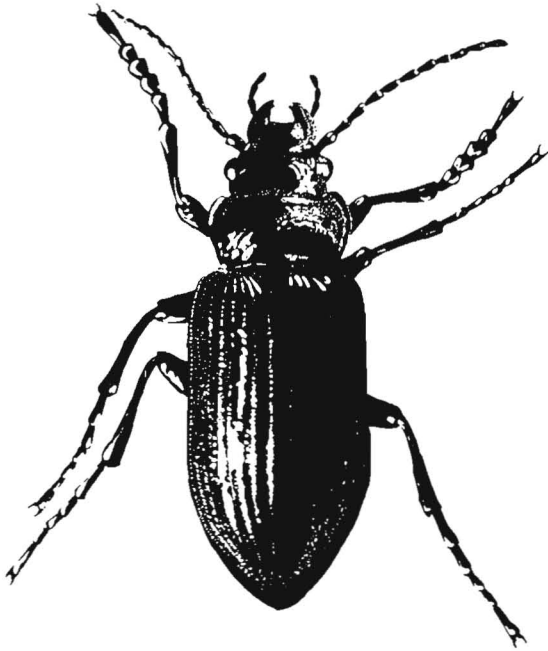


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Dr. philos. Lauritz Sømme, Zoologisk institutt, Universitetet i Oslo, Blindern, Oslo 3, Norway.

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Notes on winter activity of two *Diamesa* species (Dipt., Chironomidae) from Voss, Norway

BROR JONSSON & ODD TERJE SANDLUND

Jonsson, B. & Sandlund, O. T. 1975. Notes on winter activity of two *Diamesa* species (Dipt., Chironomidae) from Voss, Norway. *Norw. J. Ent.* 22, 1-6.

Adults of *Diamesa thienemanni* Kieffer and *D. latitarsis* (Goetgh.) Edw. were collected on the snow along the Strandaelvi river system, Voss, western Norway. Samples were taken monthly between November 1973 and March 1974, except in December when the river was ice covered. The density of Chironomidae was 5-10 individuals per m² at the examined localities. Flying and copulating specimens were observed at a temperature of approx. 0° C. *D. thienemanni* seems to be emergent throughout all winter months. We consider this to be an adjustment to emergence under extreme conditions.

Measurements of antennal hairs and segments indicate that *D. thienemanni* and *D. semireducta* Sæther are synonyms.

B. Jonsson & O. T. Sandlund, Zoological Institute, University of Oslo, Blindern, Oslo 3, Norway.

The ecology of *Diamesa* in Norway is incompletely investigated, and so far only two species are known to be winter-active (Hågvar & Østbye 1973).

Neither does very much seem to be known about this subject in other countries. Oliver (1968) states that *Diamesa* are the first species to emerge in the spring in the temperate region of North America. From Germany, hatching of *Diamesa thienemanni* Kieffer is recorded in March (Kieffer 1924, Wülker 1959). Kieffer (1924) found imagines on the snow cover at -3.4° C. Wülker (1959) also records hatching in November from Austria. Hatching of *Diamesa latitarsis* (Goetghebuer) Edwards has been recorded in February and March as well as November in the Pyrenees Mountains (Serra-Tosio 1972).

Lack of knowledge about winter-active Chironomidae may be due to their difficult taxonomy and the fact that entomological sampling activity is low during winter; not, as Hågvar & Østbye (1973) suggest, because this adaptation is rare.

In the river Strandaelvi in Voss, winter-

active Chironomidae seem to be quite common, and therefore the present study was undertaken.

STUDY AREA

The Strandaelvi river system is located at Voss, in the county of Hordaland, western Norway. The localities under discussion in this paper are in mountainous areas with coniferous and deciduous forest. The river is little affected by human activity; only at Vinje and Uppheim (Fig. 1) are there small agricultural areas. The drainage area at the outlet of lake Lønavatn is approx. 350 km².

The total alkalinity of the river is very low, approx. 0.05 meq/l. The specific conductivity (χ_{18}) varied from 9 to 12 ($\times 10^{-6}$ megamho), and the pH-values from 5.9 to 6.7 throughout 1972 and 1973.

Fig. 2 shows the locality at Grjotland. The river is up to 1.5 m deep; its current varies between 0.5 and 1.0 m/sec, and the discharge at Grjotland approx. 20-70 m³/sec. The bed

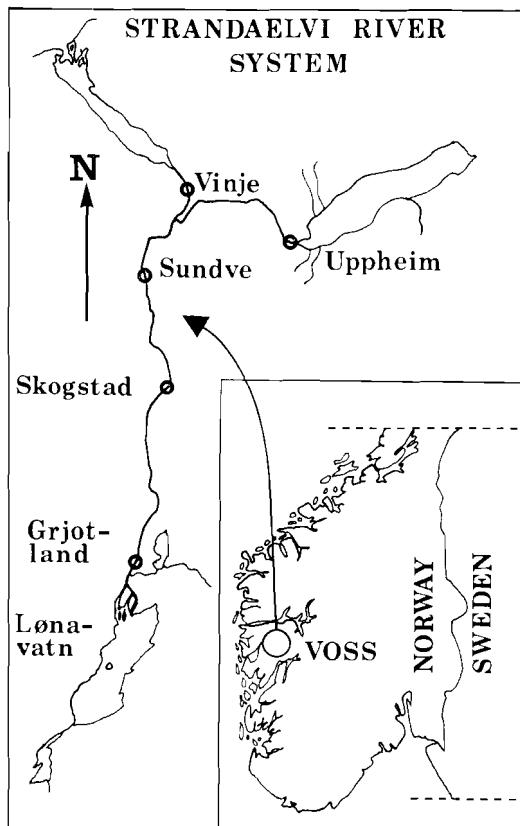


Fig. 1. Map showing the localities of sampling at Voss, Western Norway.

of the river consists largely of stones (5–15 cm diameter) and occasional areas of sand and gravel. The stones are partly moss covered, mostly *Fontinalis antipyretica*, and some *Hygrohypnum luridum* in the upper parts of the river. The other localities are very similar.

MATERIAL AND METHODS

Imagines of *D. thienemanni* and *D. latitarsis* were collected on the snow within two metres of the bed of river Strandaelvi. Samples were taken monthly between November 1973 and March 1974 with the exception of December, when the river was ice covered. Samples were taken at six different localities along the river course; each time the insects were collected from a couple of m². The material was preserved in 70% alcohol, then exam-

ined. Our data are given in Table I. Only male insects are taken into account, since females of the *Diamesa* species in Fennoscandia cannot be identified with certainty (B. Serra-Tosio pers. comm.).

SYSTEMATICS OF *D. THIENEMANNI*

B. Serra-Tosio has verified our identification of *D. thienemanni*. A very similar species was collected at Finse, Norway, and described as a nova species, *D. semireducta* Sæther (Sæther 1968).

Serra-Tosio (1969) states that the only difference between these two species is in the antennae of the males. Sæther (1968) describes the antennae of *D. semireducta* as follows: 'segment 2 with 1 bristle, segment 3 with 1 hair circle, segments 4–7 with 1 hair circle with about 255 μ long hairs and 1 reduced hair circle with about 92 μ long hairs, segments 8–13 with 2 about equal hair circles, segment 14 with about 5 circles.'

In our material we found a great variation in the lengths of the hairs of each circle of *D. thienemanni* (5–50%), and from one specimen to another. We have chosen, like Serra-Tosio (1969), to measure the longest hair in each circle. Table II gives the variation between specimens together with measurements made by Serra-Tosio (1969) on *D. thienemanni* and by Sæther (1968) on *D. semireducta*. Table III gives the variation in lengths of the antennal segments between specimens



Fig. 2. The river at Grjotland, 85 m a.s.l. A habitat where *Diamesa thienemanni* and *D. latitarsis* were found.

Table I. Sampling dates, localities of sampling with altitude above sea level, air and water temperatures, species and number of insects identified.

Date	Name of locality	Altitude m a.s.l.	Temperature °C			Insects identified
			air max.	air min.	water	
20 Nov.	Grjotland	85	1.5	-1.5	2	<i>D. thienemanni</i> , 4
24 Jan.	Vinje	220	6.0	1.0	2	<i>D. thienemanni</i> , 3
11 Feb.	Vinje	220	3.0	1.0	0	<i>D. thienemanni</i> , 4
11 Feb.	Uppheim	330	3.0	1.0	1	<i>D. thienemanni</i> , 1
13 Feb.	Sundve	200	3.0	0.0	1	<i>D. thienemanni</i> , 3
						<i>D. latitarsis</i> , 2
13 Feb.	Grjotland	85	3.0	0.0	0	<i>D. thienemanni</i> , 2
						<i>D. latitarsis</i> , 4
20 March	Vinje	220	5.5	-0.5	2	<i>D. thienemanni</i> , 4
20 March	Skogstad	160	5.5	-0.5	1	<i>D. thienemanni</i> , 2

compared to Sæther's (1968) measurements. As Sæther gives approximate numbers for the hair lengths, our measurements revealed a variation which could be considered to include all the measurements made by Sæther on only one male. This supports Serra-Tosio's (1969) opinion that *D. thienemanni* and *D. semireducta* are synonyms.

It is obvious that Sæther (1968) uses a typologic species concept. This concept does not take into account intraspecific variation (Mayr 1969, p. 32). The use of this species concept is even more questionable when a nova species is described on only one intact individual.

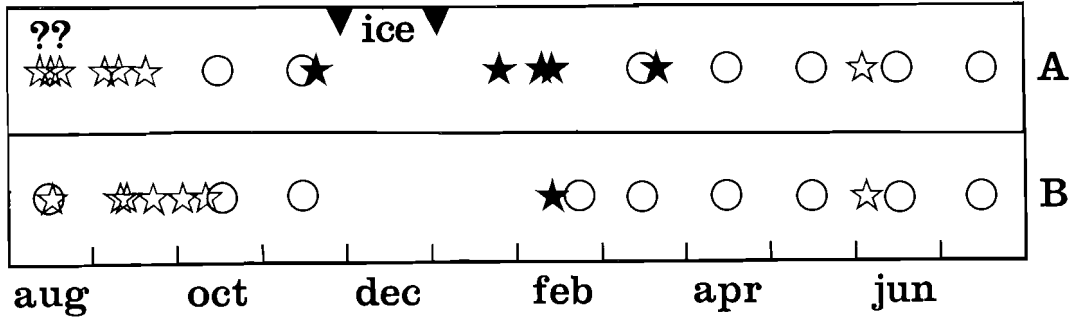
RESULTS

Winter-active Chironomidae were found along the river course between 85 and 330 m a.s.l. At the localities examined, the density was 5–10 individuals per m², except in one case when it was higher. Flying individuals were observed further away from the river.

At all samplings, animals copulating on the snow were observed. Fig. 3 shows the phenology of *D. thienemanni* and *D. latitarsis*, including additional data from Norway and Sweden, and other parts of Europe, according to Kieffer (1924), Sæther (1968), Serra-Tosio (1964, 1969, 1972), and Wülker (1959).

Table II. Measurements of antennal hairs in micrometer from 4 males of *Diamesa thienemanni*, compared to data from Serra-Tosio (1969) and Sæther (1968). * Only one individual found with hair circle; ca.: Approximate numbers; abs.: Hair circle absent; —: No measurement made.

Antennae segment no.	Long hairs			Reduced hairs		
	Present study	Serra-Tosio (1969)	Sæther (1968)	Present study	Serra-Tosio (1969)	Sæther (1968)
2	90–95	92–150	—	abs.	abs.	abs.
3	135–190	150–460	—	abs.	abs.	abs.
4	210–360	254–600	ca. 255	80–110	68–115	ca. 92
5	200–380	385–625	ca. 255	90–130	65–105	ca. 92
6	280–400	440–635	ca. 255	90–270	83–260	ca. 92
7	280–420	430–600	ca. 255	105–145	*204	ca. 92
8	245–390	380–580	—	abs.	*290	abs.
9	260–370	233–530	—	abs.	*140	abs.
10	245–320	210–450	—	abs.	*195	abs.
11	220–305	210–390	—	abs.	abs.	abs.
12	220–235	195–380	—	abs.	abs.	abs.
13	180–230	160–330	—	abs.	abs.	abs.
14	180–200	180–290	—	70–85	55–70	—



- ★ Data from Voss, Norway. Own observations.
- ☆ Data from Norway and Sweden. From literature.
- Data from Europe. From literature.
- ? Probably *D. thienemanni*.

Fig. 3. The time of hatching of two *Diamesa*-sp. in the Strandaelvi river system compared to previously known periods of emergence from Norway, Sweden and other parts of Europe. A. *Diamesa thienemanni*; B. *D. latitarsis*

The highest density of *D. thienemanni* was found 20 Nov. 1973. The density of the snow and the partial ice cover was up to 20 individuals per m². Lively predation by dipper (*Cinclus cinclus*) and brown trout (*Salmo trutta*) on emerging insects was observed. Out of 120 brown trout parr less than 10 cm, 119 had nothing but Chironomidae pupae and larvae as stomach content (Odd Snare pers. comm.). Bigger fish were observed rising for flying insects. The weather was sunny with air temperature of approx. 0° C.

Flying Chironomidae were observed at several localities along the river 24 Jan. 1974; but samples were only taken at Vinje. The only species found was *D. thienemanni*. The weather was overcast with light showers of rain and a temperature of approx. 4° C.

On 11 Feb. 1974, flying insects were observed at all stations, but samples only taken at Vinje and Uppheim. The only species was *D. thienemanni*.

