. Interactions between Pest and Host Plant in an Attack by the Broad Mite, *Hemitarsonemus latus* (Banks) (Acarina, Tarsonemidae), on Passion Fruit, *Passiflora edulis* Sims. *Norsk ent. Tidsskr.* 20, 301–304.

The broad mite, *Hemitarsonemus latus* (Banks), is recorded as a pest of purple passion fruit in Uganda. Mite attack severely inhibited shoot growth and fruit set. Increasing symptoms of damage adversely affected the mite populations. This indicates a physiological feedback between mite and host plant influencing the fluctuations of mite populations.

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During August and September 1970, previously unnoticed damage reached disturbing proportions in a passion fruit plantation at the Makerere University farm, Kabanyolo. The cause was found to be a tarsonemid mite, the broad mite ('yellow tea mite') *Hemitarsonemus latus* (Banks). Such attacks have also been of considerable economic importance in other Ugandan passion fruit plantations.

The broad mite is a well-known pest of a wide range of crops in the tropics, and in greenhouses elsewhere. It has not been possible, however, to find *Passiflora* sp. in any published list of host plants (e.g. Fox Wilson 1950, Lavoipierre 1940, Marle 1944, Smith 1933, Vrydagh 1942).

Observations on interactions between the broad mite and the passion fruit plants were made during October and November 1970, and are presented in the present paper.

MATERIALS AND METHODS

The study was made in a plantation of purple passion fruit, *P. edulis* f. *edulis*, cultivar 'Uganda variety', at the Makerere University farm. Shoots or leaves were grouped into four classes of damage: (a) No (insignificant), (b) slight, (c) medium, and (d) severe (Fig. 1). The numbers of living eggs, larvae and nymphs, and adults were

counted under a microscope on the three youngest expanded leaves on three replicates of shoots in these groups. Each replicate was taken on a one m stretch of the passion fruit row. The area of each leaf was estimated, placing it under a transparent plastic film lined with 1 cm² squares. The condition of the flower bud in the axil of each leaf was recorded.

Six shoots of the fourth order from the main stem of the plants were taken before this order of branches had produced any ripe fruits. All leaves except the three youngest on each shoot

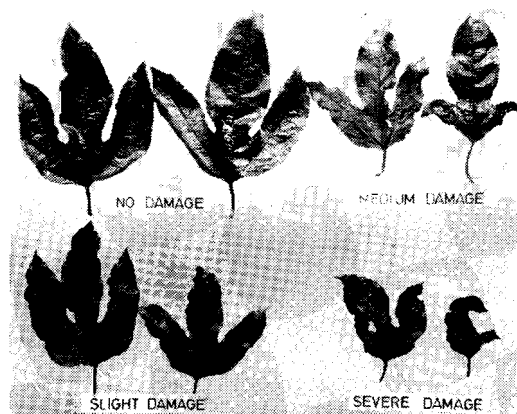


Fig. 1. Passion fruit leaves grouped into the four classes of damage used in the study.

were classified according to symptoms of damage. The condition of the generative development on the stem in the leaf axils, and the internodium length below each leaf position, were recorded for each classified leaf, and also when the leaf was missing.

The results were statistically analysed by the Centre for Experimental Design and Data Processing at the Agricultural University of Norway.

RESULTS

Effect on shoot growth

The broad mite attack severely inhibited shoot growth as measured by internodal length (Table I). The differences were highly statistically significant. Internodia below leaves showing only slight symptoms were reduced almost to the level of internodia below missing leaves. Internodia below severely damaged leaves were reduced to less than one third of those below healthy leaves. The length of internodia below missing leaves indicates that the mite attack was not the major cause of the leaf fall. Here most probably the water balance of the plants, and the brown spot disease (*Alternaria passiflorae*), were also involved.

Table I. Average length in cm of internodia below leaves with different degrees of damage by *H. latus* observed on six shoots of the fourth order from the main stem

	Leaves with					Statistical analysis
	No damage	Slight damage	Medium damage	Severe damage	Leaves absent	
Nos. of internodia observed	43	20	28	29	68	
Average internodium length	7.0	5.9	4.6	2.9	5.8	xx ¹

¹ Statistically significant at the 1% level.

Effect on fruit set

The effect of mite attack on flower bud or fruit fall is given in Table II. It is evident that the mites have prevented the development of fruits when the leaves showed medium or more damage, and also in most cases with slight leaf symptoms. Most often the flower buds were aborted at an early stage. On shoot tops of the three youngest leaves, one third of the flower buds were already missing where the leaf showed slight symptoms, eight out of nine where medium, and in all cases where the leaf symptoms were severe.

Table II. Flower bud and fruit fall in the axils of leaves with different degrees of damage by *H. latus*

	Leaves with				
	No damage	Slight damage	Medium damage	Severe damage	Leaves absent
Nos. of axils observed	47	23	30	31	69
Nos. of flower buds and fruits	23	1	0	0	5
Percent flower or fruit fall	51.1	95.7	100	100	92.8

Effect on broad mite population

The result on the relation between degree of damage on the shoots and the broad mite populations are given in Fig. 2. Fairly high populations were found on shoot tops with insignificant symptoms of damage. These populations were characterised by high frequencies of young stages, and few adults. The total density of the populations increased on slight and medium damage. The increase of adults with increasing damage was statistically significant at the 5% level on densities, and at the 1% level on the percentage values. A similar tendency occurred with increasing frequencies of adults with increasing age of the leaves. On the entire material of shoots showing severe symptoms of damage only three larvae were found on one leaf.

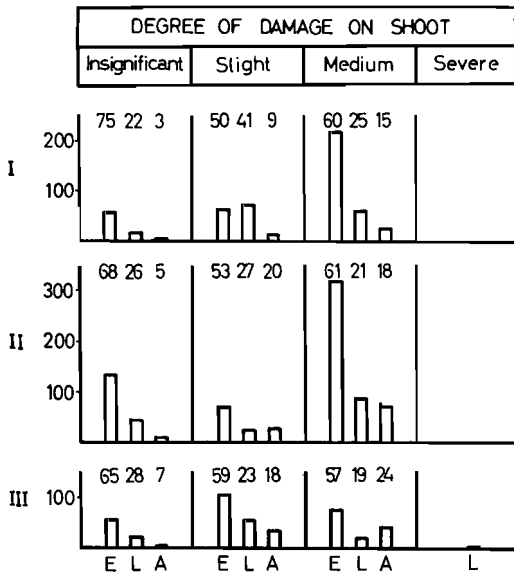


Fig. 2. Densities (columns) in individuals per 10 cm² leaf area, and percentages (numbers) of total mite population per leaf, of eggs (E), larvae and nymphs (L), and adults (A) on leaves Nos. I, II and III from top of passion fruit shoots with different degrees of damage by *H. latus*. Mean values from three replicates.

DISCUSSION

It is evident that *H. latus* may be a serious pest of passion fruit, severely inhibiting both shoot growth and fruit development, even when the symptoms of damage on the leaves are slight.

The earlier lack of records of the broad mite as a pest of passion fruit may be caused by the fact that the mites are rare or absent on the shoots with the most severe damage. The real cause of the malformed leaves and sterile shoots became apparent only after inspection of shoots with less or no apparent damage. Furthermore the distortions are similar to what could be expected from herbicide phytotoxicity, or from other types of non-parasitic physiological disturbances. Thus the symptoms of attacks by the broad mite on cotton were first believed to represent a physiological disorder (Jones & Mason 1926).

It is apparent that the degree of damage greatly influences the population development of

the mite. On shoots with normal vigorous growth and on young succulent leaves at the top, the mite populations have an age distribution typical of a population in rapid expansion: high number of eggs and young and few adults. The increasing frequencies of adults with increasing damage indicate populations in increasing stagnation, and a total collapse seems to occur on shoots with medium to severe symptoms of attack. This may be explained by a feedback mechanism on the mite population from the physiological response of the plant to the mite attack.

Dispersal of the broad mite is mainly done by the males which carry female nymphs to the young tender growth of the shoot tip where mating and oviposition take place (Gadd 1946). With increasing damage new growth is increasingly inhibited, and on severely damaged shoots the terminal bud is killed and further development is arrested until new buds develop. The top leaves are then partly malformed, hard, brittle, and of an abnormal dark green colour. These shoots evidently do not offer suitable living conditions for the mites. On several of the shoots with medium damage a high number of dead eggs and larvae were found. This indicates that the hardened leaves caused an unsuitable microclimate, resulting in desiccation of the eggs, and that these leaves were also unfit for larval feeding. The rapidity of the population cycles is explained by the short life cycle of the mite, which is 4–6 days (Gadd 1946, Vrydagh 1942).

Physiological feedback mechanisms as indicated in the present study have rarely been included in discussions on population dynamics. Dixon (1970) found a related interaction between an aphid population and its host. The present study seems to strengthen his conclusion that food plants may play a more important part in the population dynamics of herbivorous animals than has hitherto been suspected.

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I wish to thank Mr. Charles Lwanga for his able technical assistance.

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Spiders (Araneida) Collected in Strawberry Fields

GUDMUND TAKSDAL

Taksdal, G. 1973. Spiders (Araneida) Collected in Strawberry Fields. *Norsk ent. Tidsskr.* 20, 305–307.

On 1510 sampled strawberry plants in Southern Norway in 1968 and 1969 591 spiders were collected, including 21 identified species and a number of unidentified juveniles. *Theridion ovatum* comprised 54% of the specimens. The spider populations were low after spraying with azinphos-methyl, demeton-S-methyl, DDT, dimethoate, fenthion, malathion, and methomyl.

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During an investigation of Miridae in strawberries in 1968 and 1969 in Southern Norway, an unexpected number of spiders appeared in the samples. The high proportion of spiders among the collected arthropods was found to be of considerable interest since spiders are potentially beneficial to the natural control of plant pests.

MATERIALS AND METHODS

The samples were collected with a sweep-net with an opening diameter of 32 cm. The net was placed at an angle with the soil surface at the base of a strawberry plant. The plant was then bent into the bag and shaken. Thus only animals present on the plant above ground level were sampled, and not those staying among the litter on the ground. Further details are given elsewhere (Taksdal & Sørum 1971).

Information on insecticide usage was collected from all sampled fields. Some samples were also taken from field experiments on control of capsids (Taksdal 1971).

Samples were taken from the following counties and municipalities: Østfold: Askim, Fredrikstad, Moss, Rygge; Akershus: Asker, Ås; Oppland: Gjøvik; Vestfold: Nøtterøy, Sem, Stokke; Aust-Agder: Øyestad; Hordaland: Ullensvang; Møre og Romsdal: Norddal.

RESULTS

The total material of collected spiders is given in Table I. The material comprises 21 identi-

fied species, and a number of juveniles which could not be identified to the species level. *Theridion ovatum* was the most numerous species, with the highest number in 6 of the 13 municipalities where samples were taken, and comprising 54% of the total number of 591 collected spiders.

In Table II the samples are grouped according to the growers' information on the use of pesticides in the fields. All pesticides reduced the frequencies of spiders. The heaviest suppression of spider populations apparently occurred after combined applications of DDT and an organophosphate.

The spiders collected in two field experiments, one at Fredrikstad (Exp. I) and one at Asker (Exp. II), are given in Table III. The suppression of spider populations by insecticides used in these experiments was evident. No statistically significant differences were found between these insecticides in analysis of variance.

DISCUSSION

Strawberry fields often have a rich spider fauna comprising a number of species with a frequent predominance of *T. ovatum*.

The results do not indicate any real differences between the investigated pesticides in their detrimental effect on spider populations.

The collecting method employed does not sample the soil surface fauna. The spiders were, therefore, present on the plants above ground level where a number of pest species might be

Table I. Spiders collected in strawberry fields in 1968 and 1969

	Østfold	Akershus	Oppland	Vestfold	Aust-Agder	Hordaland	Møre og Romsdal	Total
No. of sampled plants	420	635	105	200	50	50	50	1510
<i>Dictyna pusilla</i> Thorell		1		2				3
<i>Drassodes</i> sp. juv.	10			3				13
<i>Clubiona stagnatilis</i> Kulczynski				2				2
<i>Anyphaena accentuata</i> (Walck.)		1						1
<i>Misumena vatia</i> (Clerck)				1				1
<i>Xysticus cristatus</i> (Clerck)	9	27			2	2		40
<i>Philodromus</i> sp. juv.		2		1				3
<i>Pardosa prativaga</i> (L. Koch)	1	1						2
<i>Pardosa amentata</i> (Clerck)	1							1
<i>Pisaura mirabilis</i> (Clerck)	1							1
Lycosidae div. juv.	16							16
<i>Theridion impressum</i> L. Koch	1	5	2					8
<i>Theridion ovatum</i> (Clerck)	27	222		62	1	7		319
<i>Theridion bimaculatum</i> (L.)	10	20						30
<i>Theridion</i> sp. juv.	4	13	1	1	1			20
<i>Tetragnatha</i> sp. juv.	1	2						3
<i>Meta</i> sp. juv.	1							1
<i>Araneus cucurbitinus</i> (Clerck)		3					1	4
<i>Araneus</i> sp. juv.	1	1						2
<i>Entelecara acuminata</i> (Wider)		1						1
<i>Entelecara erythropus</i> (Westring)		1						1
<i>Gongylidium rufipes</i> (Sundevall)	15	5		5				25
<i>Dismodicus bifrons</i> (Blackw.)					1			1
<i>Oedothorax apicatus</i> (Blackw.)		5						5
<i>Erigone dentipalpis</i> (Wider)		1						1
<i>Erigone atra</i> (Blackw.)				1		1		2
<i>Meioneta rurestris</i> (C. L. Koch)		1	3					4
<i>Leptyphantas</i> sp.		3						3
<i>Linyphia clathrata</i> Sundevall						1		1
<i>Linyphia</i> sp. juv.	11							11
Linyphiidae div. juv.	11	8	14	3	4			40
Juv. indet.	11	7		8				26
	131	330	20	89	9	11	1	591

Table II. Spiders collected in strawberry fields after different insecticide applications

Insecticide application	No. of samples	No. of sampled plants	Average (and range) per 10 plants	
			All species	<i>Theridion</i> spp.
None	13	650	6.2 (1.0–27.2)	4.7 (0.6–25.6)
Demeton-S-methyl + parathion	4	200	0.8 (0–12)	0.4 (0–0.8)
DDT	4	200	0.5 (0–1.0)	0.4 (0–0.8)
DDT + dicofol	4	250	0.1 (0–0.3)	0.04 (0–0.1)
DDT + organophosphate ¹	3	150	0.07 (0–0.2)	0

¹ azinphos-methyl, demeton-S-methyl, or diazinon.