Two days later, 13 Feb. 1974, samples were taken at Sundve and Grjotland, and besides *D. thienemanni*, *D. latitarsis* was found here. On both days the weather was overcast with some rain and the air temperature just above 0° C.

Under approximately the same weather conditions, samples were taken 20 March

1974 at Vinje and Skogstad. Only *D. thienemanni* was represented in the samples. Flying specimens were also observed at Grjotland and Uppheim, but no samples taken.

DISCUSSION

According to Fittkau (1967), *D. thienemanni* is known from most European mountain areas, including those of England. It has also been found in the Faroes. Serra-Tosio (1969) identified it in the collections of Brundin from Lappland and Jämtland in Sweden. This species has been recorded from the river Aurlandselva, Sogn og Fjordane county, western Norway, where 11 males were found in August 1968 (Serra-Tosio 1972). It has most probably been found at Finse, Norway, too; but described as *D. semireducta*.

Earlier records of *D. latitarsis* from Norway are from the river Aurlandselva. At a locality 55 m a.s.l., 7 males were found in August 1968 and 4 males in June 1969 (Serra-Tosio 1972). According to Fittkau (1967), this species is found in most European mountain areas, including the mountain regions of England, and Swedish Lappland.

Earlier records of *D. thienemanni* in Scandinavia are from June, August, and Septem-

Table III. Measurements of antennal segments in micrometer from 4 males of *Diamesa thienemanni*, compared to data from Sæther (1968).

Ant. segm. no.	2	3	4	5	6	7	8	9	10	11	12	13	14
Present study	82-90	29-47	32-45	29-43	30-40	30-40	34-40	35-45	42-51	36-46	39-51	32-50	305-410
Sæther (1968)	73	35	36	39	38	42	43	43	52	43	44	44	335

ber (Sæther 1968, Serra-Tosio 1969, 1972). From Europe, Kieffer (1924) recorded hatching in March, finding the insects on the snow. Based on the records of Serra-Tosio (1964) and Wülker (1959), Lehmann (1971) indicates that *D. thienemanni* has two hatching periods.

Our observations indicate that *D. thienemanni* is hatching continuously throughout the winter. We do not have information on the periods between samplings, but the sampling dates were chosen at random. Water temperature varied between 2° C and 0° C on the sampling localities, and air temperatures were approximately 0° C.

Serra-Tosio (1972) states that *D. latitarsis* starts hatching in February-March at low altitudes in Europe. At higher altitudes emergence will be delayed, and at 1500 m a.s.l. it has been observed in June and July, with a second generation in October.

In Europe, *D. latitarsis* has been found mostly in mountainous areas, while *D. thienemanni* is recorded as low as 70 m a.s.l. in France (Serra-Tosio 1972).

The present study records hatching of *D. thienemanni* and *D. latitarsis* from a part of a river situated between 85 and 330 m a.s.l.

The larvae of both species depend on swift current; for instance *D. thienemanni* has been found in current up to 110 cm/s (Dorier & Vaillant 1948). They are oxygen demanding, dependent on cold water (Hynes 1970, p. 402), and live in brooks and rivers with stony bottoms (Brundin 1956). This means that they are found in the rhitron region as defined by Hynes (1970, p. 392). The river Strandaelvi falls into this region, even if it is not alpine.

According to Oliver (1968) it is an advan-

tage for arctic species to be able to mate without swarming as flying might be impossible because of low temperature. We have observed copulations on the snow at all localities on all sampling dates. Hågvar & Østbye (1973) suggest that the smooth white snow cover facilitates the meeting of the sexes on the ground, but the eyes are probably of minor importance during mating, as many Chironomid species are morphologically very similar, and synchronic emergence of many species has often been recorded (Oliver 1968).

According to Sømme & Østbye (1969), the typical winter insects reproduce only during winter. This definition does not include *D. thienemanni* and *D. latitarsis*, as hatching has been recorded from other parts of the year in other countries, see Fig. 3. We do not know if this happens in the river Strandaelvi, but these two species are at least adapted to reproducing on the snow.

CONCLUSIONS

D. thienemanni in the Strandaelvi river system appears to be emergent throughout all winter months. We consider this prolonged emergence an advantage for a population hatching under extreme conditions. If *D. thienemanni* were dependent on only one or two hatching periods, as proposed by Lehmann (1971), large parts of the population could easily be extinguished due to low temperature.

Our findings of *D. latitarsis* in February are in agreement with those of Serra-Tosio (1972).

ACKNOWLEDGEMENTS

We are greatly indebted to Dr. Bernard Serra-Tosio for identification of material. During field work practical help was received from cand. mag. Olav Råd and the municipality of Voss. Thanks are also due to Mr. Liam Byrne for improving the English.

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New records of Norwegian Mecoptera

LITA GREVE

Greve, L. 1975. New records of Norwegian Mecoptera. *Norw. J. Ent.* 22, 7-8.

The present paper reports new records of the five Norwegian species of Mecoptera: *Panorpa cognata*, *P. communis*, *P. germanica*, *Boreus hyemalis* and *B. westwoodi*. *P. cognata*, previously only known from the county of Akershus, is reported from Stokke in Vestfold and Bø in Telemark.

L. Greve, Zoological Museum, University of Bergen, N-5014 Bergen-Univ., Norway.

Five species of Mecoptera have been found in Norway. Earlier records were published by Tjeder (1945) and Greve (1965). Additional information was given by Greve (1966), Greve & Fjellberg (1968), Svensson (1972) and Sømme & Østbye (1969). Additional material from earlier published localities (or areas in the vicinity of such localities) are not included in this survey. Some of the material in the present study was collected by the author, but the main part came from the following institutions: Zoological Museum, University of Oslo (Z.M.O.), Zoological Museum, University of Bergen (Z.M.B.), The Royal Norwegian Society of Science, University of Trondheim (Tr. M.), and Tromsø Museum, University of Tromsø (T.M.). The abbreviations in brackets are used in the text. The geographical divisions follow Strand (1943). The material was identified by the author, unless otherwise stated.

Panorpa cognata Rambur, 1842

VE: Stokke, Robergmyra 6 July 1969, 3 ♂♂ leg. A. Fjellberg (ZMB). TEi: Bø, Bø station

5 Aug. 1969, 1 ♂, leg. A. Fjellberg (ZMB). *P. cognata* has not earlier been recorded outside the county of Akershus (Tjeder 1945, Greve 1965). *P. cognata* seems to be restricted to the south-eastern parts of Norway. The species must be considered rare, judged from the few records.

Panorpa communis L. 1758.

VAY: Randesund, Bjørnestad 14 July 1972, 1 ♀, 23 July 1970, 2 ♂♂, leg. T. R. Nielsen (ZMB); Kristiansand, Timenes 16 July 1972, 1 ♀, leg. T. R. Nielsen (ZMB).

P. communis is new to the county of Vest-Agder. The species is not uncommon in Southern Norway, with the exception of the western parts.

Panorpa germanica L. 1758

By: Hol, Seim 26 June 1959, 1 ♀, leg. A. Løken (ZMB). SFy: Nordfjordeid, Eid 17 July 1966, 1 ♂, leg. S-R. Myklebust (ZMB). NSy: Flatmo 3 July 1946, 1 ♂, 5 July, 3 ♀♀, leg. T. Soot-Ryen (T. M.); Hommelstø 26 June 1946, 1 ♀, 28 June 1946, 1 ♂, 30 June 1946, 2

♀♀ leg. Soot-Ryen (T.M.); Terråk 13 July 1946, 1 ♀, leg. T. Soot-Ryen (T.M.).

P. germanica is new to the county of Buskerud, and to the outer parts of the counties of Sogn & Fjordane and Nordland. *P. germanica* has earlier been reported once only from outer parts of Hordaland (Greve 1965). Since then, material has been collected from several localities in Os, Fana, Samnanger and Osterøy (all in the neighbourhood of Bergen), and the species cannot be considered scarce in this area.

Boreus hyemalis (L. 1967)

On: Vågå, Sjødalen, upper Sjødalsvann 17 Oct. 1973, 1 ♂, 960 m a. s. l. pitfall trap, leg. D. Refseth. HOy: Bergen, Tarlebøvann 25 Dec. 1967, 3 ♂♂ 2 ♀♀, leg. A. Fjellberg; Bergen, Isdalen 1 Jan. 1968, 2 ♂♂ 1 ♀, leg. A. Fjellberg (ZMB). STi: Selbu, Belle 11 April 1968, 1 ♂, leg. & det. J. O. Solem (Tr. M.).

B. hyemalis is new to the northern part of Opland county and the outer part of Hordaland county, and the county of Southern Trøndelag. The specimens from the localities in Bergen had an atypical microsculpture on the vertex compared to that described for this species; it looked like an intermediate between *B. hyemalis* and *B. westwoodi* (see Tjeder 1951).

Boreus westwoodi Hagen, 1866

HEn: Tynset, Tydalskjøla, Auma 18 April 1965, 1 ♀, leg. A. Lillehammer (ZMO). AAy: Arendal, Solåsen 3 Jan. 1969, 2 ♂♂ 1 ♀, leg. T. Solhøy (ZMB). HOy: Bergen, Skomakerdiket 27 March 1967, leg. A. Fjellberg, Starefossen 28 Dec. 1967, 1 ♂, leg. A. Fjellberg (ZMB). Åsane, near Storsåta 26 March 1970, 1 ♂ 1 ♀, leg. L. Greve (ZMB). STi: Oppdal, Kongsvoll 29 Oct. 1968, 1 ♀, 960 m a. s. l., leg. E. Alendal (ZMB). Selbu, Selbustrand 10 Ap-

ril 1968, 8 ♂♂ 4 ♀♀, 11 April 1968, 10 ♂♂ 9 ♀♀, 12 April 1968, 1 ♂, coll. & det. J. O. Solem, Belle 13 April 1968, 1 ♀, leg. J. O. Solem, 24. March 1968, leg. & det. J. O. Solem, Strandbygdfjellene 14 April 1968, 1 ♂ 3 ♀♀, leg. J. O. Solem (Tr. M.). Klæbu 13 Oct. 1971, 3 ♂♂ 3 ♀♀, leg. J. O. Solem (Tr. M.). Trondheim, Bymarka 21 March 1971, 2 ♀♀, leg. J. O. Solem, 29 March 1968, 1 ♀, leg. S. Bretten, 5-6 April. 4 ♂♂ 3 ♀♀, leg. J. O. Solem, Jonsvatnet 24 March 1968, 1 ♀, leg. B. Larsen, det. J. O. Solem (Tr. M.) NTi: Overhalla, Lille Reinsjø 7-8 April 1972, 2 ♂♂ 2 ♀♀, leg. O. Sandnes; Grong, Reinsjøhøgden 18 April 1973, 1 ♂, Reinsjøen 20 April 1973, 1 ♀, leg. O. Sandnes (ZMB).

B. westwoodi is new to the counties of Aust-Agder and Southern and Northern Trøndelag, and to the outer parts of Hedmark and Hordaland counties.

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Koleopterologiske bidrag XVI

ANDREAS STRAND

Strand, A. 1975. Koleopterologiske bidrag XVI. *Norw. J. Ent.* 22, 9–14.

Information on some Norwegian coleoptera is given. *Euthia scydmaenoides* Steph., *Microscydmus minimus* Chaud., *Scaphisoma inopinatum* Löbl., *Tachinus ochsi* Coiff., *Mycetophagus salicis* Bris., ?*Mycetophagus quadriguttatus* Müll., *Scymnus limbatus* Steph., *Scymnus femoralis* Gyll., *Stagetus borealis* Isr. and *Blaps mucronata* Latr. are new to Norway. *Colon denticulatum* Kr., *Microscydmus nanus* Schaum, *Scymnus ater* Kug. and *Scymnus rubromaculatus* Goeze should be deleted as Norwegian species.

In Norwegian material the author has found so much variation in the characters separating *Tachinus ochsi* Coiff. from *T. elongatus* Gyll., that he questions whether they are different species.

Andreas Strand, Melumveien 38, Oslo 7.

Dyschirius aeneus. Dej. Om denne arten sier Lindroth (1945) bl. a.: «Die Flügel sind voll entwickelt und sicher funktionsfähig. Es liegen aber keine Flugbeobachtungen vor.» På AK:Røa tok jeg 19. mai 1960 og 3. juni 1970 et flygende eksemplar av arten.

Dyschirius politus Dej. Lindroth (1945) sier om denne arten bl. a.: «Die Flügel sind voll entwickelt. Bei Gtl Visby wurde 27/5 40 1 Ex. durch Sonnenexponierung in Glas zum Fliegen gezwungen. Spontaner Flug wurde in Kärnten abends beobachtet.» På AK:Røa tok jeg ca. klokken 19, 4. juni 1970 et flygende eksemplar.

Agonum munsteri Hellén. Lokaliteten TRi: Rundhaug, Målselv strykes. Feilbestemmelse.

Helophorus strandi Angus. Som nevnt tidligere (Strand 1962) fant jeg på On: Vålåsjø en *Helophorus* som jeg mente mest sannsynlig måtte være *H. bergrothi* J. Sahlb., men da typen ikke kunne finnes, kunne saken ikke avgjøres sikkert. Angus (1970) har nå i materiale utlånt fra Helsingforsmuseet funnet et eksemplar som stemmer med beskrivelsen, og som han mener er et av de manglende

typeeksemplarer, og derfor har gjort til lecto-type for *bergrothi*. Vålåsjøeksemplarene regner han som en ny art og beskriver den som *strandii*. Angus har dessuten følgende navneendringer: *sibiricus* Motsch. (*fennicus* Gyll., nec Payk., *doorensis* Kuw.), *aquaticus* L. (*aequalis* Ths.) og *grandis* Ill. (*aquatiscus* auctt., nec L.).

Colon delarouzei Tourn. Den 31. august 1951 tok jeg på et vindu under verandaen på mitt hus på AK:Røa et *Colon*-eksemplar som jeg holdt for *denticulatum* Kr., en art som er erklært for synonym med *appendiculatum* Sahlb. Ved nærmere undersøkelse av dyret kom jeg imidlertid til det resultat at det passer bedre på *delarouzei*, mens det er tydelig forskjellig fra den art fra N.-Sverige som går under dette navn. For å få oppklart saken sendte jeg såvel mitt eksemplar som et svensk til spesialisten dr. Szymczakowski, som bestemte mitt eksemplar til *delarouzei* og det svenske til *cordigerum* Szym., som nylig (Szymczakowski 1971) er beskrevet etter et eksemplar fra Mongolia, men som senere er funnet å være identisk med *curvipes* Mäkl.

(Lundberg & Szymczakowski 1973). *Delarouzei* er en meget sjelden art, bare kjent fra en del steder i Tsjekkoslovakia og fra Pfalz og Oberbayern (også eksemplaret fra det sist nevnte sted var tidligere bestemt som *denticulatum*) samt fra Mongolia. Den er også nylig konstatert fra Hälsingland i Sverige (Lundberg & Szymczakowski 1973). Arten er også tidligere oppgitt fra Norge etter et eksemplar som Munster fant i On:Sørem, Vågå, og som er beskrevet som *delarouzei* v. *münsteri* Fleisch.

Euthia scydmaenoides Steph. Den 21. juni 1958 tok jeg i On:Lom i kompost et eksemplar av denne arten, som er ny for Norge.

Microscydmus minimus Chaud. De norske eksemplarer som tidligere er oppgitt som *nanus* Schaum, skal hete *minimus* Chaud. Victor Hansen har kontrollert bestemmelsen.

Acrotrichis sjoebergi Sundt. Et eksemplar av denne arten tok jeg 8. september 1967 i hårrester fra et elgkadaver sammen med en rekke *insularis* Mäkl. i AK:Sørkedalen, som er den sørligste kjente lokalitet for arten. Sundt har bestemt eksemplaret.

Scaphisoma inopinatum Löbl. Av denne nylig beskrevne arten, som ifølge Löbl (1970) har vist seg å være vidt utbredt i Europa og Sibir, og som også er kjent fra Mongolia, har jeg eksemplarer som Löbl har bestemt fra følgende norske lokaliteter: AK:Røa, Ullern, Lysaker, Hvalstad og Åsmyra. En ♀ fra hver av lokalitetene Bv:Budalen og AAy:Risør har Löbl bestemt som sannsynlige *inopinatum*. Arten likner meget på *agaricinum*, men den er normalt litt større, har slankere 4. følehornledd og som regel kortere 8. ledd, som oftest er tydelig kortere enn 6., tydeligere mikroskulptur på pygidium, oversiden er tettere og grovere punktert, men alle disse karakterer varierer og gjør det vanskelig å skille arten fra *agaricinum*. Det sikreste holdepunkt gir aedeagus, idet penis sett fra siden er sterkere bøyd med svakt bølgeformet ventralvegg (hos *agaricinum* med jevnt buet ventralvegg), og paramerene er smalere og sett fra siden mer retlinjet.

Scaphisoma subalpinum Reitt. Löbl (1970) oppgir denne arten fra «Sogn og Fjordane: Solvor», som vel er SFi:Solvorn. Det er ukjent hvem finneren er. Arten er tidligere ikke kjent fra Vest-Norge.

Oxytelus clavatus A. Str. er beskrevet etter et eksemplar som jeg fant i råtten sopp på

AK:Brønnøya. Den 30. mai 1970 fant Sundt i elglort i AK:Svartskog 90 *Oxytelus*-eksemplarer, alle *clavatus*. Det er de to eneste norske funn. Arten er imidlertid også kjent fra en del steder i Sverige og Finland, hvor den er tatt i elglort, i Sverige også i grevlinglort, i begge tilfelle i skogsområder.

Bledius fontinalis Bernh. I den nordiske billekatalogen (Lindroth 1960) er *bosnicus* Bernh. oppført som ssp. til *erraticus* Er. med en nordlig utbredelse, men i Norge med et funn så langt sør som HE:Krokhaug i Follidal. Ifølge Koch (1938) er den typiske *bosnicus* kjent bare fra Balkan, mens de mellomeuropeiske og nordiske dyr beskrives som *bosnicus* ssp. *sparsicollis*, som ifølge Lohse (1964) er identisk med *fontinalis* Bernh.

Philonthus parvus Sharp. Av denne nylig innvandrede arten tok Mehl to eksemplarer i et reir av sandsvale (*Riparia riparia* L.) på On:Dovre 18. oktober 1968.

Tachinus ochsi Coiff. Arten står nær *elongatus* Gyll. og hører som den til underslekten *Drymoporus* Thoms. Ifølge Coiffait (1954) skiller den seg fra *elongatus* vesentlig slik: Den er mindre (6—7 mm mot 8—9 mm for *elongatus*), siste kjevepalpeledd er tydelig lengre enn nestsiste (hos *elongatus* så langt som nestsiste), rotleddene av følehornene er mørke, dekkvingene er finere og mer spredt og mindre retlinjet punktert, spissen av flikene på 9. ryggledd hos ♂ har hver 2 (hos *elongatus* 4) store børster, aedeagus er av samme type som hos *elongatus*, men tegningene viser paramerer som sett fra siden er smalere og mer jevnbrede med mer spissvinklet uttrukket apeks enn hos *elongatus*.

Arten er beskrevet etter eksemplarer fra Alpes maritimes og Pyreneene og er ifølge Horion (1967) også tatt i Engadin i Sveits og i Sydtirol og Østtirol, overalt i høyder mellom 1800 og 2400 m, bl.a. i kanten av snøfonner.

For mange år siden var Lahtiperä kommet til det resultat at det i det nordiske materiale av *elongatus* er en form som han regnet som en rase. To eksemplarer som jeg fikk, og som er tatt av Hellman i Bv:Ustaoset i 1948, har etiketten «*T. elongatus* ssp. *borealis* m. i. litt. E. K. Lahtiperä det.» Det er den samme form som nå er beskrevet som *ochsi*. Så vidt jeg vet har Lahtiperä ikke publisert det resultat han kom til.

Coiffait har sett en del av mitt materiale

og har bestemt eksemplarer fra HES:Mårud og TRi:Rundhaug i Målselv som *elongatus* og eksemplarer fra On:Fokstua, TRi:Nordreisa og Fn:Lakselv i Porsanger som *ochsi*.

Mitt materiale av de to former viser adskillig variasjon. Hos enkelte eksemplarer er noen av karakterene typiske for *elongatus* og noen for *ochsi*, slik at det er vanskelig å avgjøre til hvilken art dyrene skal regnes. Børstene på flikene av 9. ryggledd hos ♂ er meget utsatt for å brekkes av, og er brudt like ved roten, kan det være vanskelig å avgjøre hva antallet virkelig er. Forholdet mellom siste og nest siste kjevepalpeledd er på det materiale jeg har undersøkt, som ca. 12 til 10 hos *elongatus* og som ca. 10 til 7 hos *ochsi*, men noen variasjon er det. Det er vel derfor et spørsmål om *ochsi* virkelig er artsforskjellig fra *elongatus*.

Oligota pusillima Grav. var. *ytensis* Sharp. Denne form, som er litt kortere og smalere enn hovedformen, med kortere flyge- og dekkvinger og kortere følehorn med forholdsvis bredere kølle, har jeg fra følgende norske lokaliteter: AK:Brønnøya og Langåra, HES:Kongsvinger, Bø:Bingen, TRi:Nordmo og Bjørkeng i Målselv. Williams (1970), som har behandlet de britiske arter av slekten, har bestemt de norske eksemplarene.

Bolitochara lucida Grav. E. Jünger har latt meg få se ett av de eksemplarer som han tok i MRI:Eidsbygda og Voll. Eksemplaret er rett bestemt.

Atheta (Microdota) nesslingi Bernh. Denne nordlige arten er tatt på en rekke steder i Sverige og Finland og er også kjent fra Mongolia. I Norge har den tidligere bare vært kjent fra Bø:Teksle og On:Vålåsjø, men jeg har tatt den i sauelort og duelort i AK:Sørkedalen, Sundt har tatt 13 eksemplarer i elglort i AK:Svartskog 30. mai og 13. september 1970, og A. Bakke har tatt 3 eksemplarer i en felle i HES:Mårud.

Atheta (Acrotona) amplicollis Muls. & Rey. I kommentarene til tegningene av genitalorganene hos de nordiske *Atheta*-arter (Strand & Vik 1964) er følgende oppgitt for *fungi* Gr.: «*Fungi* scheint eine sehr heterogene Art zu sein, und es ist wohl eine Frage, ob es sich nicht bei den für diese Art gehaltenen Tieren um mehr als eine Art handelt.»

Det har nå vist seg at den største av de to tegninger av penis (Strand & Vik 1964, Fig. 198) gjelder den art som er tolket som

amplicollis Muls. & Rey. Også spermathekaen er større hos *amplicollis* enn hos *fungi*, den er av samme størrelse som hos *orbata* Er. og er en neppe forskjellig fra den.

Atemeles pubicollis Bris. Den 13. mai 1970 tok jeg et eksemplar av denne arten i rusk som ble fisket opp av elven i AK:Lommedalen like utenfor Oslo. Det er tidligere kjent to funn av arten i Norge. Det første er gjort av den kjente sveitsiske psykiater og entomolog Auguste Forel (1890). Fra en reise fra Bergen til Oslo over Fagernes berettes bl. a. følgende: «Sehr häufig ist dagegen in Norwegen unsere in Mitteleuropa nur alpin vorkommende schönste Rasse, die *M. (Myrmica) sulcinodis* Nyl. In Faegerness fand Forel zwei Colonien derselben mit vielen Prachtexemplaren (wahre Riesen) des *Atemeles pubicollis* Bris. und einem ebenfalls sehr grossen Exemplar des *Atemeles emarginatus*. Sehr auffallend war das Vorkommen dieser *Atemeles* am 29. August mit den geflügelten ♀ und ♂ der Ameisen zusammen, während *Atemeles* sonst nur im Frühjahr zu treffen ist, wie es Wasmann in seinen schönen Studien über Myrmecophilen gezeigt hat.»

Det andre funnet har Munster (1903) gjort, det gjelder et eksemplar som han fant ved Bø:Kongsberg, uvisst når og hvordan.

Microglotta pulla Gyll. I et reir av fossekallen (*Cinclus cinclus* L.) fra AK:Asker, som Mehl har undersøkt den 20. juni 1969, var ca. 150 eksemplarer av *Microglotta pulla*, som var den eneste billeart i reiret. Ifølge Hicks (1959) er *pulla* tatt en gang i reir av *Cinclus* sp., det er alt som tidligere er kjent av billearter hos denne fugleslekten.

Microglotta nidicola Frm. Et eksemplar av denne arten, som er typisk for reir av sandsvale (*Riparia riparia* L.), tok Mehl i reir av løvsanger (*Phylloscopus trochilus* L.) i AK:Enebak den 17. august 1969.

Aleochara peezeiana Lohse. Av denne nylig beskrevne arten, som hos oss tidligere er kjent bare fra en lokalitet i Fø:Sørvaranger, fant Sundt den 27. september 1971 et eksemplar i elglort i AK:Svartskog.

Gnathonus nanus Scriba. Et eksemplar av denne arten tok Mehl i et reir av krykkje (*Rissa tridactyla* L.) på MRy:Runde den 11. august 1969. Ifølge Hicks (1959) er det ikke kjent noen billeart fra reir av denne fuglen.

Brachypterolus linariae Steph. (*cornelii* Spornraft). Ved undersøkelse av typemateri-

ale av *linariae* har Johnson (1967) påvist at det er samme art som går under navn av *cornelii*.

Epuraea longipennis Sjöb. Av denne arten, som er beskrevet etter et eksemplar fra Transbaikal, og som ellers bare er funnet i noen få eksemplarer på AK:Røa og i Jämtland og Ångermanland i Sverige, tok A. Bakke et eksemplar i en felle i HES:Mårud.

Atomaria soedermani Sjöb. Om denne arten sier Sjöberg (1947): «Die Art gleicht sehr *clavigera* Ganglb. und ist von dieser nur schwer, am besten durch die Flügeldeckenpunktierung, zu unterscheiden.» En ting som hverken Sjöberg eller Lohse (1967) nevner, er at brystskjoldet er uten mikroskulptur hos *clavigera*, mens det, særlig i den basale del, har tydelig mikroskulptur hos *soedermani*.

Enicmus planipennis A. Str. Arten er i Norge tidligere bare kjent i ett eksemplar fra AK:Ullern, men A. Bakke har tatt et eksemplar i AK:Syverud og 6 eksemplarer i HES:Mårud, begge steder i feller. Ellers er arten bare kjent fra noen få steder i Sverige og Finland og er også en gang tatt i Østerrike.