Table III. Spiders collected per 10 plants in field experiments on insecticide testing

Treatment ¹	% active ingredient	Exp. 1		Exp. 2	
		All species	<i>Theridion</i> spp.	All species	<i>Theridion</i> spp.
Azinphos-methyl (35 % W.P.)	0.05	1.5	0.5		
Dimethoate (50 % E.C.)	0.03	1.0	0.5	12.7	4.7
Fenthion (50 % E.C.)	0.05	4.0	0.5		
Malathion (60 % E.C.)	0.07	5.0	1.5	10	4.7
Methomyl (25 % W.P.)	0.025	10.0	2.0	4.7	2.7
No treatment		12.0	7.0	14.0	8.0

¹ W.P. = wettable powder; E.C. = emulsifiable concentrate.

among the prey. The effect of spiders on pest populations is, however, difficult to estimate. According to Turnbull (1973), research on the potentialities of spiders as agents of biological control is so far inconclusive.

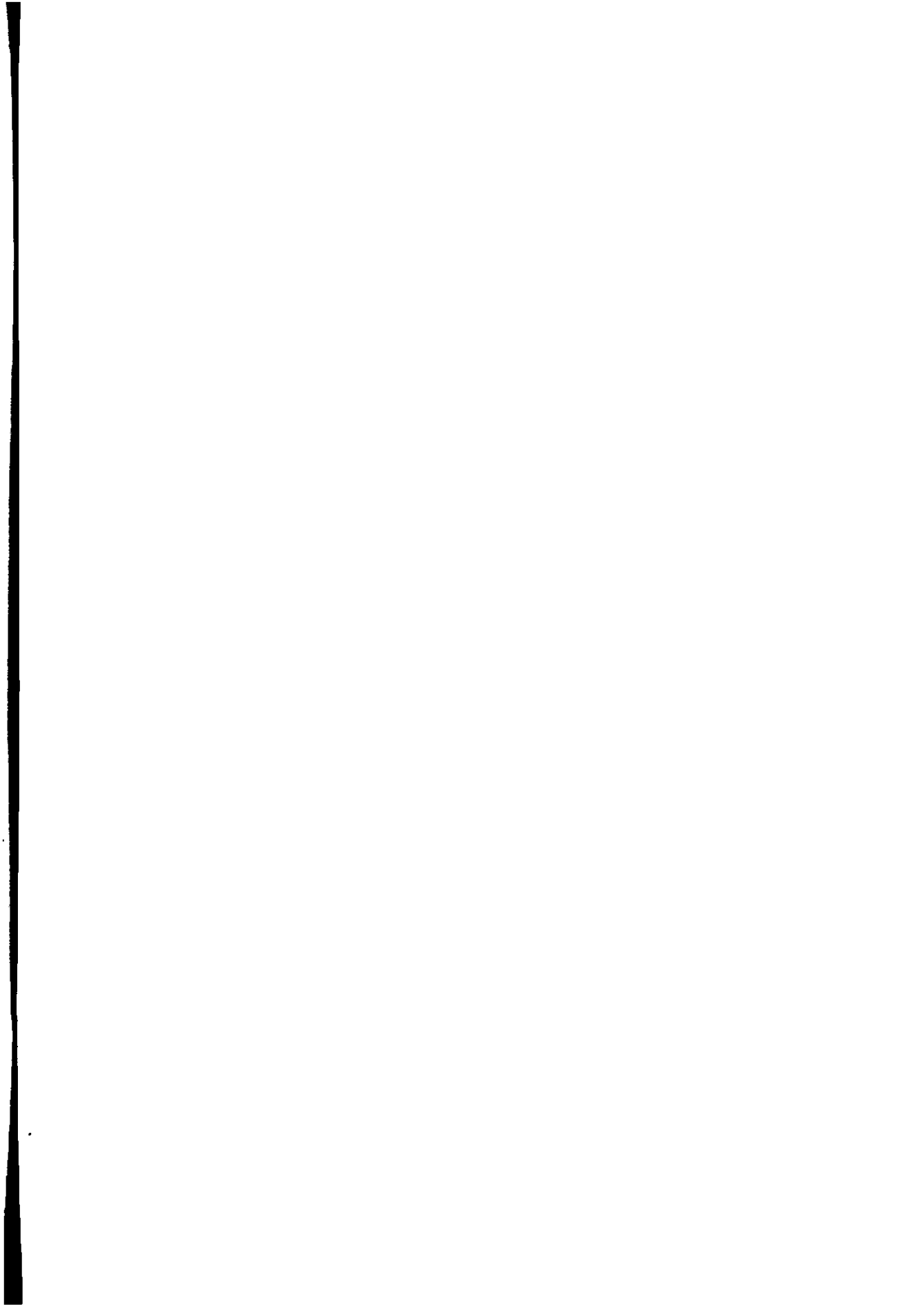
ACKNOWLEDGEMENT

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Ecological Studies on a Winter-Active Spider *Bolyphantes index* (Thorell) (Araneida, Linyphiidae)

SIGMUND HÅGVAR

Hågvar, S. 1973. Ecological Studies on a Winter-Active Spider *Bolyphantes index* (Thorell) (Araneida, Linyphiidae). *Norsk ent. Tidsskr.* 20, 309–314.

Field studies revealed that the spider *Bolyphantes index* (Thorell) may be active on the snow surface, making webs in small natural crevices in which Psyllidae and Collembola were caught. The winter-active collembolan *Isotoma hiemalis* Schött, which was trapped in the webs, occurs on the snow surface during similar temperatures as *B. index*. During unfavourable climatic conditions, *B. index* probably remains in the subnivean air space, this migration occurring along tree trunks and branches. Copulation takes place on the webs in late winter. Specimens collected during the end of March and the beginning of April proved to be well adapted to low temperatures. Mean values of different reactions to temperatures were: Supercooling point -15.3°C , chill-coma -9.3°C , haemolymph freezing point -1.2°C , preferred temperature 4.1°C , and upper thermal paralysis as high as 39.6°C . *B. index* was active in a supercooled state, but did not survive freezing.

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The ability to use the snow surface as habitat is a well-known ecological adaptation of some arthropods, chiefly insects. The actual insect species are characterized by their ability to be active at temperatures around or below 0°C (Svensson 1966, Dahl 1969, Sømme & Østbye 1969, Hågvar 1969). There is very little information about spiders in this respect.

During winter, different species of spiders may often be found active on the snow surface, mostly at temperatures close to 0°C . Most of these species probably visit the snow surface accidentally.

Østbye (1966) found a specimen of *Centromerus incilius* (L. Koch), which captured collembolans in a web constructed in a little crevice on the snow surface.

This study concerns *Bolyphantes index* (Thorell), a species which may occur numerously in webs on the snow surface, using this habitat for feeding and copulation.

FIELD OBSERVATIONS

Study area

Field observations were made 9–11 April 1971, 3 April 1972 and 30 March–1 April 1973 at

Kroksgogen near Oslo, in a spruce wood about 500 m a.s.l. Most animals were found in quite open habitats with young trees (3–4 m high), often mixed with small birches (2–3 m high), the distance between trees being 0.5–5 m. The depth of the snow was 1–1.5 m in 1971 and 1972, and 20–50 cm in 1973. The air temperature measured with a shaded-bulb mercury thermometer at the actual sites of the animals (from 1971, either at the snow surface or at the net surface) varied between 3.8 and -5.5°C . During the day, the upper layers of the snow were wet. These spiders appeared during both cloudy and sunny days when there was little or no wind.

Webs and prey

15 webs of *B. index* were found during 1971, one in 1972 and about 50 in 1973. They were situated in 5–30 cm wide crevices in the snow, 2 to 20 cm deep, sometimes partly attached to a branch penetrating through the snow. The webs, which were 1.5 to about 10 cm (mostly 3–5 cm) in diameter were 0.5 to about 5 cm (mostly 1–2 cm) above the bottom of the hole. Among the webs found in 1971–72, 5 webs contained males, 8 webs females, one web contained two females, and two webs contained



Fig. 1. A pair of *Bolyphantes index* in a web constructed over a footprint from a fox in the snow.

pairs. The animals were usually situated on the under side in the middle of the web. Fig. 1 shows a pair in a web constructed over a footprint from a fox.

The highest density of webs observed (1973) was estimated to about one web per 2 m². Seven of the webs found in 1971 contained prey (Collembola in six cases with a maximum of seven Collembola per net, a specimen of Psyllidae in one case). At the time of observation active collembolans were seen on the snow surface. In three webs the species was *Isotoma hiemalis* Schött. Also in 1973, collembolans were observed in some webs.

In addition to the locality near Oslo, two webs with a female in each were found on the snow in a wood of Scotch pine at Furusjøen, Oppland 22 April 1973, 920 m a.s.l.

Activity

Occasionally the spiders were found walking on the snow surface and even feeding on Collembola (2 observations). The highest density, about one animal per m², was recorded on 11 April 1971 (1830 hr) at 0° C.

Nine webs were found in holes which were less

than one day old. In one case a web was made at a temperature below 0° C, and even at -5.5 °C this animal was active in the web. Consumption of prey occurred both day and night. Copulation was observed on 11 April (at 1800 hrs, 2 °C) in a 3 cm wide net.

Other records of *B. index* on snow

Specimens of *B. index* were found on snow in the same locality near Oslo 12–13 April 1968. Other localities are: Elverum (HEs) 22 November 1964 (leg. E. Østbye); Dagali (Bv) mid-April 1965 (Greve 1966); Tverrelvdalen (Fi) 9 and 24 May 1971 (leg. G. Hågvar), and Furusjøen (On) 17–20 April 1968.

LABORATORY EXPERIMENTS

Material and methods

The animals used were collected 11 April 1971 and 30–31 March 1973 when the surface temperature was about 0° C, and kept separately without food in darkness at 4° C. In 1971, the thermopreferendum was measured after 3–5 days, supercooling points after 10 days, chill-coma temperatures after 15–17 days, the haemolymph freezing points after 16–18 days and upper thermal paralysis after 17–18 days. Even after 18 days at 4 °C, the animals were in good condition. In 1973, supercooling points were measured after 5–8 days, upper thermal paralysis after 7–9 days, haemolymph freezing points after 9 days, and chill-coma temperatures after 10 days. The thermopreferendum tests were carried out in a 70 cm long insulated aluminium apparatus equipped with six thermometers and covered with paper in the bottom. The temperature gradient in the apparatus was very even and stable and ranged from approximately -5 to 30 °C. As the air close to the snow surface has a high relative humidity, this was kept between 75 and 100 percent by means of dishes with water and cotton hanging closely over the bottom. The humidity was read by means of calibrated cobalt paper. The spiders were tested individually. Each animal was placed in the middle of the gradient and found its range of

Table I. Supercooling points, chill-coma temperatures, haemolymph freezing points, and upper thermal paralysis of *Bolyphantes index*

Year Sex	S.c.pt. °C	Chill-coma °C	Fr.pt. °C	Upper thermal paralysis °C
	n mean range	n mean range	n mean range	n mean range
1971	♂ 5 -16.4 -14.7/-18.3	2 -7.7 -7.5/-7.9	1 -1.7	3 40.3 40.1/40.7
	♀ 5 -14.3 -11.6/-17.5	3 -7.8 -7.5/-7.9	1 -1.2	2 39.4 39.2/39.6
1973	♂ 11 -15.1 -9.4/-18.7	3 -10.2 -9.1/-11.8	1 -1.0	5 39.5 39.0/40.1
	♀ 13 -15.3 -10.0/-18.5	2 -11.8 -	2 -1.1 -1.0/-1.1	6 39.5 39.1/40.1
Total	34 -15.3 -9.4/-18.7	10 -9.3 -7.5/-11.8	5 -1.2 -1.0/-1.7	16 39.6 39.0/40.7

preference within a few minutes. The thermopreferendum is defined as the mean of three observations – after about 10, 20, and 30 min. The temperature, interpolated between two thermometers, was read only when the animal stood quiet on the bottom of the apparatus. The supercooling points, or the temperatures at which the animal froze, were measured with a copper-constantan thermocouple in contact with the outer surface of the spider (Sømme 1964). The temperature was lowered 1–2 °C per min, and the supercooling points were read from a recording potentiometer.

Chill-coma temperatures and upper thermal paralysis were measured by a thermometer in a 100 ml Erlenmeyer flask containing the spider (Sømme & Østbye 1969). This flask was suspended in a beaker, which was lowered either into a bath of cold alcohol, or warm water, respectively. The temperature was changed about 1 °C per 10 min in the range where chill-coma or upper thermal paralysis were observed. In 1973, the chill-coma temperatures were measured by a thermocouple close to the animal. Haemolymph was obtained by cutting off one of the legs. The drops were placed in liquid paraffin and frozen, and the melting point during slowly, manually regulated heating was defined as the haemolymph freezing point (Biological cryostat/nanoliter osmometer, Clifton Technical Physics, New York).

Seven males collected 3 April 1972 were tested for glycerol according to Sømme (1964).