Mycetophagus salicis Bris. Det har vært adskillig diskusjon om den taksonomiske stilling for denne formen. Mens enkelte regner den som ab. til *piceus* F., holder andre den for en egen art. Den store variasjon gjør det vanskelig å finne sikre holdepunkter for en avgjørelse av saken. Normalt er den mørke dekkvingefargen mørkere hos *salicis* enn hos *piceus*, og grensene mellom de lyse og mørke farger er skarpere og kontrasten mer markert, det gjelder også forskjellen i fargen for det siste og de nestsiste følehornsledd. Hos *piceus* dekker den lyse flekken ved basis av dekkvingene skuldrene helt, mens skuldrene hos *salicis* har en større eller mindre svart flekk. Hos *salicis* er også ennvidere dekkvingetegningene mer takket enn hos *piceus*, brystskjoldet er sterkere og tettere punktert, og hos ♂ er siste følehornsledd kortere enn hos *piceus*. Kavan (1949) hevder bl. a. at aedeagus skal være forskjellig og at behåringen på brystskjoldet og dekkvingene er tydelig lengre og lysere hos *salicis* enn hos *piceus*, men Vogt (1967) gjør oppmerksom på at flere forfattere ikke har godtatt dette. Ganske nylig har Korge (1973) behandlet spørsmålet og godkjenner *salicis* som egen art, et resultat som jeg slutter meg til.

Fra Norge er *piceus* bare kjent fra TEy:

Sandnes i Drangedal, hvor Munster i mai 1918 tok den i antall i sopp på eikestokk. To eksemplarer fra HES:Grue som Siebke har tatt, og som er på Zoologisk museum i Oslo, og har vært bestemte som *piceus*, er *decempunctatus* F.

Fra Norge har *salicis* ikke vært oppgitt tidligere. I Zoologisk museum, Oslo, står et eksemplar fra presten Bergs samling, men det er uten lokalitetsoppgave. I lektor Hanssens samling, som jeg fikk av ham, er et eksemplar fra Ø:Halden (Hov 8. mai 1919). På AK:Røa har jeg den 7. mai 1950 tatt 3 flygende eksemplarer, og den 3. juli 1959 tok jeg et eksemplar på *Polyporus sulphureus* på *Salix alba* på AK:Tøyen.

De norske eksemplarer av de to artene er ikke vanskelig å holde fra hverandre.

Mycetophagus quadriguttatus Müll. Av denne arten, som ellers ikke er kjent fra Norge, står det et eksemplar uten lokalitetsoppgave fra presten Bergs gamle samling på Zoologisk museum, Oslo. Det dreier seg sannsynligvis om et norsk eksemplar, men da Berg også hadde utenlandske dyr i sin samling, kan spørsmålet om eksemplaret er norsk ikke sikkert avgjøres.

Scymnus ater Kug. og *limbatus* Steph. Det norske materiale som har vært bestemt som *ater*, har vist seg å være *limbatus*. Det er fra følgende lokaliteter: Ø:Halden (Siebke), AK:Oslo (Esmark), Lysaker (Munster), Høland (Hanssen), On:Sørem, Vågå (Munster), Bø:Kongsberg (Munster). *Ater* utgår som norsk.

Scymnus femoralis Gyll. og *rubromaculatus* Goeze har vært holdt for synonyme, men Fürsch (1967) fører dem nå opp som forskjellige arter. Hos *femoralis* er kroppsformen forholdsvis bredere og sterkere rundet, dekkvingenes behåring er kortere, lårene er normalt mørkere, hodet (unntatt overleppen og forkanten) og brystskjoldet er sorte også hos ♂, penis sett fra siden, er smalere og rettere og apeks spissere, paramerene er smalere med en betydelig mindre børstebunt, som det fremgår av tegningene hos Fürsch. Både kroppsformen og aedeagus er ifølge Fürsch (l. c.) som hos *interruptus* Goeze, men fargen er vidt forskjellig, og noen overgang synes det ikke å være.

Det norske materiale, som har vært bestemt som *rubromaculatus*, er *femoralis* og er fra følgende lokaliteter: Ø:Kirkeøya, Hvaler (Munster), AK:Eidsverk, Høland (Munster),

Brønøy, Asker (A. Strand), HES:Mårud (Bakke), VAY:Kristiansand (Ullmann). Eksemplaret fra Brønøy har Fürsch kontrollert, og eksemplaret fra Mårud, som er en ♂, er genitalpreparert. Gyllenhal (1827) oppgir at arten holder til «in frondibus Pini silvestris». Bakkes eksemplar ble tatt i en felle som stod over lokketrær av gran, så det kan se ut som om arten har noen tilknytning til bartrær. *Rubromaculatus* utgår som norsk.

Stagetus borealis Israelson. Av denne arten, som nylig er beskrevet etter eksemplarer som stammer fra en rekke steder i Sverige og tidligere har vært regnet som *pilula* Aubé, fikk Bakke et eksemplar i en felle i HES:Mårud i mai 1972. Den er ellers ikke kjent fra Norge.

Ptinus sexpunctatus Panz. Den 30. mai 1971 ble det i en lysfelle som T. Edland hadde satt opp i prestegården i TEi:Sauherad, tatt 6 eksemplarer av denne overalt sjeldne arten. Fra Norge er det bare to tidligere oppgaver, nemlig fra On:Laugård i Sel (Moe, ifølge Schøyen 1878) og fra On:Dovre (Thomson 1863). Thomson oppgir hverken samler eller kilde, og det er ikke usannsynlig at det er Moe som har underrettet ham om sitt funn, således at det bare dreier seg om et enkelt funn.

Aderus pygmaeus DeG. Denne arten har tidligere vært regnet som synonym med *oculatus* Panz., som lever på eik, men etter at det er påvist at de to er artsforskjellige, har det vært usikkert til hvilket treslag *pygmaeus* er knyttet. Palm har en gang tatt den i kronen av en vindfelt furu, og også Wörndle (1950) oppgir et eksemplar tatt på furu. Den 25. juni 1972 tok jeg i en felle på AK:Røa, Oslo et eksemplar som synes å tyde på at arten har tilknytning til bartrær. I fellen, som stod tett ved et opplag av granstokker, ble nemlig også tatt en rekke arter knyttet til gran.

Blaps mucronata Latr. En del eksemplarer av *Blaps* som veterinær Hans G. Sandbu sendte til Statens plantevern, og som J. Fjeldalen videresendte til meg, viste seg å være *mucronata*, som er en ny for Norge. Den forekom i stort antall i en stall i VAY:Kristiansand inne i og under høyballer. I Sverige er den tatt i Göteborg og i Danmark er et eksemplar funnet i Rønne.

Macroplea (Haemonia) mutica F. ssp. *ruppiae* Germ. I den nordiske billekatalogen (Lindroth 1960) er ikke noen art av denne

slekten oppført som norsk. Fjellberg (1970) har nå publisert to nordnorske funn, som sannsynligvis gjelder *mutica* ssp. *lapponica* Hellén. Formen *ruppiae* er imidlertid tidligere oppgitt som norsk av Reitter (1920), idet han om utbredelsen sier: «Schweden, Norwegen, an der Küste des Sundes an *Ruppia maritima*.» Hvor Reitter har oppgaven fra og hvilken lokalitet det gjelder, er ukjent.

Polygraphus subopacus Ths. Denne arten og *poligraphus* L. varierer adskillig, og det er til dels vanskelig å holde ♂♂ fra hverandre etter de karakterer som er oppgitt, men en forskjell som ser ut til å være konstant, og som jeg ikke har sett nevnt, består i at *poligraphus*, i motsetning til *subopacus*, har hår mellom skjellene på hele brystskjoldet.

Xyloterus piceus A. Str. Av denne arten, som er beskrevet etter eksemplarer tatt i gran i nærheten av Oslo og ellers bare er kjent fra TRi:Målselv og noen steder i M.- og N.-Sverige, tok Øystein Austarå ved Bø:Kongsberg den 1. oktober 1971 noen rester i borehull i vindfall av furu.

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Developmental rate, longevity, fecundity, and oviposition period of *Ephedrus cerasicola* Starý (Hym., Aphidiidae) parasitizing *Myzus persicae* Sulz. (Hom., Aphididae) on paprika

TROND HOFVANG & ELINE BENESTAD HÅGVAR

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Rate of development, longevity, fecundity, and oviposition were studied in *Ephedrus cerasicola* Starý parasitizing *Myzus persicae* Sulz. on paprika. The development from egg to adult lasted 33.7 days at 15° C, 21.1 to 21.6 days at 21° C, and 19.0 days at 24° C. Longevity, which was investigated at 6 different temperatures, increased gradually from 2.8 days at 32° C, to 26.2 days at 15° C, and decreased again to 16.9 days at 12° C. Average fecundity was 68 mummies per surviving female, varying from 0.6 to 14 mummies per female per day. *E. cerasicola* apparently produced eggs throughout most of their lives. The total sex ratio of *E. cerasicola* was 0.34 females/males. During the last 7 days when all males had died, the surviving females produced 43 parasites, of which 42 were males.

Trond Hofsvang & Eline Benestad Hågvar, Agricultural University of Norway, Department of Zoology, Box 46, N-1432 Ås-NLH, Norway.

The aphid parasite, *Ephedrus cerasicola* Starý, was described by Starý (1962c). It is distributed in Europe (Starý 1962c, Mackauer & Starý 1967). Apparently, *Myzus cerasi* Fabricius is its most important host (Starý 1962c, 1963, 1966), but *Myzus persicae* Sulz. has later been included in the host list (Mackauer & Starý 1967). In Czechoslovakia, *E. cerasicola* occurs quite commonly on *M. cerasi*, but is not so abundant as *Ephedrus persicae* Froggatt and *Ephedrus plagiator* Nees on this host (Starý 1966, Starý pers. comm.). Further data on the biology of *E. cerasicola* are not available.

Concerning the biology of other *Ephedrus* species, studies on developmental rate, longevity, fecundity, and oviposition period, are either lacking or incomplete (Withington 1909, Skriptshinskij 1930, Dill 1937, Vidano 1959, Schlinger & Hall 1960, Starý 1962a, 1963, Rogers et al. 1972).

E. cerasicola was observed in Norwegian greenhouses, parasitizing *M. persicae* on chrysanthemums. Most probably, the parasite had made its way into the greenhouse from

outside, rather than accompanying plant material from abroad. Because considerable parasitism was observed, it was of interest to test this species on paprika plants infested with *M. persicae*, and compare important biological characteristics with those found under similar conditions in other aphidiid species (Hofsvang & Hågvar 1975).

MATERIAL AND METHODS

The green peach aphid, *M. persicae*, was reared at room temperature on swedes (*Brassica napus napobrassica* (L.) Rchb.) and paprika (*Capsicum annum* L.). The parasite, *E. cerasicola*, was collected in July 1973 on cultivated chrysanthemums infested with *M. persicae*, in an unheated greenhouse at Jeløya, Moss, southern Norway. The parasites spent several generations in the laboratory before being used in the experiments. They were reared together with the plants at room temperature in 50 × 50 × 50 cm cages, illuminated from above by fluorescent tubes in

addition to daylight. The parasites were supplied with honey on the cage wall.

Mummified aphids were removed from paprika plants and placed in moistened Petri-dishes (5.5×2.0 cm) in incubators. The newly emerged parasites from these cocoons were used in the experiments. To study oviposition, mummies were taken from swedes.

To study developmental period, a known number of males and females of the parasite were allowed to parasitize aphids on one paprika plant placed in a $50 \times 50 \times 50$ cm cage of plexi-glass at the experimental temperature, with three 85 W Atlas fluorescent tubes above. In the series at 15°C and 24°C , the parasites were 1–2 days old when used in the experiment, but the age of the parasites used at 21°C (exp. 1) was unknown. After one day, all the parasites were removed; each day thereafter the plant was examined for mummified aphids, and the new cocoons were removed from the plant and placed in Petri-dishes for adult parasite emergence. In these studies, the photoperiod was 16 hrs and humidity higher than 70% RH.

Longevity was studied by means of 0.5 l glass jars, which contained one male and one female. The parasites were never more than a few hours old when the experiment started. In all series the glass jars had a moistened filter paper in the bottom and a dram vial filled with a moistened cotton plug as water source. In a recent investigation on two *Aphidius* species (Hofsvang & Hågvar 1975), it has been shown that longevity of adults is strongly influenced by food conditions. Honey and water are considered to be the most suitable food source for aphidiid parasites (Starý 1970). Accordingly, honey was supplied through the cloth gauze covering the glass opening. The glass jars were placed in incubators with 18 hrs photoperiod and humidity higher than 70% RH. The jars were checked once a day.

To study fecundity and oviposition period, a population of ten males and ten females, at most 3 hrs old, was allowed to oviposit an excess of aphids throughout their lives at 21°C . They were released into a $24 \times 24 \times 32.5$ cm cage containing one aphid-infested paprika plant. Every day thereafter, the parasites were counted, the sex was checked, and those that were alive transferred to a

new similar cage with a new paprika plant. The old cage with its plant was every day thereafter examined for mummified aphids, as described above in the study of developmental period. From the 13th day, the alive parasites (only females) were kept in the same cage with the same plant until death. Accordingly, daily parasitism could not be estimated in this period, only the total one for the whole period (7 days). The photoperiod was 16 hrs and humidity higher than 70% RH.

Because of the chance of some superparasitism (Force & Messenger 1965) or egg and larval mortality, the resulting number of mummified aphids expresses a minimum value of female fecundity. For simplicity, this value is in the following often referred to only as female fecundity.

The sex of the parasite was determined by shape of the terminal end of the abdomen. Aphids mummified as adults were distinguished according to Sylvester (1954).

RESULTS

Rate of development

In Table I, the developmental time of the parasite and the percentage of adult emergences from the cocoons are shown at three different temperatures. At 21°C , data are given from two experiments. In the first (exp. 1), parasites of unknown age were allowed to parasitize aphids during one day (see Material and Methods). The second experiment was identical to the fecundity/oviposition period experiment, which also furnished data on development (see Material and Methods). The two experiments are compared to show that a random sampling from a parasite culture (exp. 1) gives about the same results regarding developmental rates as using newly emerged females parasitizing throughout their lives (exp. 2).