RESULTS

The thermopreferendum for 8 males and 7 females ranged from 1.1 to 9.4 °C, the mean value being 4.1 °C. The mean value for males, 4.9 °C, and for females 3.3 °C, are not statistically different (t-test). From Table I it can be seen that the values for the supercooling points, chill-coma temperatures, haemolymph freezing points and upper thermal paralysis are also quite similar for the two sexes. As the chill-coma temperatures are much lower than the haemolymph freezing points, *B. index* is obviously capable of active movements in a supercooled state. The movements are quite normal down to at least -5 °C. Below this temperature, the movements become slower and less coordinated. The somewhat lower chill-coma temperatures in 1973 compared with the values from 1971 may partly be caused by the change in method.

When freezing occurs following supercooling, the inner temperature of the animal is raised. The spider was not removed from the apparatus until the temperature reached the supercooling point for the second time. After freezing the animals were placed at 4 °C, but none showed any signs of life during the next 24 hours.

All animals except two survived upper thermal paralysis. Three of the five animals tested for chill-coma in 1971 and four of the five animals tested in 1973 recovered immediately, but the other three spiders did not recover after being placed in 4 °C for two hours. Probably these

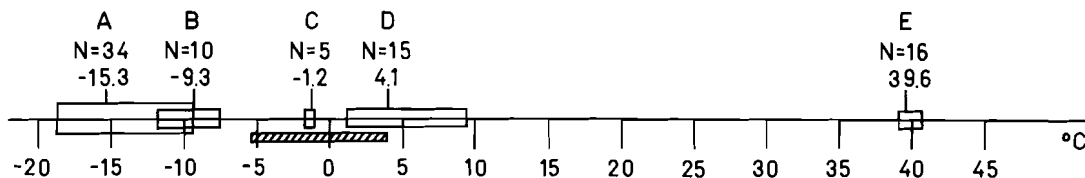


Fig. 2. Different reactions to temperature in *Bolyphantes index*. A = supercooling points, B = chill-coma temperatures, C = haemolymph freezing points, D = temperatures preferred, E = upper thermal paralysis. The range is indicated together with the mean value. N = number of specimens. Hatched block: Temperature range during field observations. See also Table I.

animals froze, thus being active down to their supercooling point.

The different reactions to temperature are depicted in Fig. 2. In relationship to the haemolymph freezing points, the thermopreferendum and temperatures during field observations are very low. The thermopreferendum is also very low compared with the upper thermal paralysis of the species.

Glycerol was not found in the animals investigated.

DISCUSSION

Mature specimens of *B. index* have been found in July and August (Brinck & Wingstrand 1951, Waaler 1972). The adults probably overwinter in the subnivean air space and climb to the snow surface along stems and branches of trees and bushes during favourable weather conditions. This behaviour corresponds to that of certain winter-active insects, such as *Chionea* sp. (Diptera, Tipulidae), *Scoliocentra nigrinervis* Wahlgr. (Diptera, Helomyzidae), some species of Trichoceridae (Diptera) and *Boreus* sp. (Mecoptera) (Dahl 1970, Hågvar 1969, Strübing 1958, Svensson 1966, Sømme & Østbye 1969). These insects copulate on the snow surface, probably because it is easiest for the sexes to encounter one another above the snow.

The low thermopreferendum, chill-coma temperatures and supercooling points are in support of *B. index* being well adapted to a life on the snow surface. The haemolymph freezing points, chill-coma temperatures, and the supercooling points of *B. index* are all lower than in the winter-active insects *Boreus hyemalis* (Hag.), *B. westwoodi* (L.), and *Chionea araneoides* Dalm. Specimens of

Scoliocentra nigrinervis showed slightly lower supercooling points than *B. index* (Sømme & Østbye 1969). Like *B. index*, none of the insects mentioned contain glycerol (Sømme & Østbye 1969). However, glycerol has been found in the spider *Araneus cornutus* Clerck. during winter, with supercooling points down to about -27°C (Kirchner & Kestler 1969).

The temperatures preferred by *B. index* fall well within the range of those recorded for other winter-active spiders and insects (Buche 1966, Herter 1953, Wojtusiak 1950, Wolska 1957).

The air temperatures during field observations of *B. index* were slightly lower than the temperatures preferred (Fig. 2). The body temperature during the day might, however, have been higher due to absorbed radiation.

The values of upper thermal paralysis in *B. index* are very near those measured for the majority of spiders investigated by Holm (1950) during summer at Torneträsk, Sweden. It is interesting that his value for *B. index* (41°C) is in close agreement with my winter recordings. This indicates that the point of upper thermal paralysis does not change much during the year. Understandably, the values for *B. index* are lower than in most of the spiders living on sand dunes (Almquist 1970, Krogerus 1937). Two winter-active species of Trichoceridae reached upper thermal paralysis at $30\text{--}34^{\circ}\text{C}$ (Dahl 1969), and according to Strübing (1958) $32\text{--}33^{\circ}\text{C}$ would be lethal to *B. hyemalis* and *Chionea* sp. Two specimens of *B. westwoodi* were killed at 34 and 37°C , respectively (Herter 1953). Obviously *B. index* is an eurytherm winter-active species, compared with several winter-active insects. This may be explained by the fact that *B. index* is already fully grown in late summer,

and even the young stages occur in relatively warm habitats (in the vegetation or on the ground).

As already pointed out by Almquist (1970), Holm's (1950) suggestion that it is generally enough to fix one point of reaction to characterize the thermal behaviour of the species, does not prove to be generally relevant. The values of *B. index* in winter do not follow the general trend among different arthropods for correlation between upper thermal paralysis and thermopreferendum, and upper thermal paralysis and chill-coma temperatures as presented by Petersen (1948).

The ability to colonize fresh holes in the course of a few hours makes it possible to use even short periods of favourable weather conditions, and allows the animals to find new holes within a short time after a snow fall. Furthermore, this preference for holes makes it easier for the sexes to meet.

The collembolan species recorded in the webs, *Isotoma hiemalis*, is a winter-mature species (Gisin 1960) and has often been found by the author on the snow surface from January to April. Generally the air temperature at the snow surface has been approximately 0 °C, with the upper snow layer often being wet. Thus *I. hiemalis* and *B. index* occur on the snow surface during the same temperature conditions, making *I. hiemalis* an excellent prey for *B. index*. In addition, collembolans on the snow surface often have a tendency to accumulate in small crevices.

Psyllidae are also common on the snow throughout the winter, probably dropping from spruce branches (Hågvar & Hågvar, unpubl.).

An advantage for spiders which make their webs in small crevices where trunks or branches break the snow surface is being able to retreat quickly to the subnivean air space if the temperature becomes too low. A physical characteristic for the areas supporting the highest density of *B. index* on the snow was the numerous passages connecting the snow surface and the subnivean air space.

It is not known whether or not *B. index* occurs on the snow throughout the winter, but at least during the last part of the winter, the snow surface is an alternative habitat. According to

Brændegaard (1946), *B. index* is a boreo-arctic species, which in the boreal area has almost exclusively been found in alpine localities. It is obvious that this species is adapted to a cold climate.

As shown by Tretzel (1954), many species of spiders may be active during winter, and a few species also reproduce during this season. In the subnivean air space many groups of insects are active (Näsmark 1964), and the temperature remains close to 0 °C (Coulianos & Johnels 1962). Therefore the hypothesis is proposed that *B. index* colonizes the snow surface primarily to facilitate a meeting of the sexes, and not to procure food or to achieve more optimal temperature conditions. Copulating animals on the snow surface support this assumption. The behaviour thus becomes parallel to that of the winter-active insects mentioned above. Furthermore, *B. index* has the advantage of being able to feed in this habitat.

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Food Competition in Larvae of *Syrphus ribesii* (L.) and *Syrphus corollae* (Fabr.) (Dipt., Syrphidae)

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Hågvar, E. B. 1973. Food Competition in Larvae of *Syrphus ribesii* (L.) and *Syrphus corollae* (Fabr.) (Dipt., Syrphidae). *Norsk ent. Tidsskr.* 20, 315–321.

A diagram is presented to illustrate important factors in a simple experiment previously conducted, where larvae of *Syrphus ribesii* (L.) and *Syrphus corollae* (Fabr.) of the same age competed for a scarce supply of aphids (*Myzus persicae* Sulz.). The experiment was repeated under somewhat different experimental conditions but principally with the same result. Measured as percentage population survival, *S. ribesii* was the winner in both experiments. The different factors in the diagram are discussed and rough estimates are given for some of them. The outcome of competition is further discussed, specially concerning the combined effect of predator efficiency, food demand, predatory or cannibalistic tendencies, and the influence of the food amount which was offered.

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In a previous paper (Hågvar 1972), a simple system was described which allowed intra- and interspecific competition for food to occur among larvae of two syrphid species, *Syrphus ribesii* (L.) and *Syrphus corollae* (Fabr.). The purpose of this paper is to discuss, by a 'box diagram', which factors are working in such a system. Some of the most important ones are subsequently dealt with, without trying to give exact estimations or to make any quantitative analysis of the whole system. Finally, parts of the box diagram are discussed in more detail. In the competition experiment described by Hågvar (1972), a 'competing unit' consisted originally of six newly hatched larvae in a Petri dish (5.5 × 2.0 cm), all *S. ribesii* (series R), all *S. corollae* (series C), or three larvae of each species (series R+C). Each dish was daily given a certain amount of about equally-sized aphids (*Myzus persicae* Sulz.). The supply was varied from one day to the next in a previously fixed manner, in accordance with, but always well below, the individual daily *ad libitum* consumption, as found for larvae of different ages (Benestad 1970 b). The larvae thus had to compete for the food. Dead larvae were not replaced during the experiment; the aphid supply that

was offered was thus independent of larval density in the dishes.

The most important factors in this competition experiment, where both intra- and interspecific competition occurred, and how these factors might be connected, are illustrated in Fig. 1. The only factor imposed upon the system from the outside, in addition to constant, abiotic ones, was prey density. This was regulated regardless of what was going on inside the system. The time unit, or one turn through the system, could, for instance, be one day.

Starting with predator density = 6 and a certain prey density per dish, this gives an average amount of aphids to each larva on that particular day. However, the actual amount that each larva consumes depends upon its efficiency as aphid predator. Predator efficiency is a function of searching capacity (speed of movement, searching pattern), capture efficiency and handling time, qualities dependent on the species, age and previous consumption of the predator. The three latter factors determine how much food is required to survive on that particular day. The actual amount of aphids each larva consumes together with its food require-

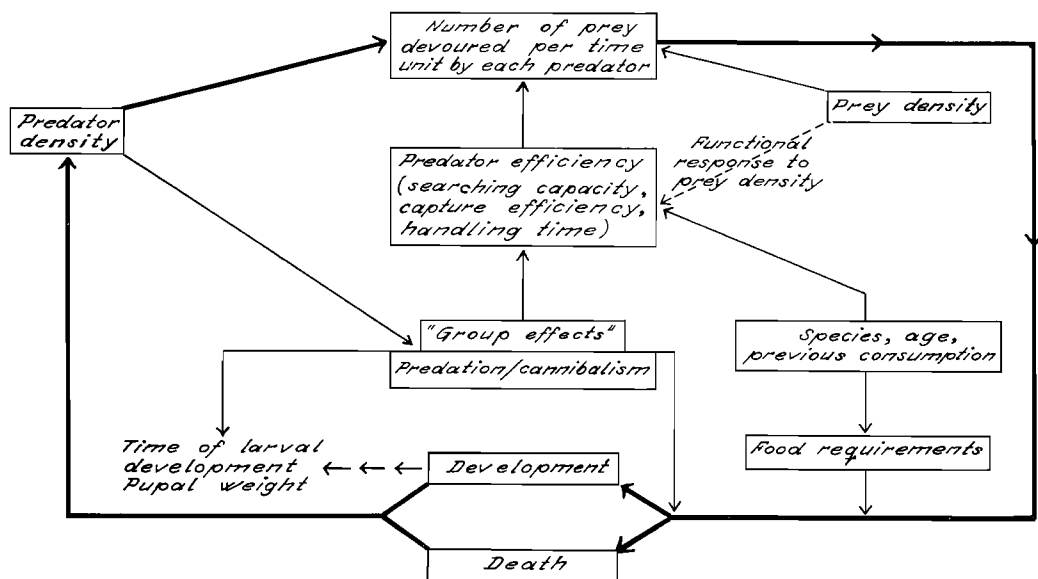


Fig. 1. Important factors in the competition experiment described by Hågvar (1972), where larvae of *Syrphus ribesii* and *S. corollae* competed for food (*Myzus persicae*).

ments, or food demand, eventually results in further development or death.

Because dead larvae were not replaced, mortality will influence the larval density and thereby the food conditions of the predators in the next turn through the system. Thus high mortality one day improves food conditions for the remaining larvae the next day.

Food exploitation usually becomes more serious with increasing predator density. This is the resource use type of competition (Odum 1971), which is described by the three upper boxes in Fig. 1. However, when several predators are grouped together, other effects may appear which could affect efficiency, consumption, developmental rate and survival:

1. Predation on the other predator species, or cannibalism, may result from poor food conditions. This is the direct interference type of competition (Odum 1971) and is illustrated in Fig. 1 by the predation/cannibalism box.

2. The remaining effects of grouping are called 'group effects' in Fig. 1. Physical contacts between the larvae other than those resulting in predation or cannibalism may change the behaviour of the larvae. Non-physical interference may also occur. Such group effects may

influence the efficiency, rate of development, food consumption, and survival of the predators.

MATERIAL AND METHODS

The present work is partly based on data from earlier investigations (Benestad 1970a and b, Hågvar 1972, Hågvar in press), where material and methods have been described.

In addition, experiments were made with *S. ribesii* and *S. corollae*, derived from adult flies captured outdoors at Blindern, Oslo, southern Norway, during the summer of 1971. These experiments are illustrated in Fig. 2 and Table I. At restricted food conditions, the methods were as described by Hågvar (1972), except that the competing unit consisted of two instead of six larvae. Further, each unit within a series was given the same amount of aphids every day, this amount being halved when one larva died. In all experiments, the syrphid larvae were fed with *Myzus persicae*.

RESULTS

Intra- and interspecific competition

A new competition experiment was performed,

similar to that previously described (Hågvar 1972), but with two predators per dish and with 50 aphids/dish/day, or 25 aphids/dish/day in those dishes where only one larva was left.

Fig. 2 illustrates the result, which was principally the same as in the previous study (Hågvar 1972). This time, however, interspecific competition resulted in complete elimination of the *S. corollae* larvae during seven days, whereas 70 % of the larvae pupated at intraspecific competition. On the contrary, larval survival in *S. ribesii* increased from 21% to 67% from intra- to inter-specific competition respectively.

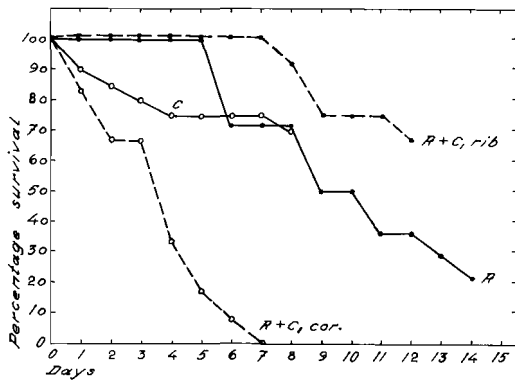


Fig. 2. Percentage survival of larvae of *Syrphus ribesii* and *S. corollae* during development under equally restricted food conditions (*Myzus persicae*) at 20 °C and 16 hrs light; R : *S. ribesii*, C : *S. corollae*, R+C : the two species together.

Group effects, predation, and cannibalism

As shown in Fig. 1, group effects, predation, and cannibalism may influence the development of the syrphid larvae.

The high mortality of *S. corollae* in competition with *S. ribesii*, found in the present study (Fig. 2) and by Hågvar (1972), appeared partly to be due to predation by *S. ribesii* larvae on the smaller larvae of *S. corollae*. On the other hand, the influence that presence of other larvae of the same species may have on the individual predator can be studied by comparing larval development between larvae reared singly and larvae reared in groups. To exclude the direct influence of the food supply, the larvae which were compared had theoretically the same food conditions whether they were reared singly or together (2, 6, or 12 larvae). Table I illustrates such experiments for both syrphid species at intraspecific conditions. Differences between single and grouped larvae with same food supply are probably due to 'group effects' or cannibalism. In *S. corollae*, no significant differences in development appeared between single and grouped larvae, neither at *ad libitum* conditions nor restricted ones. It is possible that more severe food conditions than 25 aphids/day/larva might have induced cannibalism, although such behaviour has never been observed in starvation experiments with this species.

Table I. Development of *Syrphus corollae* and *S. ribesii* at 20 °C, 16 hrs light, at different densities (group sizes) and food conditions k = Average number of aphids (*Myzus persicae*) supplied per day per larva. n = Total number of larvae tested

Predator	<i>S. corollae</i>				<i>S. ribesii</i>				
	1	6	6	12	1	1	2	1	2
Group size									
k		Ad libitum			10	25	25	25	50
n	46	6	6	12	16	30	20	20	14
Larval period (days)	9.6	9.2	9.6	10.1	13.7	9.5	9.3	15.0	18.0
Pupal period (days)	8.4	8.2	8.2	8.4	8.8	8.8	7.4	10.1	10.7
Pupal weight (mg)	27.3	25.7	28.8	26.2	11.6	17.8	15.9	32.6	38.3
Larval survival (%)	78	83	100	83	75	73	70	85	21
Pupal survival (%)	83	100	100	90	42	59	64	94	67

On the contrary, the grouped (paired) larvae of *S. ribesii* had lower survival and slower developmental rate than the single larvae. Though the size of the material is rather small, the difference between the grouped and single larvae appeared both when 25 aphids/day/larva and 50 aphids/day/larva were offered. Thus, in spite of equal food conditions, larval survival dropped from 85% to 21% (25 aphids/day/larva) or from 100% to 35% (50 aphids/day/larva) when single larvae are compared with the paired ones. This indicates cannibalism, which is supported by the appearance of the dead larvae, mostly 3rd instars, in the paired series. In neither case did both larvae that were reared together survive. The prolonged larval period in both paired series of *S. ribesii*, of about 3 days, cannot easily be explained by cannibalism. The surviving larvae from the paired series behaved until a certain stage in 3rd instar similar to the single ones with respect to developmental rate and aphid consumption. Subsequently they became rather inactive and had a reduced or no food intake until they finally pupated. The difference in developmental time between the single and paired *S. ribesii* larvae was thus mainly due to the longer duration of 3rd larval instar in the paired larvae, partly spent without food ingestion. Apparently, cannibalism is not the only 'group factor' involved when *S. ribesii* larvae are reared together at poor food conditions.

DISCUSSION

Exact measures of the different factors in Fig. 1 are difficult to obtain and are not available. However, some information can be drawn from earlier investigations (Benestad 1970 a and b, Hågvar 1972, Hågvar in press) and from the present ones. Some of the factors in Fig. 1 are discussed below, followed by a discussion on the outcome of such a competition experiment.

Predator efficiency

Two important aspects of predator efficiency, capture efficiency and handling time, have been studied in a previous paper (Hågvar in press). The three larval instars of *S. ribesii* and *S. corollae* were confronted with 1st and 5th aphid instar (*Myzus persicae*). On comparable stages,

S. ribesii was superior (2–4 times) or equal to *S. corollae* in these two qualities, the difference being greatest in newly hatched larvae. Because the larvae in the competition experiments were always of the same age, *S. ribesii* is likely to catch and eat considerably more aphids during a fixed time interval than the *S. corollae* larvae in the same dishes when they compete for about equally sized aphids.

The speed of movement of the predators has not been thoroughly studied, but is probably to the advantage of *S. ribesii*. However, in the relatively limited space available in the dishes, both speed of movement and other aspects of searching capacity are probably of moderate importance in this special competition experiment.

Influence of aphid consumption on larval developmental rate and pupal weight

In Fig. 1 the number of prey devoured by each predator eventually affects the time of larval development and pupal weight. When food conditions are sufficiently poor, as when *S. corollae* receives 10 aphids/day/larva and *S. ribesii* 25 aphids/day/larva (Table I), the larval period is for both species lengthened by about 30–40% of the *ad libitum* period (Hågvar 1972, Table I). However, it has previously been shown (Hågvar 1972, Table I) that larvae may develop at the same rate but have significantly different pupal weights (i.e. food consumption). When a certain stage in development is reached, and the larva has ingested a sufficient amount of aphids, pupation occurs. Adults, as pupae, from different series therefore may show striking differences in size.

The amount of food ingested by a larva can be expressed in several ways. If the number of aphids consumed during larval development is counted, this gives information of predatory capacity. However, it is not a very exact method to measure the real amount of food obtained by the larva, due to variations in aphid size and because different aphids may be sucked out to different extents. Indirectly, the total amount of food ingested is more exactly expressed by pupal weight, which represents the production or growth of the animal and is easy to measure.

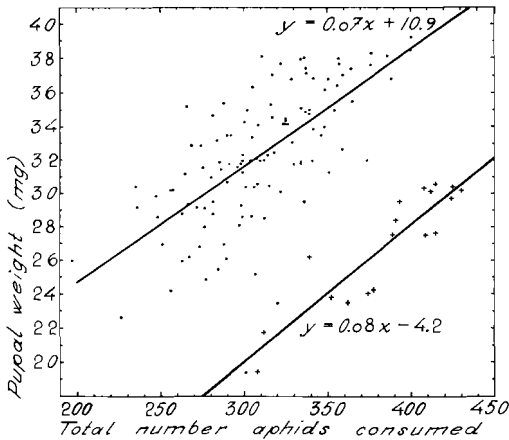


Fig. 3. Relation between larval food consumption and pupal weight in *Syrphus corollae* at *ad libitum* conditions. ● = 8–28 °C, + = 28 °C.

However, Fig. 3 illustrates that it may be possible, under certain conditions, to transform pupal weight to total number of aphids consumed during larval development. The data are from Benestad (1970b), where only the average values on consumption and pupal weight were given.

Fig. 3 shows a lineary relationship between the two measures of food consumption for *S. corollae* at *ad libitum* conditions. The aphid size is not strictly constant, the aphids being a mixture of 3rd – 5th instars. This, together with counting errors etc., may at least partly explain the spreading of the points. Nevertheless, the method gives a rough estimate of aphid number when pupal weight is known. It is of some importance that the pupae are of the same age when weighed, because of a drop in pupal weight the first 2–3 days. The influence of temperature is indicated in the figure: larvae at 28 °C have to eat more aphids than those at 8–28 °C (Benestad 1970a), to obtain the same pupal weight. The respiratory loss thus appears relatively greater, or assimilation efficiency lower, at 28 °C, in spite of the faster development at this temperature. It is also possible that each aphid was sucked out to a lesser extent at 28 °C, though observations do not support this.

If the difference in size between the two syrphid species, and thereby in the rate of metabolism, is assumed to be moderate, Fig. 3 could be

applied for *S. ribesii* as well. This is supported by scarce measurements previously obtained on *S. ribesii* at 8–28 °C. If the values were plotted, the points would roughly cluster around the prolongation to the right of the upper line in Fig. 3.

At poor food conditions, the larvae may spend relatively more energy in searching for prey, leaving a smaller percent of the ingested food available for growth. If this is the case, the lines in Fig. 3 will curve downwards to the left.

Food requirement

In Fig. 1 the food requirement of the species may decide whether the amount of prey consumed is sufficient for survival or not. The daily food demand in the two species has not been investigated. However, some information is available on total demand, expressed indirectly as minimum pupal weights. This is achieved by considering the pupal weights of pupae that hatched from starved series, in which a considerable fraction of the pupae did not develop to adults. The lowest pupal weights that resulted in emergence of an adult at 20 °C are: *S. ribesii* 14 mg, *S. corollae* 9 mg, i.e. *S. corollae*/*S. ribesii* = 0.64. At *ad libitum* condition and 8–28 °C the pupal weights of the two species are similarly related (35.8 mg/56.0 mg = 0.64). Assuming that this also holds for *ad libitum* conditions and 20 °C as well, the ability to tolerate reduction in food intake from the *ad libitum* consumption is about equal in the two species.

Because it is uncertain whether the lines in Fig. 3 can be prolonged to the left, the figure cannot be used, without further investigations, to transfer minimum pupal weights to number of aphids. However, Table I gives some information on upper limits for minimum aphid supply required for development. For *S. corollae* 10 aphids/day/larva were sufficient for 75% larval survival and 42% pupal survival at 20 °C. The larval period was 13.7 days, giving a maximum consumption of 137 aphids per larva. The pupal weight, 11.6 mg, corresponds to a value somewhat lower than 137 aphids, because consumption decreased the last days before pupation, and because 10 aphids/day are more

than the newly hatched larvae can consume the first few days.

For *S. ribesii*, 25 aphids/day/larva is the lowest value tested in feeding experiments (Table I). The high survival indicates that food conditions are well above the critical ones. By the same argumentation as above, 32.6 mg corresponds to a value somewhat lower than 375 aphids.

Indicated by pupal weight in Table I, 10 aphids/day are not very far from the minimum amount required in *S. corollae*. At such poor food conditions, it is reasonable to assume that the relation between food consumption and pupal weight is rather constant. It is further assumed that the two species tolerate the same degree of reduction in food supply, as indicated by the pupal weights. Based on these assumptions, a very rough estimate for the number of aphids necessary for development to adult can be made: *S. corollae* about 100 aphids ($137 \times 9/11.6 = 106$) and *S. ribesii* around 180 aphids ($100 \times 574/307 = 187$, Hågvar 1972).

The outcome of the competition

Fig. 1 illustrates that requirements coupled with the amount of ingested food influence the survival of the larvae. Indirectly, this means that requirements, or food demand, together with predator efficiency could be important factors in competition experiments. Generally, low food demand and high predator efficiency are advantageous qualities for a predator when food conditions are poor. If two predator species compete for the same, limited food supply, and one species has low efficiency and food demand, the other high efficiency and food demand, there might be a conflict in each species between the two counteracting qualities. If predation, cannibalism, or other interferences are ignored, the relative size of efficiency and food demand in the two species could determine the result of the competition.

In Fig. 1 the prey density influences the actual food consumption of the individual predator and ultimately its survival. In the competition experiments, the prey density was largely chosen by the author. The question therefore arises whether the result, measured as percentage

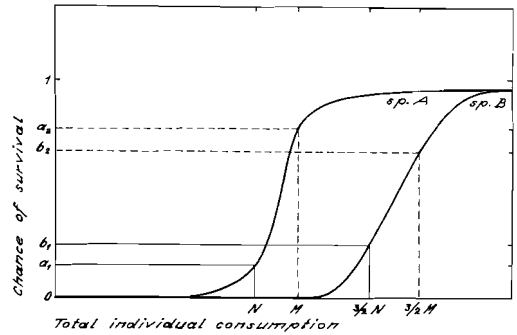


Fig. 4. A hypothetical example which illustrates how different food supplies may change the relative survival of two species, A and B, competing for the same, limited food resources. Predatory efficiency of species A = $2/3 \times$ predatory efficiency of species B.

survival of each population, was partly dictated by the imposed food conditions and could be reversed by changing the food supply. Thus one food amount might favour one species, another food amount the other species. The idea of such an influence of food supply is illustrated in Fig. 4.