As shown in Table I, the developmental rate varied considerably at each temperature. Both the periods before and after mummification were considerably shortened when temperature was raised from 15°C to 24°C , especially the period after, which was more than halved when temperature increased by 9°C .

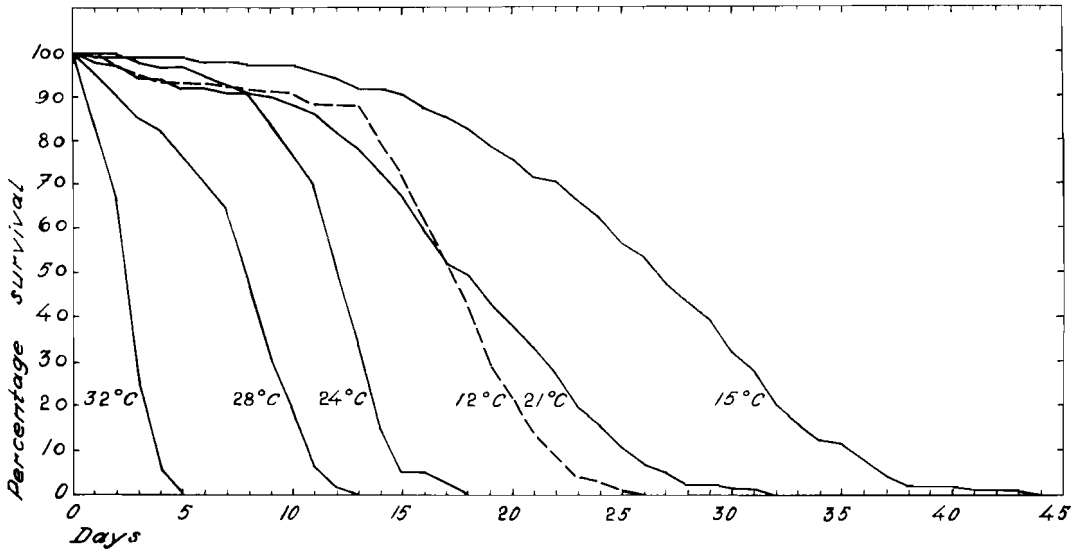


Fig. 1. Percentage survival of *E. cerasicola* at 6 different temperatures, given water and honey as food. 18 hrs photoperiod. The survival of the adult parasites was checked once a day.

No distinct differences in developmental time were found between the sexes.

Adult parasites emerged from 64–81 % of the cocoons (Table I), but no obvious effect of temperature on the percentage of emergence could be demonstrated.

Both adult aphids and earlier nymphal stages appeared as mummies. Of the mummies which were classified to instar (Table I), adults made up 43–70 %.

Longevity

Table II shows that average longevity is strongly temperature dependent, ranging from about 3 to 26 days within a temperature scale of 20° C. The effect of temperature on survival is also shown in Fig. 1, which illustrates a rather strict and regular dependence between temperature and survival. The survival increased gradually when temperature fell from 32° C to 15° C. Below 15° C the

Table I. The average developmental period with minimum and maximum values (in brackets) of *E. cerasicola* parasitizing *M. persicae* reared on paprika, at various temperatures. 16 hrs photoperiod. Exp. 1 and exp. 2: see text.

Temp. (°C)	From oviposition to mummification of the aphids			From mummification to emergence from the cocoon			Total developmental period			Percentage of parasites hatched from the cocoons	Percentage of mummies as adult aphids
	Days	SD	n	Days	SD	n	Days	SD	n		
15	17.1 (15-20)	1.1	48	16.7 (14-20)	1.4	41	33.7 (32-40)	1.7	41	81	70
21 (exp.1)	11.9 (8-21)	2.9	113	9.5 (6-12)	1.7	76	21.1 (16-31)	3.6	76	66	43
21 (exp.2)	12.2 (7-22)	3.3	419	9.6 (5-14)	1.1	254	21.6 (16-32)	3.3	278	64	69
24	11.7 (6-19)	3.3	403	8.0 (4-13)	1.0	273	19.0 (13-25)	3.1	274	73	63

Table II. Adult average longevity at different temperatures in *E. cerasicola*, given water and honey as food. 18 hrs photoperiod.

Temp. (°C)	Longevity		
	Days	SD	n
12	16.9	5.2	135
15	26.2	7.9	113
21	17.9	6.7	112
24	12.2	2.9	100
28	7.7	3.1	120
32	2.8	1.1	129

survival again decreased. Thus, about 15°C appears to be an optimum temperature for survival of this species at the experimental conditions. There were no big differences between the longevity of the males and females, although females tended to live slightly longer than males at 15°C and 21°C.

Fecundity and oviposition period

The oviposition study resulted in 509 mummies, giving an average female fecundity of 51. The maximum average value was 68, estimated by summarizing the daily egg production values per surviving female.

In Fig. 2, the mean daily production of eggs that resulted in mummies is illustrated throughout the parasites' lives. Parental survival is also shown. The females are obviously most productive the 4th - 7th day after emergence, culminating in 14 mummies per female the 7th day of her life. From the 13th day and throughout the females' lives, only the total number of mummies from this period were recorded. The daily average female fecundity this last week is estimated to be 2.5. At the extreme, all the eggs from this period could have been deposited the 13th day, giving an average fecundity of 14.3 this day.

As shown in Fig. 2, the females of *E. cerasicola* oviposit through most of their lives. At 21°C, 50% of the females were still alive after 11 days, and all were dead after 19

days. Because of the experimental conditions (see Material and Methods) the exact oviposition period cannot be given, but is between 13 and 19 days.

Influence of parental age on progeny development

The experiment shown in Fig. 2 led to an analysis of relationships between parental age and certain qualities of the progeny (Table III). Apparently, the female age had no obvious influence on the percentage of emergence from the cocoons. Totally, adults emerged from 64% of the mummies in this experiment at 21°C.

The sex ratio of the emerging offspring showed no clear dependence on the mother's age during the first two weeks of her life. However, eggs deposited by females 13-19 days old developed to 42 males and only one female. The daily sex ratio ($\frac{\text{♀}}{\text{♂}}$) was nearly always considerably less than one, the total ratio being 0.34 or about one female to three males (Table III). This ratio was about the same as those obtained from the investigations on developmental time at different temperatures: 0.41 (15°C), 0.43 (21°C), and 0.37 (24°C).

Table III. Relationships between the age of adult *E. cerasicola* and the development of the progeny on *M. persicae* at 21°C and 16 hrs photoperiod.

Parental age Days	Emergence from mummies n	Sex ratio $\frac{\text{♀}}{\text{♂}}$	Average total developmental time Days	n	
1	28	61	3/14	22.3	17
2	57	39	7/15	23.1	26
3	26	58	4/11	21.1	17
4	75	67	15/35	20.5	52
5	84	75	23/40	20.8	63
6	26	54	2/12	21.0	18
7	74	59	11/33	22.8	50
8	5	40	0/2	18.0	2
9	6	50	3/0	22.7	3
10	25	84	6/15	21.4	23
11	5	100	1/4	22.3	8
12	3	67	1/1	20.0	2
13-19	54	80	1/42	max. 19.3	46
Total	468	64	77/224	max. 21.2	327

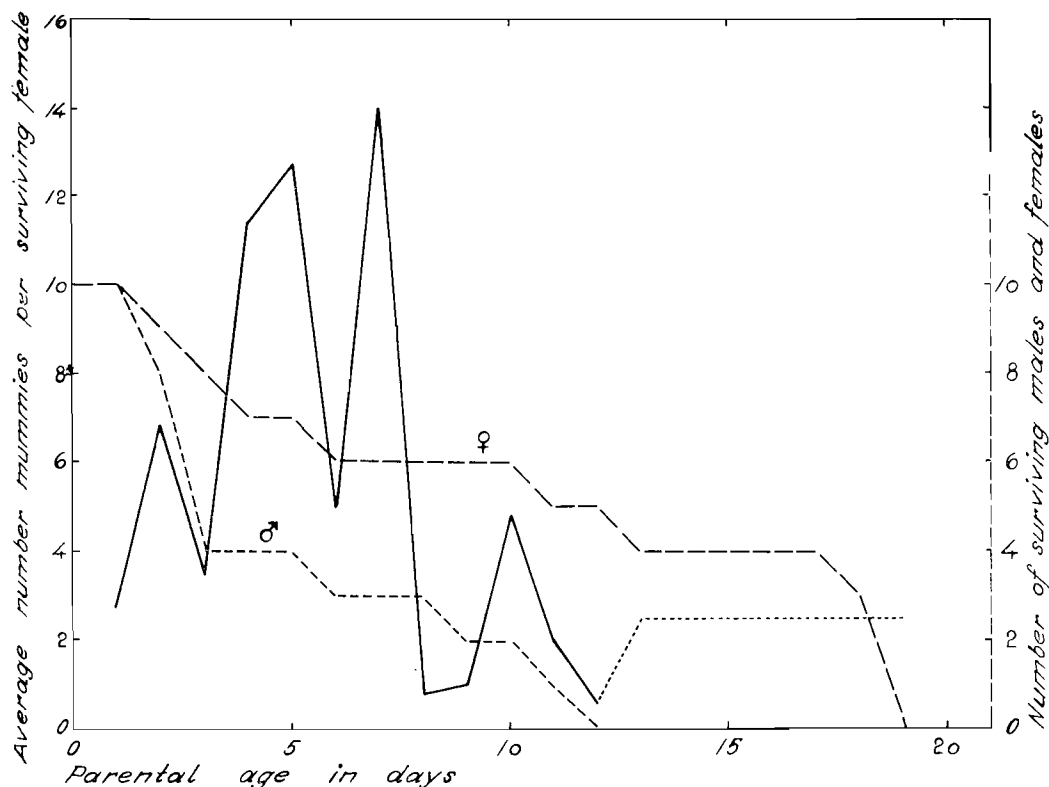


Fig. 2. Daily oviposition pattern (solid lines) and survival (dotted lines) during adult life of *E. cerasicola* parasitizing *M. persicae* at 21°C. Daily records on oviposition are not available from the 13th day; the average oviposition throughout this period is indicated. 16 hrs photoperiod.

The developmental rate of the progeny appeared to be independent of parental age (Table III). In the table, the maximum developmental time of progeny produced the last week (13th–19th day) is estimated. It is assumed that all the eggs were deposited the 13th day. The value 19.3 days is surprisingly low, indicating that the majority of the eggs must in fact have been laid the 13th day.

In Table I, exp. 2, data from this last period is not included because of the uncertain depositing date. The total average presented in Table I, exp. 2, might thus be a little too high.

DISCUSSION

Rate of development, longevity, fecundity, and oviposition period are four important qualities influencing a parasite's efficiency.

Development in *E. cerasicola* proceeds

considerably slower than in most aphidiid species investigated. Values for *Ephedrus incompletus* Provancher on *Siphonophora rosae* (Reaumur) at fluctuating temperature with an average about 25°C seem to agree fairly well with the present results at 24°C, but the temperature conditions make direct comparisons difficult (Withington 1909). Rogers et al. (1972) found that *E. plagiator* developed in 14.3 days on *Aphis helianthi* Monell at 23.9–26.7°C. Compared with the 19.0 days at 24°C (Table I) in *E. cerasicola*, the latter seems to have a slower developmental rate. However, both host species and host size (instar) may affect the developmental rate of an aphid parasite (Hafez 1961, Fox et al. 1967, Starý 1970, Raney et al. 1971, Monadjemi 1972, Michel 1973) and must be taken into consideration. The somewhat heterogeneous size of the aphids that were offered in the present study may partly explain the great variation in developmental

rate in *E. cerasicola*, illustrated in Table I by S. D. and extreme values. Rogers et al. (1972) found a range of comparable size in their studies of *E. plagiator*.

Compared with *Aphidius platensis* Brèthes, which has been studied under the same conditions (Hofsvang & Hågvar 1975), *E. cerasicola* needs about one week more at 21° C and 24° C and two weeks more at 15° C to complete its development.

However, under equal food conditions and temperatures, *E. cerasicola* had a considerably higher longevity than *Aphidius ervi* Haliday and *A. platensis* (Hofsvang & Hågvar 1975). This difference between *E. cerasicola* and *A. platensis* was about 5, 5, and 17 days at 24° C, 21° C, and 15° C respectively. Maximum longevity was recorded at 21° C in *A. platensis* and at 15° C in *E. cerasicola*. This different response to cooler conditions might partly be explained by the more southern distribution of *A. platensis*.

Longevity at 21° C shown in Fig. 1 is considerably higher than that illustrated in Fig. 2. In Fig. 1, 50% of the parasites were dead after 18 days. In Fig. 2 such a reduction was recorded after 2.8 days (♂) and 11.0 days (♀). The difference between the two experiments was amount of space, oviposition possibility, and parasite density. In Fig. 2, 10 males and 10 females were kept in a cage with an aphid-infested plant. This probably resulted in energy-demanding activities, as flying, copulation, searching for hosts, and oviposition. Several authors have demonstrated that presence of hosts reduces longevity in both sexes of aphidiids (Wiackowski 1962, Starý 1970, Hofsvang & Hågvar 1975). In Fig. 1, only one male and one female were kept together in small glass jars with no oviposition possibility. At such conditions, little energy is used, and longevity is probably near the maximum for the species at the existing temperature, humidity, and photoperiod. The values in Fig. 2 are probably more close to natural survival.