In the hypothetical example with species A and B, the individual chance of survival in relation to its food intake is supposed to be known for both species, based on series where the individuals have been reared in separation. Multiplied by 100, the curves give the percentage survival of each population in relation to average individual consumption. The food supply is assumed to be poor, and interference between the individuals is neglected. Species A is supposed to have the lowest food demand, illustrated in the figure by a curve displaced to the left of the B-curve. Further, species A is supposed to be the least effective of the two, exemplified in the figure by an efficiency equalling $2/3$ of that of species B. This implies that an individual of species A will eat during a certain time $2/3$ of the food consumed by a B-individual. Fig. 4 illustrates for two different food conditions the average individual share that each species takes from the food offered to a mixed population, and the corresponding chance of survival. If the food supply is such that the average individual consumption of species A is N , the average individual consumption of species B is $3/2 N$.

The corresponding individual chances of survival are a_1 and b_1 respectively, where $b_1 > a_1$. This food condition thus favours species B with respect to percentage population survival. If the food supply is increased, so that species A has an individual average consumption = M , where $M > N$, the corresponding amount for species B is $3/2 M$. The chances of survival are a_2 and b_2 respectively, where $a_2 > b_2$. This food condition thus gives the highest percentage population survival to species A.

From Fig. 4 it is evident that the shape of the curves, their relative position, and the relative efficiency of the two competing species decide whether the competition result could be reversed at all by changing the food supply. Thus different species may behave differently in this respect. At least theoretically, however, it cannot be excluded that food resources, which may show great fluctuations through seasons or years, may affect relative composition and abundance of species that use the same food resources. Fig. 1 illustrates that predator density, group effects, predation on the competing species and cannibalism are additional factors which may influence the survival rate of the predators.

In both competition experiments (Hågvar 1972 and Fig. 2), *S. ribesii* had the highest survival of the two species in the mixed series. In the single series, *S. corollae* had greater survival than *S. ribesii*. Based on the discussion above, the survival of *S. ribesii* in the mixed series is probably explained as follows:

1. At the experimental conditions, cannibalistic and predatory tendencies appear in *S. ribesii* but not in *S. corollae*. Because the *corollae* larvae are smaller they are possibly the easiest victims for the *ribesii* larvae in the mixed cultures.

2. *S. ribesii* is equal or more efficient in capturing aphids and handles the prey quicker than *S. corollae* (Hågvar in press). The higher food demand of *S. ribesii* is a disadvantage but is probably overwhelmed by its greater efficiency and predatory tendencies.

Fig. 1 was constructed to illustrate how important factors may work together in the special case of competition described by Hågvar (1972). In more natural, closed systems, as green houses,

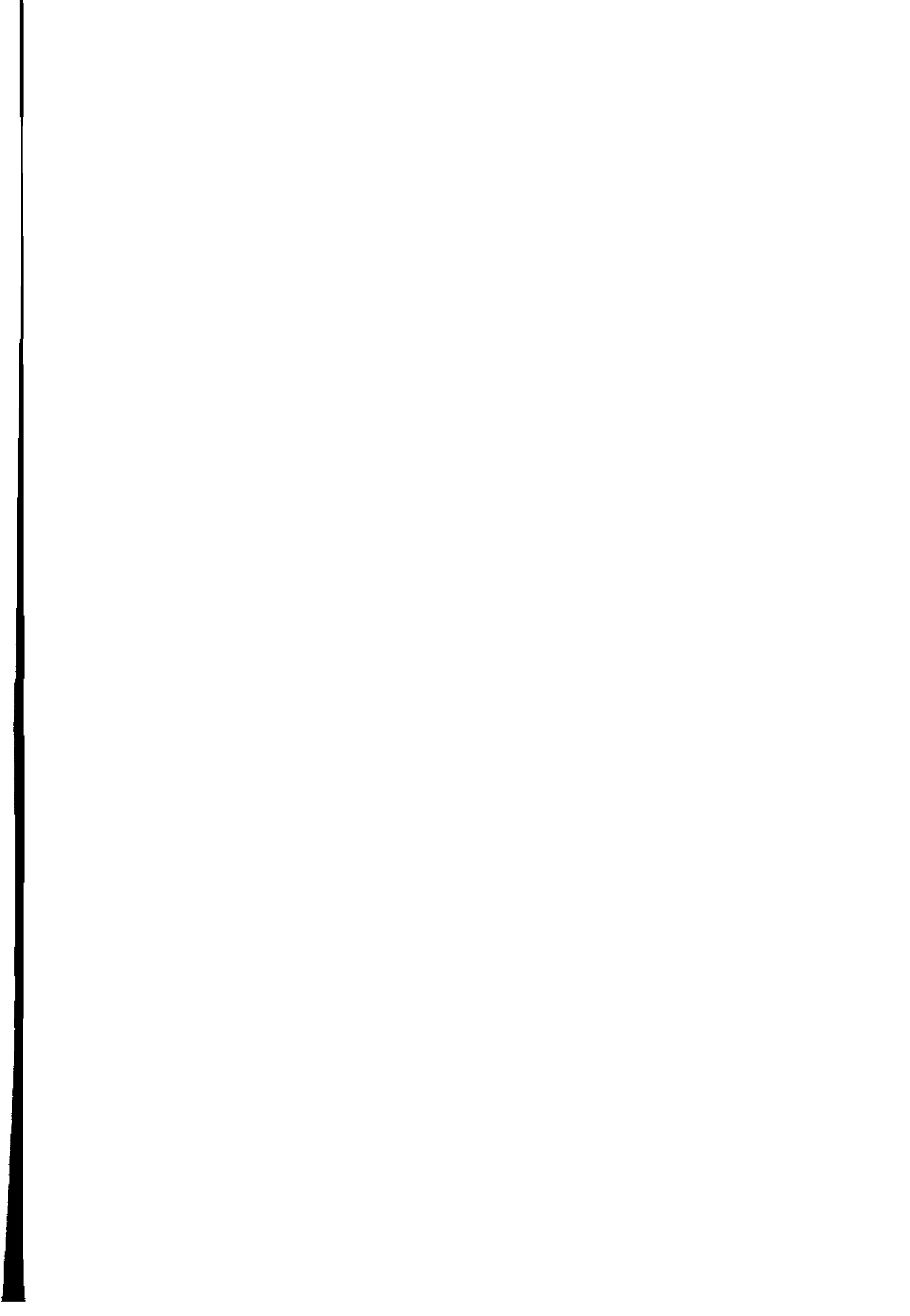
Fig. 1 may have an application if some factors are added. Intrinsic rate of natural increase (Odum 1971) of the prey and predator affects the prey and predator densities respectively. The prey density could further be influenced by the consumption of the predator, which could be illustrated in Fig. 1 by adding an arrow from the upper box to the prey density box. The functional response to prey density in Fig. 1 could be of great importance in natural systems with high population densities (Hassel 1966, Hassel & Rogers 1972, Holling 1961).

Natural competing populations seldom consist of an equal number of individuals, even more seldom are all the individuals of the same age. Furthermore, all stages in the life cycle of the competing species have to be studied in their natural biotopes and through several generations to get a picture of which factors are important for the outcome of the competition. Nevertheless, it may sometimes be useful to construct simple, unnatural situations to discuss a few factors which may have relevance also in natural systems.

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Tolerance to Hypoxia and Hypercapnia in Adult *Rhagium inquisitor* L. (Col., Cerambycidae)

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Påsche, A. & Zachariassen, K. E. 1973. Tolerance to Hypoxia and Hypercapnia in Adult *Rhagium inquisitor* L. (Col., Cerambycidae). *Norsk ent. Tidsskr.* 20, 323-224.

Adult *Rhagium inquisitor* L. is found to tolerate high tensions of CO₂ and low tensions of O₂ for a period of four months. Insects which were inactive at the end of this period recovered and appeared to be normal two days after being transferred to atmospheric conditions. At the end of a hypoxic period of six weeks a concentration of 28 mmole lactic acid/kg haemolymph was found.

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Adult longicorn beetles of the species *Rhagium inquisitor* L. were placed in air-filled 2 ml glass tubes with polyethylene stoppers and kept at +5 °C for 4 months. During this period the O₂ in the tubes was consumed due to the respiration of the animal and CO₂ accumulated. At the end of the period samples of gas were taken from the tubes and analysed on a Scholander 1/2-cc. analyser (Scholander 1947). The results of the gas analyses and the corresponding activity of the beetles at the end of the test period are given in Table I. The variability in the gas concentrations may be due to different respiratory quotients or to leakage through the stoppers.

The results show that the beetles are able to survive not only at very low tensions of O₂, but also at extremely high tensions of CO₂. Ability to survive anaerobic conditions is repor-

ted for many insect species, and in several of these cases high concentrations of lactic acid in the animals have been found (Wigglesworth 1972). The exposure periods reported in the literature usually do not exceed 17 days, which is considerably shorter than the period of exposure in the present experiment. Overwintering adults of *Pelophila borealis*, however, survived about 4 months in nitrogen at 0 °C (Conradi-Larsen & Sømme 1973). CO₂ is reported to have an anaesthetic effect on many insects (Beadle & Beadle 1949), and the passive state of the beetles at the end of the incubation period might be due to this effect. The reported time for recovery from CO₂ induced narcosis is, however, maximally one hour, while in this experiment more than one day was necessary to reach normal activity. This prolonged period of recovery may be determined by the rate of metabolic breakdown of accumulated substances, such as lactic acid. To test this hypothesis one beetle was kept in a vial for 6 weeks at +5 °C. At the end of this period the gas composition in the tube was similar to those obtained in the former experiment (0.32 vol.% O₂ and 16.41 vol.% CO₂). A haemolymph sample taken from the beetle at the end of the test period and analysed for lactic acid showed a concentration of 28 mmole/kg haemolymph. The method used is described by Barker & Summerson (1941). This value is considerably higher than the normal

Table I. Gas composition in tubes containing one *Rhagium inquisitor* each, and state of activity of the beetles after 4 months at +5 °C

Beetle No.	O ₂ -content (vol. %)	CO ₂ -content (vol. %)	State of activity
1	0.16	20.52	Passive (active after 2 days).
2	0.00	15.64	Passive (active after 2 days).
3	11.76	8.40	Active
4	0.30	16.46	Only very moderately active

values reported for other insects (Wigglesworth 1972). This finding suggests that the lethargic state of the beetle at the end of the test period may be due to accumulation of lactic acid.

Adult *R. inquisitor* stay in their pupal chambers during winter. The chambers are located under the bark of dead conifer trees and stumps and have a volume of about 2 ml. During the winter these chambers seem poorly ventilated, and the tensions of the respiratory gases may be considerably changed by the metabolism of the animals. It may therefore be necessary for the beetles to tolerate low tensions of O₂ (hypoxia) and high tensions of CO₂ (hypercapnia) for a long period. To test this hypothesis more experiments should be performed.

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The Overwintering of *Pelophila borealis* Payk.

II. Aerobic and Anaerobic Metabolism

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Although enclosed by ice or submerged in water for several months, about 90 percent of the adults of *Pelophila borealis* Payk. (Col., Carabidae) survived the winter of 1972/73 at Finse, 1200 m a.s.l. The oxygen consumption of the beetles was highest in the summer and lowest in the middle of the winter. In the laboratory almost all beetles survived from 8 to 127 days in nitrogen at 0°. During anoxia, lactate and alanine were accumulated in the haemolymph, while the concentrations of pyruvate and α -glycerophosphate were changed. High contents of lactate were also found in beetles that had been enclosed by ice at their overwintering sites. An oxygen debt was demonstrated in beetles enclosed by ice outdoors, and in beetles that were stored under anaerobic conditions in the laboratory. It is concluded that anaerobiosis is an important part of overwintering in *P. borealis*.

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As described by Østbye & Sømme (1972) and by Conradi-Larsen & Sømme (1973), *Pelophila borealis* Payk. overwinters as adults in the soil. At Finse, Hardangervidda, 1200 m a.s.l., large numbers of the species are found in a sedimentation flat, deposited by a mountain river. In late autumn or during the winter the flat may be flooded by the adjacent river (Østbye & Sømme 1972). When soil temperatures are below 0°, a thick layer of ice is formed after flooding. In addition to ice and water the sedimentation flat is usually covered by snow from early October till the end of June.

To survive under these conditions the beetles must be able to tolerate temperatures around or below 0° for extended periods. Østbye & Sømme (1972) have shown that in dry surroundings the beetles may be supercooled to temperatures around -20°. This is far below those registered at their overwintering sites. If the beetles are in contact with ice, however, freezing takes place at much higher temperatures. Although a large proportion of the beetles probably did freeze, about 40 percent was found to survive the winter of 1971/1972.

Beside cold-hardiness, the survival of adult *P. borealis* apparently depends on their ability to

tolerate an oxygen deficiency during the winter months. Under the conditions described, the overwintering sites of the beetles may be entirely covered by ice, and the beetles themselves often completely encapsulated. At other times, as during flooding in autumn, and during the long melting period in spring, the beetles may remain submerged in water for several weeks.

From these observations in the field, it appears that anaerobic metabolism may be an important aspect of winter survival in *P. borealis*. One purpose of the present study was to investigate the ability of the beetles to survive under anoxia, and to see what kind of metabolites are formed during anaerobiosis. Beside demonstrating this by laboratory experiments, we wanted to confirm that anaerobiosis occurs in the field as well by analysing beetles collected from their overwintering sites during the winter. Another aspect of anaerobiosis is the 'oxygen debt' which is formed, and which may be demonstrated by measuring the oxygen consumption of beetles removed from anoxia, similarly, oxygen consumption was measured in beetles removed from their overwintering sites in the middle of winter. While a short account of the results regarding anaerobiosis has been published previously (Conradi-Lar-

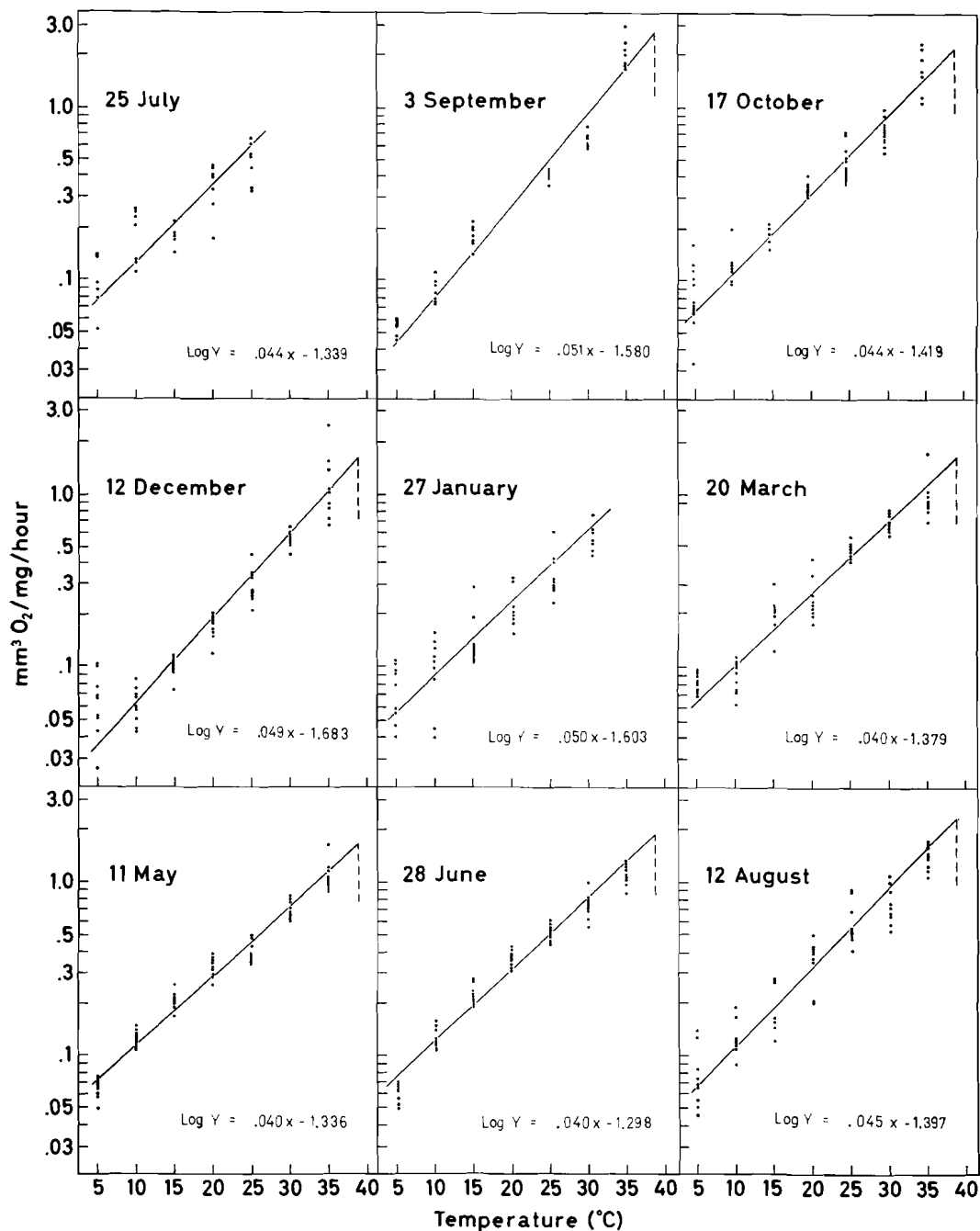


Fig. 1. Oxygen consumption in *P. borealis* at various times of the year. The dots represent one beetle each.

sen & Sømme 1973), more details and additional data are given in the present article.

In addition to studies of anaerobiosis, aerobic metabolism of *P. borealis* was measured at regular intervals throughout the year. The purpose of this part of the investigation was to see if different levels in oxygen consumption in the beetles could be found in winter and summer. In many insects, cold-acclimation results in increased metabolism (Mutchmoor 1967), and this is often associated with an increased ability to remain active at low temperatures. This type of adaption, however, may not be expected in adults of *P. borealis*, which appear to remain inactive in their soil cavities during the winter.

METHODS

Outdoor storage

Approximately 1600 adults of *P. borealis* were collected at their overwintering sites in the first week of September 1972. The beetles were divided in groups of about 50 or 100, and put in plastic boxes filled with soil and grass turfs. The boxes, which were of a household type, were made from soft polyethylene, and measured 8 × 8 × 12 cm or 12 × 8 × 18 cm. Both lid and bottom were perforated with small holes to allow water to seep in and out. The boxes were placed in the soil at the overwintering sites of the beetles. From each box a string led to a pole, about 2 m high, to facilitate recovery during the winter (Østbye & Sømme 1972). Boxes containing the beetles were dug up at regular intervals throughout the year. At each removal the rate of survival, soil temperature, and snow depth were registered.

Aerobic metabolism

Oxygen consumption was measured with the constant pressure respirometer described by Engelmann (1963). All results were converted to normal pressure and temperature. For studies of aerobic metabolism at different times of the year, measurements were made with five-degree intervals at temperatures from 5° to 40°. From

the time they were dug up from the soil and until they were measured, the beetles were kept at the same temperatures as those of their outdoor surroundings.

Anaerobic metabolism

To test the ability of survival under anoxia, adults of *P. borealis* were placed in glass tubes filled with 99.9 percent nitrogen. The tubes were 0.8 cm in diameter and about 30 cm long. Before introducing the beetles, one end of the tube was heated and pulled out. From six to eight beetles and a small piece of moist filterpaper were placed in each tube, which was then pulled out at the other end. Nitrogen was flushed through each tube for about two minutes, after which the tube was rapidly sealed by melting both the pointed ends. The tubes were stored in an incubator at 0°.

Following removal from anoxia, the survival rates of the beetles were recorded after one or two days at room temperature. Apparently normal beetles were counted as alive, beetles moving but unable to walk as moribund, and those without movements as dead.

In beetles that had previously been kept in nitrogen at 0°, oxygen consumption was measured at 20°. The first measurements were made a few hours after removal, and then with intervals between 12 to 48 hrs for several days. Between measurements the beetles were kept without food at 20°. For comparison, beetles stored aerobically in the laboratory at 0° for about 50 days were transferred to 20°, and their respiration measured for several days.

Lactate analysis was carried out on haemolymph samples from beetles stored in nitrogen at 0°, as well as from beetles dug up from their overwintering sites. Drops of haemolymph were collected with a micropipette from a small puncture in the neck of the beetles, and analysis of lactate carried out according to Strøm (1949). For analysis of alanine 10 microlitre samples of haemolymph were obtained from two to three beetles. The samples were diluted five times with water, deproteinised by heating in boiling water for 60 sec, and centrifuged before being applied to silica gel thin-layer chromatogram plates. Two-dimensional thin-layer chromatography was used according to Brenner et al.

(1969), with the first run in methanol:chloroform:17% NH_3 (40:40:20) and the second run in phenol:water (75:25). Alanine was determined spectrophotometrically after elution of the spots as described by Chen & Diem (1961). For analysis of pyruvate, α -glycerophosphate and glycerol extracts of individual beetles were prepared as described by Sømme (1964). Pyruvate was determined spectrophotometrically according to Sloneker & Orientas (1962), α -glycerophosphate by the enzymatic method described by Heslop et al. (1963), and glycerol from paper chromatograms according to Sømme (1964).

RESULTS

Outdoor survival

During the winter of 1972/1973 the temperature at the overwintering sites of the beetles remained fairly constant at or slightly below 0° (Table I). The ground was covered by snow from the end of October, and the thickness of the snow cover increased until the middle of May. At the location, where beetles used for the present study were overwintering, the last snow disappeared around 20 June. Flooding of the sedimentation flat occurred in the first part of February, leaving the beetles partly submerged in water, and partly enclosed by ice for the following months.

During the first part of the winter almost no mortality occurred among the overwintering beetles (Table I). From the end of January some mortality was registered, but almost 90 percent of the beetles were alive at the end of June.

Table I. Survival rates of beetles removed from their overwintering sites during the winter of 1972/73

Date	Soil temp.	Snow depth	No. of beetles	Percentage survival
15 Oct.	1.0°	0	142	100
14 Dec.	-0.5°	75	248	98
10 Jan.	-0.5°	—	50	100
25 Jan.	0°	65	175	94
17 Feb.	0°	80–120	41	95
18 March	-0.5°	110–120	192	92
8 May	-0.5°	110–130	93	82
29 June	10.0°	0	83	89

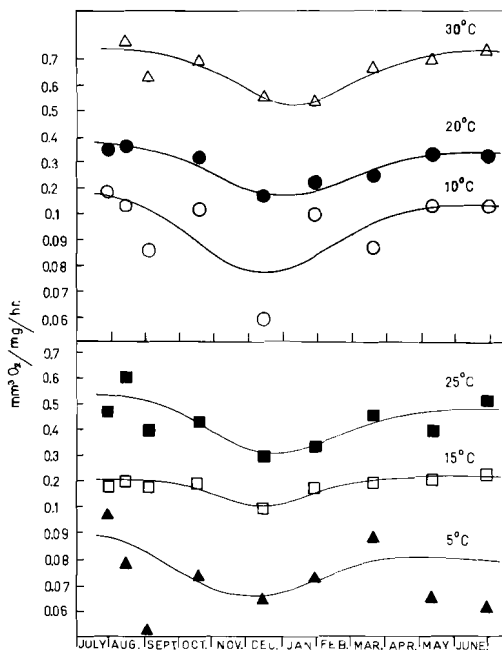


Fig. 2. Average oxygen consumption of *P. borealis* at various temperatures in relation to time of the year.

Aerobic metabolism

The results of measurements of oxygen consumption in adult *P. borealis* at various temperatures are presented in Fig. 1. A linear relationship appears to exist between the logarithm of oxygen consumption and temperature. At 40° , however, the beetles were rapidly immobilized, and died within a few hours. Beetles removed from their overwintering sites in March and May had been enclosed by ice since February. As will be explained later, a period of anoxia greatly affects the respiration rate. For this reason measurements of oxygen consumption were made within the first day after the beetles had been removed from their overwintering sites. During this period the level of oxygen consumption is about the same as after the oxygen debt has been paid (Fig. 3). In June the beetles were dug up about two weeks after the snow had melted, and thus had a period of aerobic conditions before their oxygen consumption was measured.

By comparing the curves presented in Fig. 1, it appears that the oxygen consumption of the

beetles was highest in the summer months, and decreased during the fall. Lowest oxygen consumption was measured in December and January, while slightly higher values were found in March and May. The trends of these results can be seen more clearly from Fig. 2, where the average oxygen consumption at each temperature has been plotted against time of year. Curves of approximately the same shape were obtained at all temperatures, reflecting the parallelism of the regression lines in Fig. 1. The oxygen consumption was highest in the summer, and lowest in the winter, while intermediate values were found in the fall and spring. The significance of these results were tested by two-way analysis of variance. From this it appeared that the differences in oxygen consumption at various times of the year were significant at the 1 percent level.

Anaerobiosis

The survival rates of beetles stored at 0° in tubes filled with nitrogen are presented in Table II. With few exceptions all beetles survived from 8 to 127 days at these conditions. The tests included beetles dug up from their overwintering

Table II. Survival of adult *P. borealis* stored in nitrogen at 0° for various time intervals

Date of removal from overw. sites	Days in N ₂ /0°	No. of beetles	
		Alive	Dead or moribund
29 Aug.	8	18	0
	12	8	0
	16	8	1
18 Oct.	26	14	0
	49	8	1
14 Dec.	12	7	0
	49	11	0
10 Jan.	49	15	3
29 Jan.	35	4	0
	75	4	0
	86	7	0
	127	8	0
17 Feb.	35	6	1
	39	3	0
20 March	43	2	0
	58	10	0
	75	7	1
11 May	88	4	1
	—	—	—

sites at various times of the year. No indication of seasonal differences in the ability to survive anoxia from October to March was found.

During storage in nitrogen at 0° an accumulation of lactate took place (Fig. 3). The increase in concentration was largest during the first 40 to 60 days of storage. After about 90 days no further accumulation was registered.

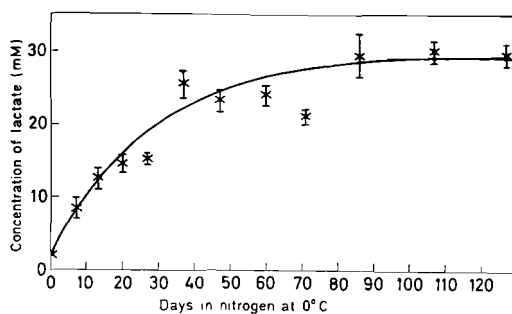


Fig. 3. Accumulation of lactate in the haemolymph of *P. borealis* stored in nitrogen at 0° for various time intervals. Mean \pm S.E. are given; each mean represents 5 to 10 beetles.

From these results it appears that under laboratory conditions adults of *P. borealis* can survive extensive periods of anoxia, and that at least lactate is formed as an end product of anaerobic metabolism. If anaerobiosis is of importance for survival of overwintering beetles, lactate should be present in their haemolymph as well. This was demonstrated in beetles removed from their overwintering sites at the end of March. The concentration of lactate in the haemolymph of ten beetles varied from 8.7 to 22.7 mM, with an average of 13.8 mM.

Since the accumulation of lactate is limited (Fig. 3), other products of anaerobic metabolism are probably produced as well. Visual examination of thin-layer chromatograms suggested that changes in the concentrations of several amino acids take place. Quantitative analysis of alanine showed that beetles kept under anoxia contained about three times more of this amino acid than beetles kept aerobically (Table III).