Fecundity data of an aphid parasite may be obtained by examinations of the ovaries (potential fecundity), by counting the number of eggs laid by dissecting aphids soon after parasitization (realized fecundity), or by recording the number of mummified aphids (parasitized aphids). The last method was used in the present investigation. Besides

giving the number of aphids parasitized, this method also furnishes the basic information required to estimate the number of female offspring that each female produces for the next generation under the experimental conditions.

The average fecundity of 51 or 68 mummies per female found in *E. cerasicola* is comparable to 53.2 parasitized aphids by *E. incompletus* (Withington 1909), 83 deposited eggs by *Aphidius (Diaretiella) rapae* (Curtis) (Hafez 1961), 50 infested aphids by *A. ervi* (Starý 1962b) and 30–60 parasitized aphids by *Aphidius smithi* Sharma and Subba Rao (Wiackowski 1962). On the other hand, considerably higher values have been recorded for several species (Starý 1970, Monadjemi 1972, Rautapää 1972). However, it should be stressed that the fecundity of a species depends on several external factors, of which the following might be of importance in the present investigation: temperature, host size, host density, and host preference (Starý 1970). The influence of these factors on the fecundity of *E. cerasicola* has not been studied.

The irregular oviposition pattern illustrated in Fig. 2 strongly indicates that *E. cerasicola*, like most aphidiids, belongs to the synovigenic species, which continue to produce eggs throughout their lives. During the resting periods, a further portion of the eggs matures in the ovaries (Starý 1970). Starý (1962a) found that *Ephedrus pulchellus* Stelfox belonged to the synovigenic species.

The oviposition pattern found in *A. rapae* by Hafez (1961) is rather similar to that shown in Fig. 2, with several peaks in egg production during the female's life span. The peak in oviposition activity the 7th day in Fig. 2 does not fully agree with Starý's statement that oviposition is generally most intensive during the first few days of aphidiid life (Starý 1970). However, *Ephedrus* species has not been studied in this respect previously. Monadjemi (1972) found that oviposition activity in *Aphelinus asychis* Walker parasitizing *M. persicae* was greatest the 6th–15th day. Besides, as demonstrated in several aphidiid species, the oviposition pattern is dependent on temperature (Messenger & Force 1963, Force & Messenger 1964b, Messenger 1964).

Theoretically, external factors that operate

differently from day to day may influence the oviposition pattern and interfere with the inherent egg production rhythm of the parasite. In the present experiment, the parasite density was the only external factor that changed daily. Messenger & Force (1963) state that only isolated females could be expected to reproduce at the maximal rate. Influence of parasite density on parasitism efficiency has in general been well documented for several parasites other than aphidiids. In such cases, increased density results in more encounters between parasites which interfere with their oviposition activities (Hassel 1971). As mentioned in the results, *E. cerasicola* might also have a peak in oviposition around the 13th day. At least this peak could be due to the reduced parasite density, although the authors are inclined to believe that the pattern in Fig. 2 basically reflects inherent rather than external changes. This is because the parasite densities were always rather low.

Females of aphidiids mate only once in their lives, whereas males can mate several virgin females (Starý 1970). *E. cerasicola* obviously has the arrhenotokous type of reproduction, which implies that both sexes are produced; fertilized eggs are diploid and give rise to females, whereas unfertilized eggs are haploid and become males (Starý 1970). Starý (1962a) found that both males and females emerged from *E. pulchellus*, and thus included this species among the arrhenotokous ones.

The total sex ratio in Table III was 0.34. Rogers et al. (1972) state that the sex ratio favoured males in *E. plagiator*. Withington (1909) found that 52.2% of the emerging *E. incompletus* were females.

The importance of studying the sex ratio in relation to female age is very much stressed by Force & Messenger (1964b). Constructions of useful life tables require such information. The sex ratios of the progeny of *E. cerasicola* given in Table III reveal that mating occurs from the first day on, because females appeared from eggs deposited the first day of adult life. Because females copulate only once, and usually soon after emergence, the dominance of male progeny after the 13th day indicates that the sperm supply in the female's spermatheca is probably exhausted by then. A similar decrease in the percentage of female offspring according to increasing

age of the parents has been showed by Vevai (1942), Sekhar (1957), Starý (1962b), Force & Messenger (1964a, 1964b) and Messenger (1964).

From the data at 21° C on fecundity, percentage of emergence, and sex ratio, average maximum number of female offspring per female can be estimated: One female *E. cerasicola* gives rise to 44 adults for the next generation, of which 11 are females.

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Studies on the invertebrate fauna on branches of spruce (*Picea abies*) (L.) during winter

ELINE BENESTAD HÅGVAR & SIGMUND HÅGVAR

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The invertebrate fauna on branches of spruce (*Picea abies* (L.)) was studied monthly from November to March near Oslo. The following average density and dry biomass per m² foliage was recorded for the five months: 47.9/14.2 mg, 37.6/13.0 mg, 34.4/10.3 mg, 41.1/12.0 mg and 21.6/8.6 mg. In numbers, Araneida and Psyllidae were about equally represented, and together made up 56 to 78 % of the total material, and respectively 57 to 71 % and 6 to 31 % in biomass. The spiders, almost exclusively immature, were represented by at least 10 species. *Philodromus* sp. (*aureolus* – group) dominated with 33 to 45 % of the total spider number. Among the 19 species of psyllids, *Trioza urticae* (L.) and *Psylla klappaleki* Sulc. made up respectively 70 to 84 % and 10 to 16 % of the material. The density and biomass of psyllids decreased significantly in March.

E. B. Hågvar, Agricultural University of Norway, Department of Zoology, Box 46, N-1432 Ås-NLH, Norway.

S. Hågvar, Solveien 121 B, Oslo 11, Norway.

This investigation had two main aims. The first was to study the composition and density of the overwintering invertebrate fauna on the branches of spruce (*Picea abies* (L.)), listing the actual groups and species. Very little is known about this fauna in spruce woods during winter. The second aim was to study whether the density of invertebrates on the branches decreases markedly during winter. Such a reduction may be caused by bird predation. The density may also decrease due to invertebrates leaving the branches, either actively or passively. As for the first factor, several overwintering passerine birds in the Norwegian spruce woods prey on the invertebrate fauna on branches (e.g. Palmgren 1932, Haftorn 1956). Gibb (1960) showed that tits (Paridae) and goldcrests (*Regulus regulus* (L.)) depend to a large extent on this kind of food for their survival during winter in English pine woods. He found that during severe winters the birds may strongly reduce the density of invertebrates on branches of pines, and the winter survival of tits and goldcrests depends on the invertebrate density.

MATERIAL AND METHODS

The material was collected from spruce wood at Øverland, Bærum, near Oslo during the winter 1970/71. The trees from which the samples were taken were 10–20 m high, mostly 14–18 m, and were chosen at random. Each sample consisted of the outer half of one or several branches midway up the tree. Both goldcrests and several species of tits visited this part of the trees during food-seeking in winter.

A method modified after Palmgren (1932) and Gibb (1960) was used in collecting and sorting out the material. A plastic bag, about 50 cm in diameter and 120 cm deep, was fastened to a metal ring on a handle, and the bag was gently placed around the branch and closed. The branches were then cut off the tree. The bags were stored at –20° C. Each month, 18–20 samples were taken. The sampling dates were as follows: 9 November, 16 and 19 December, 11 January, 12 February, and 11 March. The branches were covered with snow only at the first sampling. In January, the branches were collected in



Fig. 1. Degree of cover used when the area of spruce foliage from the samples were measured. The picture covers 50×50 cm.

rainy weather. The rest of the samples were either a little wet, or dry.

The further handling of the samples was rather tedious. When ice and snow had melted, the branches were cut in smaller pieces and beaten against the inside wall of a metal bucket (about 30 cm in diameter and 35 cm deep) with a plastic bag on the inside. Because the twigs were often wet, implying that invertebrates might still stick to their surface, the twigs were always afterwards gently stirred under water in a white tray. Invertebrates washed off in this way were easily detected.

The contents of the bucket were then carefully examined by placing small bits in a white tray with water. Most invertebrates were found on the water surface. The remains in the original sample bag were treated in the same way.

Of the total material of Araneida, 5.3% were found by stirring the beaten twigs under water, 40.1% were found in the metal bucket, and 54.5% in the sampling bag. Corresponding values for Psyllidae were 4.8%, 28.4%, and 66.8%, and for the rest of the material treated together (excluding Thysanoptera, which were too small to be picked out systematically) 11.7%, 37.0%, and 51.3%.

The sample size was expressed in m^2 by

spreading the foliage evenly on a measured background. The degree of cover used is illustrated in Fig. 1. Mean size of samples \pm SD from November to March was, respectively: 0.46 ± 0.10 , 0.87 ± 0.33 , 0.83 ± 0.20 , 1.00 ± 0.20 , and $0.84 \pm 0.30 m^2$.

To control the efficiency of the method, fractions from eight samples were carefully studied with binoculars after beating. Only two Araneida, one Aphididae, and one nymph of Homoptera were discovered from altogether $1.63 m^2$ studied in this way. This made up 8.3% of the mean total density recorded in the eight samples, when Thysanoptera were disregarded. This indicates that stirring under water is effective in detecting those animals which are left on the twigs after beating. Studying twigs with binoculars did not reveal any groups which were so firmly attached that they would not be released in water.

The invertebrates were frozen, and later dried at $75^\circ C$ and weighed. Then they were kept for one day in a moist chamber and preserved in alcohol. Araneida and Psyllidae, being the dominant groups, were then as far as possible identified to species.

Some Acarina and Collembola were observed, but these groups were not taken into account in this investigation. Thysanoptera were picked out as far as possible, but the density of this group is obviously underestimated.

Table I gives mean monthly temperature and precipitation, compared with average conditions (Det norske meteorologiske insti-

Table I. Mean monthly temperature ($^\circ C$) and precipitation (mm) during the winter of 1970/71, compared with normal conditions.

	Nov.	Dec.	Jan.	Feb.	March
Temperature					
1970/71	-0.8	-1.4	-2.4	-0.5	-2.0
Normal	1.1	-2.0	-4.7	-4.0	-0.5
Precipitation					
1970/71	180	24	61	40	72
Normal	69	63	49	35	26

Table II. Composition and density of the invertebrate fauna on branches of spruce (*Picea abies*) during winter. The density of Thysanoptera is underestimated. \bar{x} = mean number per m² (see Fig. 1), S.E.=standard error, k= number of samples of the total number (n), in which the group was present.

Group	November			December			January			February			March		
	\bar{x}	S.E.	k	\bar{x}	S.E.	k	\bar{x}	S.E.	k	\bar{x}	S.E.	k	\bar{x}	S.E.	k
Araneida	13.3	3.3	17	10.3	2.0	18	8.7	1.7	18	13.3	3.2	18	10.0	1.9	17
Psocoptera				0.04		1	0.05		1						
Hemiptera															
Heteroptera				0.1		2	0.06		1	0.06		1	0.04		1
Cicadidae	0.4		4	0.4		4	0.2		2	0.4		2	0.7		4
Psyllidae	13.8	5.9	14	13.8	4.3	16	18.8	5.5	16	14.5	4.4	14	3.9	1.3	10
Aphididae	6.3		13	3.0		14	1.0		9	1.9		8	0.3		3
Homoptera nymph	0.1		1							0.06		1			
Thysanoptera	11.9		13	8.0		16	4.4		9	9.1		10	5.2		8
Coleoptera															
Staphylinidae							0.04		1						
Chrysomelidae				0.06		1									
Col.imago indet.	0.09		1							0.04		1			
Col.larva "	0.1		1	0.04		1	0.08		1	0.04		1			
Hymenoptera															
Tenthredinidae													0.03		1
Parasitica	0.8		5	0.8		7	0.4		3	0.6		6	0.07		1
Hym.imago indet.										0.04		1	0.4		4
Diptera															
Bibionidae	0.2		1	0.1		2				0.1		1			
Nematocera indet.	0.2		2	0.1		2				0.2		4			
Cyclorrhapha	0.4		4	0.5		4	0.4		4	0.4		3	0.3		4
" pupa				0.04		1									
Syrphidae larva				0.1		1	0.1		2						
Dipt. imago indet.	0.2		1				0.04		1	0.2		3	0.06		1
Lepidoptera															
Geometridae larva							0.04		1						
Lep.imago indet.										0.05		1			
Lep. pupa "				0.1		1				0.09		1			
Lep. larva "	0.08		1												
Insect imago indet.													0.03		1
" pupa "				0.08		2	0.07		1	0.05		1	0.5		4
" larva "													0.09		2
Total (except Thysanoptera)	47.9			37.6			34.4			41.1			21.6		

tutt 1971, 1972). This particular winter was obviously rather mild. Much of the precipitation was rain, and the amounts of snow were smaller than usual. The data were measured at Blindern, about 10 km away from the sampling localities, but measurements have shown that climatic conditions are very similar at these two localities (O. Hogstad, pers. comm.).

RESULTS

The composition and density of the invertebrate fauna on spruce branches during winter are given in Table II. Although a comparatively large number of groups was present, the spiders and psyllids dominated in number, followed by the aphids. Thysanoptera are listed to illustrate that their density is not insignificant, but because of underestimation (see Material and Methods), this group will not be discussed further.

The spiders were present in nearly every sample ($k = 17 - 18$), indicating a rather uniform distribution as a group on the branches. Their average density was almost the same throughout the winter. The highest density recorded in a single sample was 64 per m², but 87 % of the samples with spiders contained less than 20 individuals per m².

Psyllids were found in about 75-90 % of the samples from November to February ($k = 14 - 16$). In March they were found in 56 % of the samples ($k = 10$), and their density dropped in this month from about 14-19 per m² to 4 per m². The maximum density of psyllids in one sample was 108 per m². The density of this group showed greater variation from sample to sample than was found for the spiders. 69 % of the samples with psyllids contained less than 20 per m².