No accumulation of pyruvate or α -glycerophosphate, however, was found in beetles stored under anaerobic conditions (Table III). Traces of glycerol could be detected in beetles kept

Table III. Contents of pyruvate, α -glycerophosphate and alanine in *P. borealis* stored in the laboratory under aerobic and anaerobic conditions at 0° for 45 to 70 days. n = number of replicates. Content of alanine as mM concentration in the haemolymph, and of pyruvate and α -glycerophosphate as mg/g beetle fresh weight

	Aerobic		Anaerobic	
	n	conc.*	n	conc.*
Alanine	3	14.9 \pm 2.28	3	51.3 \pm 5.54
Pyruvate	5	0.21 \pm 0.017	5	0.17 \pm 0.018
α -glyc.phosph.	4	4.3 \pm 0.27	6	4.4 \pm 0.18

* mean \pm S.E.

aerobically and anaerobically, but apparently there was no difference in concentrations.

Following removal from anoxia an increase in the oxygen consumption of the beetles was registered during several days. The results are presented in Fig. 4, which shows oxygen consumption at 20° in beetles previously stored under aerobic and anaerobic conditions at 0° for about 50 days. Shortly after removal the oxygen consumption was about the same in both groups (Fig. 4A and B), while a gradual increase during the next days took place in beetles from anaero-

bic conditions. A maximum appeared after about three days. Following a period of decreasing oxygen consumption, a normal level was reached 8 to 10 days after removal from anoxia.

A similar 'oxygen debt' was demonstrated in beetles dug up from their overwintering sites. While a normal level of oxygen consumption was found in beetles collected in December (Fig. 4D), an increased level was found in beetles dug up after the sedimentation flat had been flooded in early February. Thus the oxygen consumption at 20° in beetles that were dug up on 17 February and on 20 March (Fig. 4C) showed a pattern similar to that of beetles removed from nitrogen tubes.

The increased level of oxygen consumption, following removal of the beetles from anoxia, indicates that anaerobic end products are metabolised. When beetles kept in nitrogen at 0° were transferred to aerobic conditions at 20°, most of the lactate in the haemolymph disappeared after one day (Fig. 5A). Similarly the concentration of lactate decreased rapidly at 20° in beetles removed from their overwintering sites in March (Fig. 5B). Small amounts of lactate were also present in beetles that had been stored anaerobically at 0° (Fig. 5A). Compared to these,

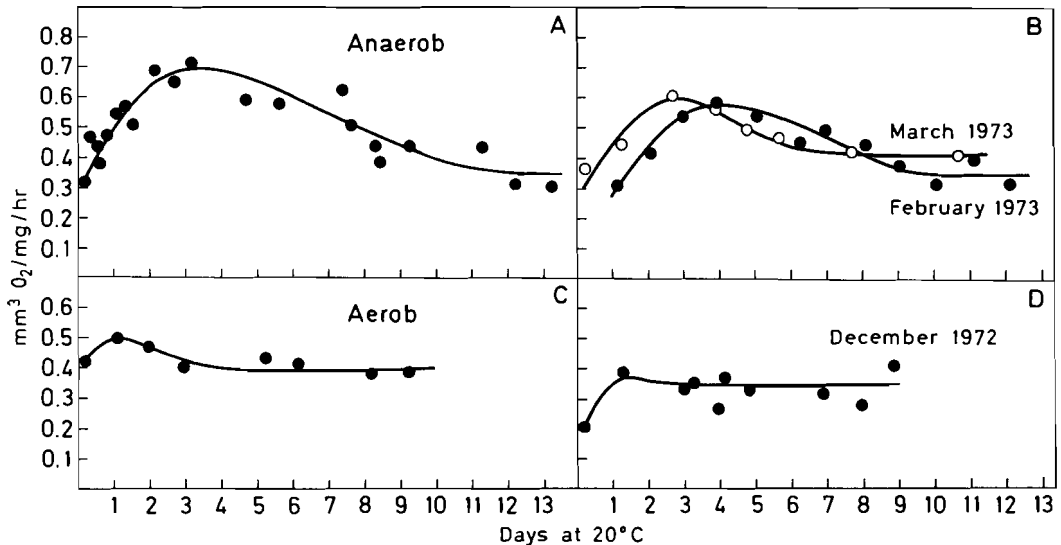


Fig. 4. Oxygen consumption at 20° in *P. borealis* stored under aerobic and anaerobic conditions at 0° (A and B), or removed from their overwintering sites (C and D). After removal from 0° or overwintering sites the beetles were kept under aerobic conditions at 20°. Each point represents the average of nine measurements.

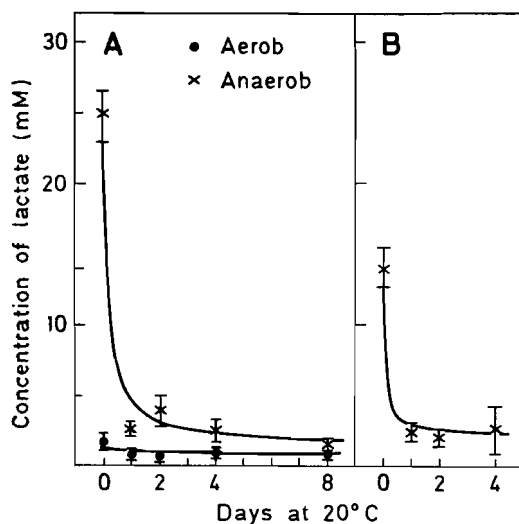


Fig. 5. Contents of lactate in haemolymph of *P. borealis* following removal from aerobic and anaerobic storage at 0° (A), and after removal from overwintering sites in March (B). Mean \pm S.E. are given; each mean represents 5 to 14 samples.

higher levels of lactate were maintained in beetles from outdoors and from nitrogen tubes. The results indicate that part of the oxygen debt is caused by the breakdown of lactate, but other metabolites are probably involved as well.

DISCUSSION

Anaerobiosis has been demonstrated in a number of insects. Many species are able to survive several hours of anoxia (Wigglesworth 1972), and some soil-inhabiting insect larvae can tolerate two to three weeks in CO₂ at room temperature (Kupka & Schaerffenberg 1947). Several end products of anaerobic metabolism are known from insects (Chefurka 1965). In many species large concentrations of lactate are accumulated during anoxia. In flight muscles, however, lactate formation is insignificant, but pyruvate and α -glycerophosphate are formed. α -glycerophosphate was also found to accumulate in the housefly (*Musca domestica*) during anoxia (Heslop et al. 1963). In addition a considerable increase in the concentration of alanine was observed by Price (1961) in this species. As has been shown in other invertebrates (Hochachka

& Mustafa 1973), pyruvate is converted to alanine by alanine aminotransferase during anaerobiosis. This also results in the formation of α -ketoglutarate, which may be further converted to succinate.

Other metabolic processes may also occur during anaerobiosis. In some insects, a conversion of glycogen to fat takes place in order to utilize the oxygen set free for energy production (Wigglesworth 1972). Although not demonstrated, glycerol could possibly be another end product of anaerobic metabolism (Chefurka 1965).

In the present study the concentrations of lactate and alanine in the haemolymph of *P. borealis* increased during anoxia. No accumulation of pyruvate or α -glycerophosphate was observed. From the shape of the curve in Fig. 3 it appears that there is a limit for the accumulation of lactate, and this suggests that other end products of anaerobic metabolism are formed as well. Alanine is apparently one of these, but further investigations should be carried out to see if other substances accumulate.

After removal from anoxia most of the lactate disappeared within a short time (Fig. 5), while the oxygen debt of the beetles lasted for several days (Fig. 4). Thus the oxygen debt cannot be explained by the breakdown of lactate alone. This also suggests the presence of more end products, or perhaps of other metabolic processes during anaerobiosis. Further studies on the accumulation and breakdown of anaerobic metabolites in *P. borealis* are necessary to elucidate these questions. Anaerobiosis should also be investigated in other species overwintering in similar biotopes before a general picture can be formed.

Like beetles kept under laboratory conditions, adult *P. borealis* removed from their overwintering sites had an 'oxygen debt' (Fig. 4) and high content of lactate in their haemolymph. From these observations it is concluded that overwintering adults of *P. borealis* may survive long periods of anoxia in their natural habitats, and that anaerobic metabolism becomes an important aspect of winter survival. Further investigations should be carried out to see how widespread this situation is among insects. Other species as well overwinter in the same biotope as *P. borealis*,

and will also be subjected to flooding and encapsulation of ice. Although this particular biotope offers extremely unfavourable conditions, anaerobiosis may also be important in other biotopes. An oxygen deficiency is likely to occur in various types of humid habitats when the ground is covered by ice and snow during the winter. Ability of the cerambycid *Rhagium inquisitor* to survive an oxygen deficiency during overwintering has recently been demonstrated by Päsche & Zachariassen (1973).

The aerobic metabolism of the beetles, measured as oxygen consumption, was generally lower in the winter months. In many insects cold-acclimation results in increased metabolism (Mutchmoor 1967), and this is often associated with an increased ability to remain active at low temperatures. This type of adaptation, however, may not be expected in *P. borealis* adults, which are inactive in their soil cavities during the winter. It seems reasonable that low metabolism would increase the chances of survival during long inactive periods, as in *P. borealis*, which spend up to nine months in their winter habitat.

ACKNOWLEDGEMENTS

Part of this work was carried out at the High Mountain Ecology Field Station, Finse. We thank Mr. Eivind Østbye, head of the station, for valuable advice during the investigation. We also thank Mrs. Randi Sømme, Department of Chemistry, the Agricultural University of Norway, for her help in analysing haemolymph samples for pyruvate; Mr. Ørnulf Borgan, University of Oslo, for advice regarding statistical analysis; and Mrs. Inger Tambs-Lyche for her conscientious technical assistance.

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Short Communications

Nye finnesteder av Lepidoptera i Norge

C. F. LUHR

A list of new localities for various Lepidoptera in Norway is presented.

C. F. Lühr, N-2680 Vågåmo, Norway

Ved gjennomgåelse av min samling og ved samhold med finnesteder angitt av Opheim (1958, 1962 og 1972) kan nye lokaliteter angis for følgende arter:

- Herse convolvuli* L. Lalm, On 12. aug. 1972. *Odontosia carmelita* Esp. Grimstad, AAY 5. mai 1973. *Drepana lacertinaria* L. Narverød, VE 4. aug. 1970. *D. falcataria* L. Vågåmo, On 4. juni 1972. *Mamestra persicariae* L. Narverød, VE 1. sept. 1972 (larve), 1. mai. 1973 (imago). *Iodis lactearia* L. Lillehammer, Os 24. juni 1961, Torpo, Bv 6. juni 1960. *Calothysanis amata* L. Søgne, VAY 26. juli 1957. *Cosymbia albipunctata* Hufn. Søgne, VAY 25. juni 1960. *C. inornata* Haw. Narverød, VE 4. aug. 1970. *Larentia clavaria* Haw. Asker, AK 14. aug. 1964. *Lobophora halterata* Hufn. Kongsberg, Bø 16. mai 1964, Grimstad, AAY 6. mai 1973. *Calocalpe cervicalis* Scop. Narverød, VE 29. apr. 1968. *Lygris prunata* L. Finnsnes, TRy 30. aug. 1965. *Thera firmata* Hb. Narverød, VE 1. sept. 1972, Grimstad, AAY 30. aug. 1972. *Dysstroma infuscata* Tngstr. Lakselv, Fn 12. juli 1963. *D. latefasciata* Stgr. Narverød, VE 4. aug. 1970. *Xanthorhoe quadrifasciata* C1. Narverød, VE 4. aug. 1970. *X. spadicearia* Schiff. Lakselv, Fn 13. juli 1965. *X. biriviata* Bkh. Harran, NTi 27. juni 1956. *X. designata* Hufn. Lakselv, Fn 10. juli 1963. *X. abrossaria* H. S. Lakselv, Fn 12. juli 1963. *Orthonama lignata* Hb. Harran, NTi 6. juli 1972. *Euphyia silaceata* Schiff. Søgne AAY 2. aug. 1962. *Epirrhoe tristata* L. Sånér, Ø 14. juni 1955. *Perizoma affinitata* Steph. Åros, Bø 15. juni 1968. *P. minorata* Tr. Narverød, VE 3. aug. 1969, Lakselv, Fn 18. juli 1968. *P. blandiata* Schiff. Åros Bø 5. juli 1969. *P. flavofasciata* Thnbg. Åros, Bø 16. juni 1968. *Venusia cambrica* Curt. Søgne VAY 27. juli 1962, Dividal, TRi 18. juli 1965. *Hydrelia flammeolaria* Hufn. Søgne VAY 22. juli 1962. *Eupithecia inturbata* Hb. Narverød, VE 23. aug. 1968. *E. immundata* Z. Søgne, VAY 26. juni 1966. *E. pulchellata* Steph. Stryn, SFi 21. mai 1964. *E. palustraria* Dbl. Søgne, VAY 30. juni 1966. *E. trisignaria* H. S. Narverød, HE 4. aug. 1970. *E. tripunctaria* H. S. Asker, AK 23. juni 1959. *E. succenturiata* L. Harran, NTi 6. juli 1972. *E. subumbrata* Schiff. Lom, On 20. juni 1968. *E. gelidata* Möschl. Narverød, VE 24. aug. 1968. *E. innotata* Hufn. Lom, On 9. aug. 1968, Narverød, VE 23. aug. 1968. *E. virgaureata* Dbl. Lom, On 15. juni 1970. *E. tantillaria* B. Søgne, VAY 10. mai 1971. *Chloroclystis debiliata* Hb. Lom, On 27. juli 1968. *Horisme tersata* Schiff. Søgne, VAY 28. juni 1966. *Arichanna melanaria* L. Søgne, VAY 22. juli 1957. *Ellopija fasciaria* L. Finnsnes, TRy 29. juli 1964. *Ennomos erosaria* Schiff. Åros, Bø 26. aug. 1969. *Selenia bilunaria* Esp. Grimstad, AAY 2. mai 1973. *S. tetralunaria* Hufn. Søgne, VAY 10. mai 1971. *Plagodis dolabraria* L. Narverød, VE 8. juni 1970, Søgne, VAY 16. juni 1960. *Epione repandaria* Hufn. Søgne, VAY 13. aug. 1959. *E. vespertaria* F. Åros, Bø 14. aug. 1969, Fyresdal, TEi 11. aug. 1969, Søgne, VAY 6. aug. 1959. *Lithina chlorosata* Scop. Lom, On 6. mai 1971. *Chiasma clathrata* L. Åros, Bø 15. mai 1968. *Itame brunneata* Thnbg. Finnsnes, TRy 31. juli 1961. *Erannis*

aurantiaria Esp. Lom, On 22. okt. 1966. *Phigalia pilosaria* Schiff. Asker, AK 24. apr. 1962. *Poecilopsis pomonaria* Hb. Vågåmo, On 29. mars og 27. mai 1973. (første funn i østfjellske Norge). *Cleora ribeata* Cl. Søgne, VAY 10. juli 1966. *Celama confusalis* H. S. Asker, AK 13. mai 1959. *Nudaria mundana* L. Søgne, VAY 17. juli 1958. *Lithosia deplana* Esp. Søgne, VAY 13. aug. 1959. *L. complana* L. Narverød, VE 4. aug. 1970. *Zygaena loniceræ* Schev. Lårdal, TEI 6. juli 1919.