The aphids also decreased in number and constancy during March. These insects, together with the remaining groups in Table II,

Table III. Monthly percentage distribution of spider species on branches of spruce (*Picea abies*) from November 1970 to March 1971. n=number of specimens.

	Nov.	Dec.	Jan.	Feb.	March
<i>Dictyna</i> sp.	14	10	7	4	15
<i>Philodromus</i> sp. (<i>aureolus</i> -gr.)	33	45	35	45	38
<i>Tibellus</i> sp.	1	2	3		
Thomisidae indet.		1	1		1
<i>Theridion tinctum</i> (Walck.)			2		2
<i>T. pallens</i> Blackw.	6	1		1	6
<i>Theridion</i> sp.	3	2	6	1	1
<i>Tetragnatha</i> sp.				1	1
<i>Araneus cucurbitinus</i> Clerk	3		2	1	1
<i>Araneus</i> sp. (<i>tuberculatus</i> -gr.)	12		2	2	
<i>Araneus</i> sp.	15	28	13	25	24
<i>Cyclosa conica</i> (Pallas)		1		1	1
<i>Pityohyphantes phrygianus</i> (C.L.Koch)	5	3	9	10	
Linyphiidae juv.	1	2			1
Juv., indet.	7	6	19	10	11
n	104	116	127	222	132

occurred in low densities or with low constancies throughout winter, and accordingly S. E. is not estimated.

The total average number of invertebrates per m² of branches ranged between 34 and 48 during the first four months, dropping to 22 in March. This decrease was primarily due to the reduced psyllid density this month.

The spider fauna was dominated by Thomisidae (*Philodromus* sp., *Tibellus* sp. and Thomisidae indet. in Table III) and Araneidae (the genera *Araneus* and *Cyclosa* in Table III), these two families making up 68% of the total material. Altogether at least 10 species of spiders were present.

All spiders were juveniles or subadults, except one adult of *Theridion tinctum* and four adults of *Theridion pallens*. Of the five species identified, only *Pityohyphantes phrygianus* occurred in such numbers that some information about the sex-ratio could be obtained. Of the 27 specimens, all subadults, in which the sex could be determined, 25 were females.

Nineteen species of psyllids were identi-

fied, representing three genera (Table IV). *Trioza urticae* was the dominating species, making up 70–84% of the psyllids throughout the winter. 10–16% of the psyllids belonged to *Psylla klapaleki* and 1–4% to *Trioza curvatineris*. The species composition and relative density did not show marked changes during winter. Whereas both sexes were quite evenly represented in *T. urticae* and *T. curvatineris*, only one male was found (in February) among the 122 specimens of *P. klapaleki*.

Fig. 2 illustrates the average biomass of spiders, psyllids, the remaining invertebrates, and the total fauna during winter, given as dry weight per m². Except for the high mean weight of spiders in February, and therefore also of the total weight in this month, the general trends for all groups was either a fairly constant weight per m² from month to month, or a slight drop in weight. The high mean value for spiders in February was mainly caused by an unusually high value in one of the samples (38.65 mg). When this extreme is disregarded, the mean value for

spiders becomes 6.7, and for the total fauna 10.2. These values are similar to those of the preceding month. When this correction is taken into consideration, the general trend for the weight of the total fauna and for Araneida is a rather even and slow decrease throughout winter. The total weight per m^2 recorded in March is about 60% of that recorded in November. The recorded biomass of spiders is also nearly halved. This drop in biomass is not followed by a corresponding drop in density (Table II).

The psyllid biomass was rather constant during the first half of winter, but during the second half the value dropped to about one fifth of the original one. This drop was most obvious from February to March. The biomass of the remaining groups showed no obvious drops during winter.

DISCUSSION

The most characteristic feature of the invertebrate spruce fauna studied was the strong dominance of Araneida and Psyllidae. Only a few works have treated the invertebrate fauna on branches of conifers. Gibb's (1960) studies, covering several winters, revealed a rather constant relative composition of invertebrates on pine branches in England. Homoptera (aphids and chermids) usually made up 85–90% of the total material. In

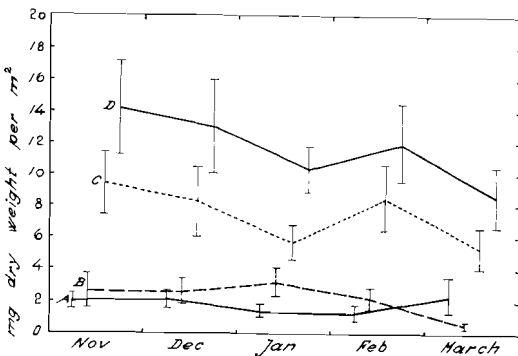


Fig. 2. Average monthly dry weight of invertebrates per m^2 spruce foliage during winter. Vertical lines: Standard error. A = Total except Araneida and Psyllidae, B = Psyllidae, C = Araneida, D = Total. Sampling was done once a month (18–20 samples); the values within each month have been displaced along the abscissa for practical reasons only.

some years, the aphids were heavily parasitized by Braconidae (Hymenoptera). Also in the present material, several aphids were evidently parasitized. Immature Thomisidae dominated among the spiders even in Gibb's (1960) studies on pine branches. However, psyllids, if present at all, were evidently of minor importance in his studies.

Palmgren (1932) studied the invertebrate fauna on spruce branches during summer at Åland island in Finland. Psocoptera dominated in numbers (38% of the material), followed by Araneida (28%). Psyllidae, being represented by the genera *Psylla* and *Trioxa*, made up only 0.6% of the total. In the present winter study, only two specimens of Psocoptera were recorded. Because these insects usually pass the winter in the egg stage (Imms 1964), this result is quite reasonable.

No psyllid species develop on spruce (Ossiannilsson, pers. comm.). It is, however, typical that many of those psyllid species which hibernate as adults migrate to evergreen conifers during late summer and autumn to spend the winter in the trees (Ossiannilsson, pers. comm., Schaefer 1949). The host plant of *T. urticae* is *Urtica dioica* L., whereas *P. klapaleki* and *T. curvatineris* are bound to *Salix* sp. As for the rest of the psyllid species, host plants of thirteen genera have been recorded (Ossiannilsson, pers. comm.).

The present results indicate that the migration to spruce had been completed in November. Palmgren (1932) found, in addition to the low psyllid density on spruce branches during summer, that the content of psyllids in stomachs of goldcrests was consistently higher in autumn than in summer. Both his observations are explained by the migration pattern of the psyllids.

P. klapaleki was represented almost exclusively by females. This can probably be explained by a high mortality rate of males (Ossiannilsson, pers. comm.). *A. affinis* has not earlier been recorded in Norway (Ossiannilsson, pers. comm.).

The density of psyllids in March is rather low compared with the preceding months. This may be due to increased activity as the temperature increases, causing parts of the psyllid population to leave the branches and prepare the migration back to their host plants. During several winters, the authors

Table IV. Monthly percentage distribution of psyllid species on branches of spruce (*Picea abies*) from November 1970 to March 1971. n=number of specimens. x denotes < 1%.

	Nov.	Dec.	Jan.	Feb.	March
<u>Aphalara affinis</u> (Zett.)					1
<u>A. exilis</u> (Web. & Mohr)		x		1	
<u>A. rumicicola</u> Loginova			1		
<u>Aphalara</u> sp.		1		1	
<u>Psylla corcontum</u> Šulc		x			3
<u>P. klapaleki</u> Šulc	12	16	11	10	12
<u>P. nigrita</u> (Zett.)	1	1	x		
<u>P. pyrisuga</u> Foerst.		x	x		
<u>Psylla</u> sp.		x	1		
<u>Trioza abdominalis</u> Flor			x		3
<u>T. acutipennis</u> (Zett.)	1				
<u>T. apicalis</u> Foerst.				x	
<u>T. cerastii</u> (L.)			x		1
<u>T. curvatinervis</u> Foerst.	3	3	4	1	3
<u>T. dispar</u> Löw		x	x	1	
<u>T. femoralis</u> Foerst.				x	
<u>T. nigricornis</u> Foerst.		x		x	
<u>T. rhamnii</u> (Schrnk.)				1	1
<u>T. salicivora</u> Reuter				1	1
<u>T. striola</u> Flor		1	1	1	4
<u>T. urticae</u> (L.)	84	76	81	83	70
<u>Trioza</u> sp.		x			
n	110	279	252	281	74

have recorded invertebrates on the snow surface of the forest floor in spruce woods around Oslo. Psyllids may be found throughout the winter, but are most common in the later part. Depending on the weather, they may be more or less active. Parts of this psyllid material were identified. As on spruce branches, *T. urticae* and *P. klapaleki* dominated, and mainly females were recorded of the latter species. Also *T. curvatinervis*, *T. striola*, *P. cornutum* and *P. nigrita* were found.

The increased activity of hibernating psyllids in spring, combined with periods with

strong winds, may result in considerable spreading of the individuals. In several cases large numbers of psyllids have been observed on snow-covered lakes in March and April, evidently blown off from surrounding conifer forests.

In Palmgren's (1932) study, *Philodromus aureolus* (Cl.) dominated among the spiders. The dominant spider group in the present material could not be identified further than to the *P. aureolus* group. *P. phrygianus* was found in both studies. Among the other spiders listed by Palmgren (1932), the following should be mentioned, as the same genera

were recorded in the present study: *Dictyna arundinacea* (L.), *Aranea* sp., *Theridion* sp., *Theridion simile* C. L. Koch and *Tetragnatha obtusa* C. L. Koch.

Waalder (1972) studied the spider fauna on branches of spruce in the beginning of August at Ringsaker, south Norway, visiting three different habitats. Of the species and groups listed in Table III, the following were recorded: *P. phrygianus*, *C. conica*, *Dictyna* sp., *Tetragnatha* sp., *Araneus* sp. and Linyphiidae indet. All were juveniles, except a few of the *P. phrygianus* specimens.

Contrary to the psyllids, the spiders probably stay on the branches during their life cycle. It is typical that they hibernate as immatures and become fully developed during spring and summer (Dahl 1926, Dahl 1931, Reimoser 1937, Locket & Millidge 1953).

No serious reduction in total dry biomass could be demonstrated during winter. The biomass of spiders was somewhat reduced, but this was not followed by a corresponding reduction in density. Analysis of stomach contents of goldcrests by Palmgren (1932) support the assumption that mainly the larger invertebrate specimens are eaten.

The overwintering psyllids represent a significant contribution to the invertebrate biomass on the branches and clearly improve the food supply for goldcrests and tits. Roughly 20% of the total invertebrate biomass recorded on the branches during winter was made up by psyllids (Fig. 2). A similar migration of chermids to pine trees during autumn was recorded by Gibb (1960).

Both goldcrests and tits feed on invertebrates on spruce branches during winter (Palmgren 1932, Haftorn 1956). Gibb (1960) found that the density and biomass of invertebrates on pine branches varied greatly from one winter to another; in some winters the density was greatly reduced, while in others it was quite constant.

Probably the invertebrate density on spruce branches also varies much from one winter to another. It is therefore difficult to say how representative the present results are. Whether the recorded density might have been a limiting factor for the overwintering populations of goldcrests and tits cannot be ascertained, as data on bird density are lacking. In this connection it should be mentioned that for birds, the amounts of

snow on the branches may be even more important than the invertebrate density itself (Hogstad, pers. comm.). Thus total invertebrate density does not always correspond with the available amounts of food.

Because of only little snow on the spruce branches in the winter in question, smaller amounts of the invertebrates than usual had fallen down together with snow dropping from the branches. This may in part explain the modest reduction in total density.

Gibb (1960) measured the caloric content of invertebrates on pine branches during winter and recorded values between 5.83 and 6.13 cal/mg dry matter. If 6 cal/mg is used as a mean value in the present study, the mean caloric content of invertebrates per m² of spruce foliage varied between 51 and 85 cal.

It is interesting that the spiders dominating the biomass seem to be relatively evenly distributed, occurring on almost every branch. This is probably due to their high moving ability and to their predatory feeding habits. For birds, this distribution pattern is an advantage as they evidently seek food quite unsystematically on the branches.

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Studies on the ecology of *Melasoma collaris* L. (Col., Chrysomelidae) in alpine habitats at Finse, south Norway

SIGMUND HÅGVAR

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Melasoma collaris L. is one of the dominant terrestrial invertebrates in the mid-alpine region at Finse, south Norway. Both larvae and imagines feed on *Salix herbacea* L., which is common in the study area. However, *M. collaris* utilizes only those parts of the *S. herbacea* communities where the snow melts very early, because the snow-free period would otherwise be too short for their life cycle. While several insects adapt to alpine communities by extending their life cycle over two or more years, *M. collaris* has a one-year life cycle. This is made possible through a combination of several factors, such as: Imagines becoming active as soon as the snow has melted, feeding first on unopened shoots which have a rather high caloric content; then achieving effective copulation by accumulating along the snow border, and laying eggs after a short time. Eggs hatch soon after the leaves are developed. The larvae grow quickly and have an unusually high assimilation efficiency. Both larvae and imagines may be active at low temperatures, and react spontaneously to even short periods of favourable weather with increased activity. In sunshine, the temperature may exceed 40°C in the *S. herbacea* communities.

S. Hågvar, Zoological Institute, University of Oslo, Blindern, Oslo 3, Norway.

To understand the functioning of high altitude ecosystems, the ecology of the dominant plant and animal species has to be studied. Invertebrates play an important role in the alpine habitats. *Melasoma collaris* L. is one of the dominant terrestrial invertebrates in the mid-alpine region at Finse (60° 36' N-7° 30' E), situated in the north-western part of the Hardangervidda mountain plateau.