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Mottatt 8. juni 1973.

Rhamphomyia platyptera Panz. (Dipt., Empididae) ny for Norge

MAGNE OPHEIM

Rhamphomyia platyptera Panz. is reported new to Norway. One ♀ was knocked down from a spruce near Bø: Holmsbu 31 May 1973.

M. Opheim, Zoological Museum, University of Oslo, Norway

Den 31. mai 1973 var jeg i Holmsbu i Hurum på jakt etter Microlepidoptera. Blant de insekter som ble banket ned fra en gran, oppdaget jeg en merkelig dipter. Vingene var meget brede og hadde en vid brunsort utkant og bakkant (fig. 1). Dyret (en ♀) ble bestemt til *Rhamphomyia platyptera* Panz. tilhørende familien Empididae. Det er ♀ som har et slikt avstikkende utseende, mens ♂ ligner mere på de andre arter av slekten.

I Sverige er arten bare funnet i Skåne (Tullgren & Wahlgren 1920–22) og den er sjelden i Danmark (Lundbeck 1910). Larven skal leve på råtnende granstubber (Collin 1961).

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 Tullgren, A. & Wahlgren, E. 1920–22. *Svenska Insekter*. 812 pp., P. A. Norstedt & Söners Förlag, Stockholm.

Mottatt 13. september 1973

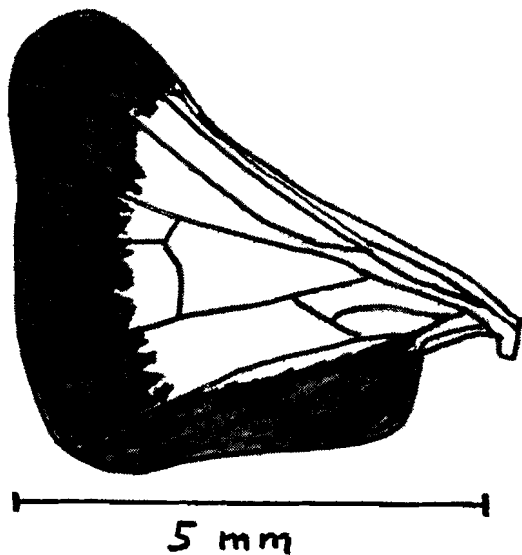


Fig. 1. Fore wing of *Rhamphomyia platyptera* Panz. from Holmsbu i Hurum. Del. M. Opheim.

Scaphidium quadrimaculatum Oliv. (Col., Scaphidiidae) New to Norway

KARL ERIK ZACHARIASSEN

Scaphidium quadrimaculatum Oliv. is reported new to Norway. Two specimens were found copulating on fungus on a thin, lying stock of leaf tree near Kragerø, Telemark county, 21 June 1973. Another specimen was found on a pile of fire-wood at the same locality 14 July 1973.

K. E. Zachariassen, Institute of Zoophysiology, University of Oslo, Norway.

Of the genus *Scaphidium* (Col., Scaphidiidae) the only European species, *S. quadrimaculatum* Oliv., has been found over most of Europe but occurs less frequently in the northern parts (Schaufuss 1916). In Sweden it has been found in many counties north as far as Hälsingaland, and in Finland it has been found north up to Kuusamo (Lindroth 1960).

Two copulating specimens were found by the author 21 June 1973 on fungus on a thin stock of leaf tree, lying in the vegetation near Berg Museum, Kragerø. One of the beetles was caught. It was a male, 5.7 mm in length. In the morning of 14 July another specimen was found by the author on a pile of leaf tree fire-wood. This specimen was also a male 5.7 mm in length.

That this conspicuous species has not previously been found in this area indicates that further coleopter collections in the Kragerø area might provide new and interesting species to the list of the Norwegian coleopter fauna.

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 Schaufuss, C. 1916. *Calwers Käferbuch Vol. II*. 1390 pp. E. Schweizerbartsche Verlagsbuchhandlung. Stuttgart.

Received 14 September 1973

Eupithecia irriguata Hb. (Lep., Geometridae) ny for Norge

C. F. LÜHR

Five specimens of *Eupithecia irriguata* Hb. (Lep., Geometridae) were caught at Groos, Grimstad, Aust-Agder, in April and May 1973. This is the first record of the species from Norway.

C. F. Lühr, N-2680 Vågåmo, Norway

Under nattfangst med lys ultimo april-primo mai 1973 tok jeg ved Groos, Grimstad, AAy, den 30. april ett eksemplar, og de senere nettene ytterligere fire eksemplarer, av *Eupithecia irriguata* Hb., som ny for landet. Imago og hannlige genitalorganer er vist i Fig. 1.

Sommerfuglen, som har sin vesentlige utbredelse i syd omkring Middelhavet, har sin

nordgrense i Danmark, Syd-Sverige og Syd-Finnland, og blir overalt omtalt for sin store sjeldenhet. Hoffmeyer (1952) anfører således i sin bok om «De danske Målerer»: *Irriguata* er ihvertfald internasjonalt så sjælden, at dens bilde mangler i «Culot»: han hadde ikke kunnet skaffe et eksemplar af den, og W. Petersen havde kun et eksemplar til sin raadighet. Det var sendt

ham af selveste Dietze, men bagkroppen var forkert: en linariata eller noget i den retning». I Danmark har man bare spredte funn (Bornholm, Lolland-Falster-Møn, Sjælland, Fyn, Jylland), mens den ifølge Nordström (1943) bare er funnet i Skåne, Blekinge og Halland. I Tyskland ytterst få funn.

Eggene legges på eik (*Quercus*) eller bøk (*Fagus*) i april-mai og puppen overvintrer.

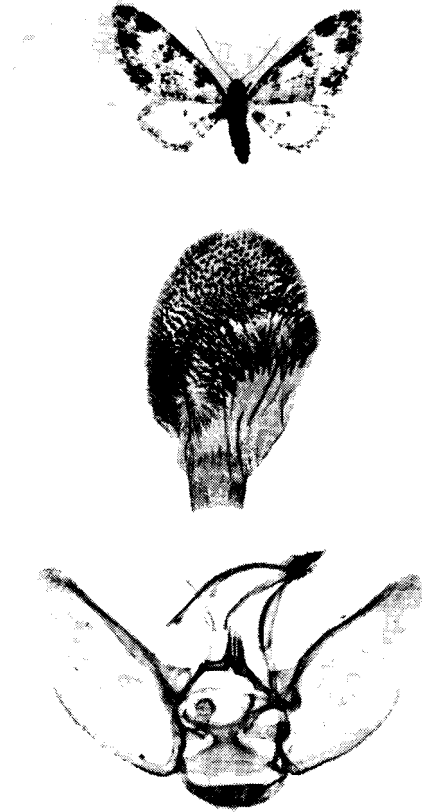
Jägmästare Ingvar Svensson, Kristianstad, Sverige, har kontrollbestemt mitt første eksemplar, og jeg nytter anledningen til å takke ham for dette. Likeledes takker jeg herr Henning Hansen, Holte, Danmark for utførelse av fotografiene.

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Nordström, F. 1943. Förteckning över Sveriges storfjäriler. 120 s. Entomologiska Sällskapet, Lund.

Mottatt 5. juni 1973

Fig. 1. *Eupithecia irriguata*. Imago (ca. 2× forstørret) og hannlige genitalorganer (ca. 25×).



ERRATA

Rolf Dahlby: A Check-list and Synonyms of the Norwegian Species of Ephemeroptera. Norsk ent. tidsskr. Vol. 20, No. 2, pp. 249–252, 1973.

The following corrections should be noted:

p. 249 – Second column:

Gen. *SIPHLONURUS* Eaton, 1869

Correct date is 1868

p. 250 – First Column:

FAM. BAËTIDAE CONTINUATION

This heading should be struck out. The section following, down to *Cloëon bifidum*, should be replaced by:

Gen. *CENTROPTILUM* Eaton, 1869

16. *luteolum* (Müller), 1776 (sub nom. *Ephemera luteola*)

Gen. *CLOËON* Leach, 1815

17. *dipterum* (Linnaeus), 1761 (sub nom. *Ephemera diptera*)

Syn.: *Cloëon inscriptum* Bengtsson, 1914

18. *simile* Eaton, 1870

Syn.: *Cloëon praetextum* Bengtsson, 1914

Gen. *PROCLOËON* Bengtsson, 1915

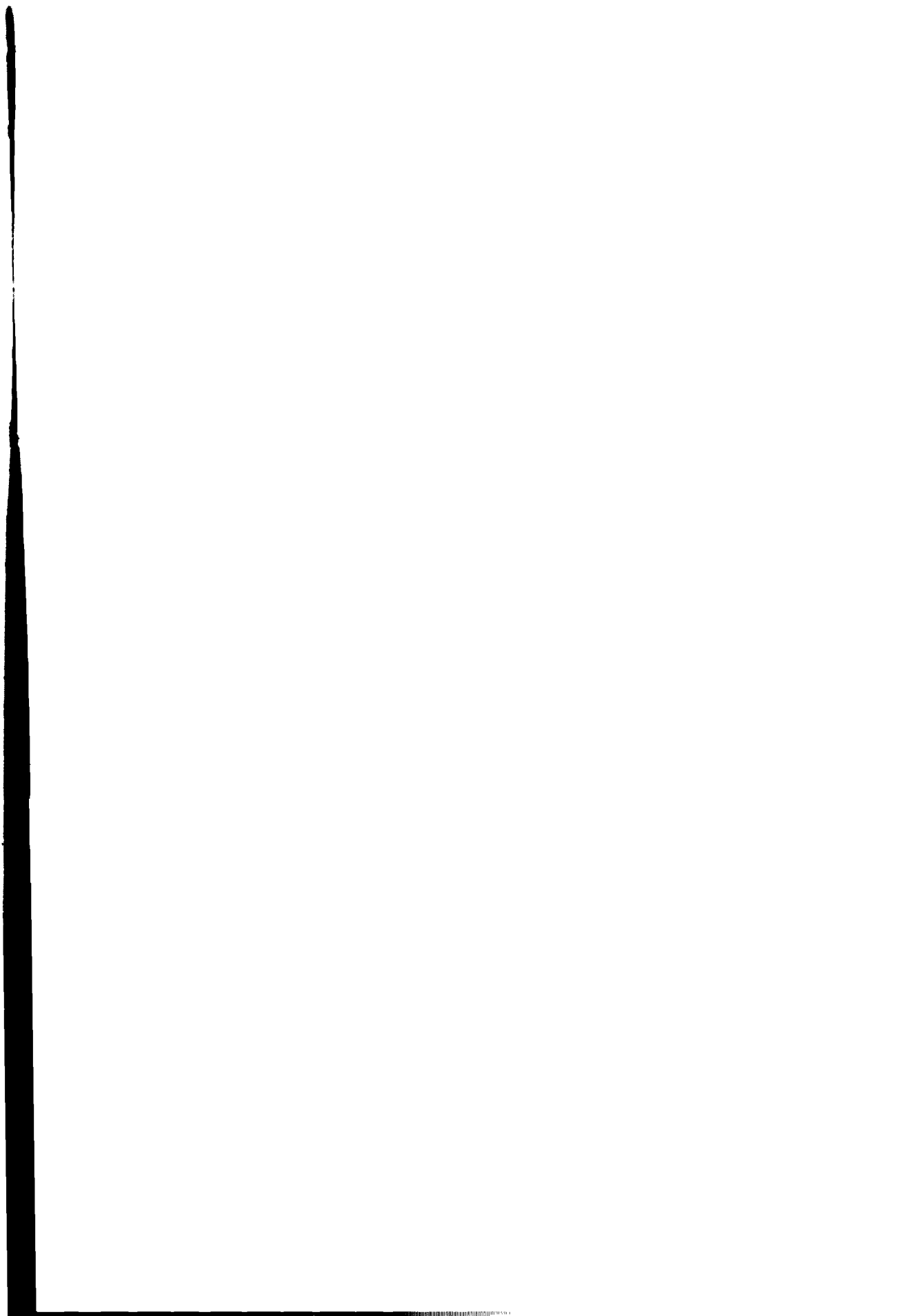
19. *bifidum* (Bengtsson), 1912 (sub nom. *Cloëon bifidum*)

p. 250 – Second Column:

FAM. AMETROPODIAE

This heading should read

FAM. AMETROPODIDAE



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