Very little is known about this species in alpine habitats. As far as can be judged from the literature, no study has been published on its ecology and its role in an alpine ecosystem. In the present paper, even some morphological data are given. The actual data, partly necessary to describe ecological relationships, are either lacking or only superficially treated in the literature.

The present studies were carried out over four years (1969-72) in different habitats, 1200-1250 m a. s. l., and are part of an analysis of a high mountain ecosystem.

At Finse, both larvae and imagines feed on *Salix herbacea* L., which is very common in the actual area. Growth and energy budget

during the development were studied at 20°C (S. Hågvar, in manus).

SOME MORPHOLOGICAL DATA

Females can be distinguished from males by their longer body and by the processes on the hind part of the elytra (Hansen 1927) (Table I, Fig. 1). Most females are also heavier than males. The morphology of the genitalia is quite constant in males, but more variable in females (Fig. 2). Eggs are mostly about 1.4 mm long, but may be only 1.1 mm. They are either green or red-brown, all eggs in the same clutch having the same colour. There are three larval instars, which can easily be distinguished by the breadth of the head capsule (Table II, Fig. 3).

METHODS

Temperature preference was measured in a 90 cm long apparatus equipped with eight



Fig. 1. Male (left) and female (right) of *M. collaris* (x 4.5). Photo: J. Basberg, Laboratory of applied microscopy.

thermocouples (Østbye 1970). A miniature bomb calorimeter was used for the caloric measurements (Phillipson 1964). Wind speed was determined with a thermal anemometer (Lambrecht, type 641 6N).

As far as possible, the study of the ecology of *M. collaris* was based on field data.

LIFE CYCLE AND HABITAT SELECTION

General

In short, the life cycle at Finse can be described as follows. One generation a year. The imagines hibernate among litter and become active at snow melt in their habitats. This, in normal years, will be at the end of May and in June. After a feeding period, when both unopened shoots and developed leaves are eaten, copulation and egg-laying occurs. The new generation of imagines hatch mainly in the first half of August. These also have a feeding period before hibernation.

Table I. Body length of males and females in *M. collaris*, measured on living specimens from front of head to apex of elytra. Mean values are given in mm together with standard deviation, minimum and maximum values, and number of specimens measured (n).

	\bar{x}	SD	min/max	n
♂♂	5.6	0.16	5.3/5.8	20
♀♀	6.7	0.36	5.9/7.4	20

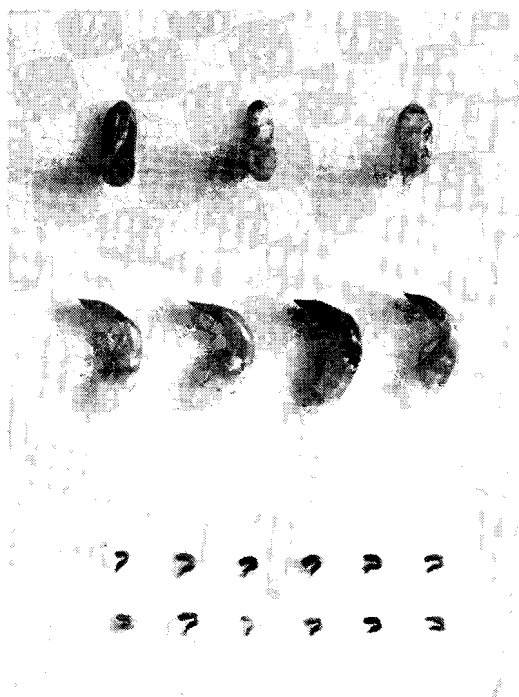


Fig. 2. Penis in front view and lateral view, and spermatheca of *M. collaris*. The form of the spermatheca is more variable than that of penis (x 8.5). Photo: J. Basberg, Laboratory of applied microscopy.

Fig. 4 illustrates the progress in larval development in four representative habitats, giving the dates for observations of imagines of the new generation.

It is typical of high mountain areas that snow melts very unevenly in the terrain. Because of strong winds during winter, none or very little snow is present on the hilltops, while large amounts, up to several metres in thickness, accumulate in crevices and depressions. Places where the snow melts very late are called snow beds.

In snow beds, there is usually a zonation of plant communities from the outer border of the area to the inner part, where the snow melts very late, or not at all (Gjærevoll 1956). Most snow beds in the Finse area contain an outer zone, several metres broad, which is dominated by *S. herbacea*. Only a few species of mosses and lichens are present (mainly *Dicranum starkei* Web. et Mohr., *Cetraria islandica* (L.) Ach., *Cladonia ecmocyna* (Ach.)

Table II. The breadth of the head capsule in different larval instars of *M. collaris*, given in mm. Mean values are given, together with standard deviation (SD), minimum and maximum values, and number of specimens measured (n).

Instar	\bar{x}	SD	min/max	n
I	0.600	0.017	0.564/0.615	50
II	0.865	0.032	0.769/0.924	50
III	1.270	0.043	1.180/1.360	51

Nyl., *C. mitis* Sandst. and *Stereocaulon paschale* (L.) Fr. This zone is thus almost a monoculture of the host plant for *M. collaris*.

Snow beds with a well-developed *S. herbacea* zone have a coverage of approximately 23% in north-facing and 25% in south-facing slopes in the Finse area (J. Schmidt & E. Østbye in prep.)

Besides in snow beds, *S. herbacea* is found in various mixed plant communities. *S.*

herbacea is often one of the dominant species also in these habitats. *M. collaris* occurs both in the *S. herbacea* zone in snow beds, and in other habitats where *S. herbacea* dominates.

Egg-laying

Eggs are laid in clusters on *S. herbacea*, either on leaves, on the stem, or on unopened buds. The egg surface is smooth, and is covered by a sticky substance which keeps the eggs together and fastens the cluster to the plant. 41 clusters contained 17–28 eggs each, mean value being 23.3 (SD = 2.4). In about one third of the clusters (19 of 52), the eggs were red-brown. Fig. 5 shows a cluster attached to a leaf.

Data from cultures kept at 20° C indicate that each female lays only two clusters of eggs. Of 12 pairs collected in newly snow-free habitats in June 1971 and kept in culture for 2–4 weeks, 10 of the females laid eggs. Three of them laid two clusters, with periods of 1, 3 and 3 days between. In two other cases the time was 1 and 2 days. The short time between the two succeeding clusters indicates that they have been produced in different ovaries. The eggs in both ovaries are obviously developed very soon after snow melt, and eggs may be laid on undeveloped plants close to the snow border. Probably the females in the nine cultures which produced only one cluster or none at all had deposited one or two clusters earlier. The assumption that only two clusters are produced and that the ovaries are not 'refilled' is supported by other observations from cultures, as animals taken from habitats which have been snow-free for a few weeks rarely lay eggs.

In the five cases mentioned when females

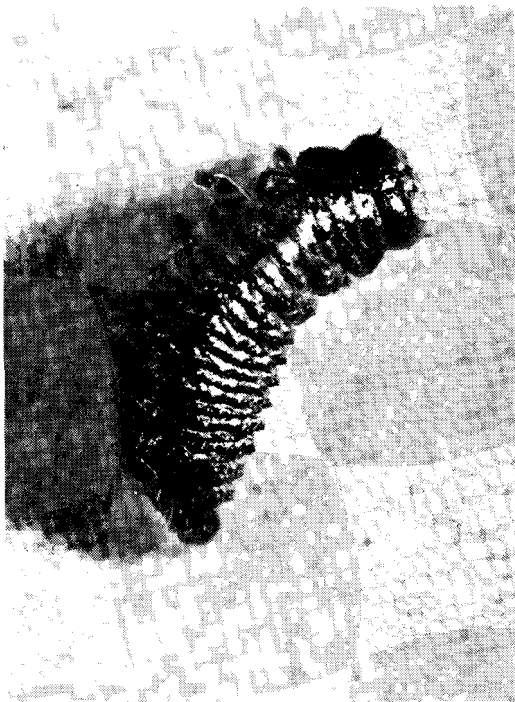


Fig. 3. Larva of *M. collaris*, second instar (x 19). Photo: J. Basberg, Laboratory of applied microscopy.

Table III. Mean fresh weight (mg) at the beginning of each larval stage and the pupal stage, measured just after ecdysis. Standard deviation is given together with minimum and maximum values, and number of specimens (n). All data are from field collected material.

Beginning of stage	\bar{x}	SD	min/max	n
Instar I	0.33			20
Instar II	1.41	0.16	1.2/ 1.8	10
Instar III	6.94	0.88	5.5/ 8.7	12
Pupa	25.03	2.59	21.2/29.7	16

Table IV. Caloric content given in cal/g dry weight \pm SD, for males and females of different dry weight groups. All data are from animals taken just after hibernation. n=number of samples, each sample containing about 20 mg dry matter.

Dry weight mg	Males			Females		
	5.3-6.5	6.5-7.5	7.5-8.7	7.1-9.0	9.0-10.5	10.5-15.6
\bar{x}	5535	5619	5485	5459	5403	5500
SD	288	387	264	272	170	197
n	6	9	9	9	11	11

in cultures laid two clusters each, eggs from the same female always had the same colour. Two females produced green eggs and three females red-brown eggs. The colour is probably genetically determined, being independent of temperature, etc. There seemed to be no difference between the red-brown/green ratio found in cultures and in the field.

At 20° C, eggs hatch after 5-6 days. In the field this time will be prolonged, depending on temperature. One cluster studied in the field did not hatch during 14 days of observation.

Larval development

First instar larvae are unable to eat through the unopened buds and will die in cultures where there is no access to green leaves. Therefore the question arises whether larvae hatched from eggs laid close to the snow border will develop at all. However, studies made at different temperatures show that the buds always develop faster than the eggs. For the larvae, it is enough if the bud is only partly opened, so that they have access to parts of the folded green leaf. In the field, such green parts in the bud can be seen about five days after snow melt. At 20° C, green parts appear after two days, and after 5-6 days, when the larvae hatch, the leaves are already unfolded.

In the first larval instar, all larvae from the same clutch usually keep together. They are often partly hidden between the two leaves being developed from each bud, for these often form a 'funnel' together at the beginning of their development. During the second and third instar, each group spreads more and more, but the larvae probably

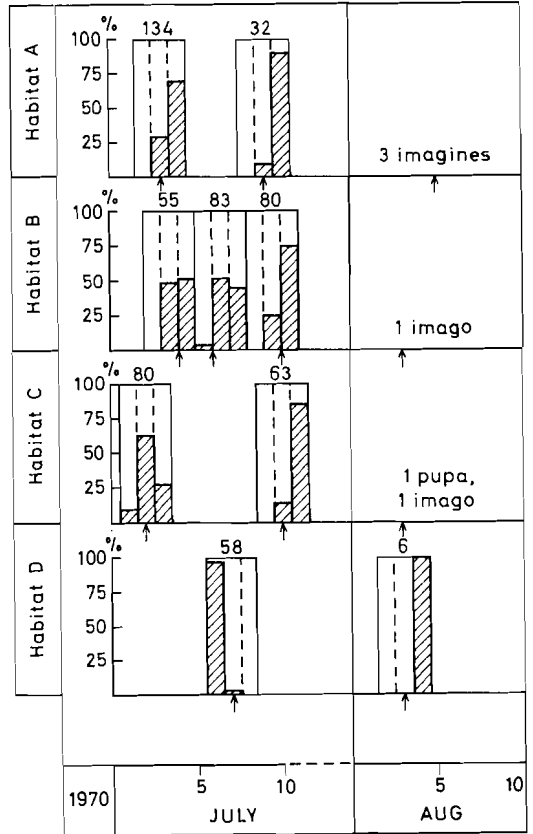


Fig. 4. Typical development pattern of *M. collaris*, showing the one-year life cycle. Data are presented from four habitats, A-D. Arrows indicate dates of observation. The three parallel columns within each box represent the larval instars, the length of the cross-hatched columns indicating the percentage of each instar. Number of specimens collected is given above the boxes.

pupate within a few decimetres of the hatching point. In favourable weather the larvae often expose themselves so that they are easily observed.

Midway through their last stage, the larvae attach their hind parts to the underside of a leaf, or often to the underside of a suitable stone. They hang motionless, head down, and eat no more food; weight is therefore much reduced before pupation (Hågvar in manus).

Table III gives the fresh weight at the beginning of each larval instar and pupal stage; all data are taken from field animals.

From Fig. 4 it can be seen that the development is markedly delayed in habitat D. In



Fig. 5. An egg cluster of *M. collaris* deposited on a leaf of *S. herbacea*, the base of which has been fed upon by imago (x9.5).

1971, closer investigations were made to discover the developmental delay rate in different habitats occupied by *M. collaris*, and whether this delay depended on the date of snow melt, i. e. the day when the last snow disappeared.

The results are presented in Fig. 6, showing the phenology in four habitats with different days of snow melt, from 20 May to 9 July. The first date was about the earliest time of snow melt in the *M. collaris* habitats this year. It is seen from the two first habitats, named E and F, that first instar larvae dominate the picture at about one month after snow melt. Development seems to be somewhat faster in habitat F with the latest snow melt of the two, probably due to higher temperature at the start of development. In habitat G where snow melt was more than a month later than habitat E, eggs were observed, but neither larvae, pupae, nor imagines were found later. Obviously the density must have been very small. In habitat H, no stages at all were recorded, and *M. collaris* probably did not use this habitat.

Fig. 6 thus indicates that the development of *M. collaris* may be a little over a month

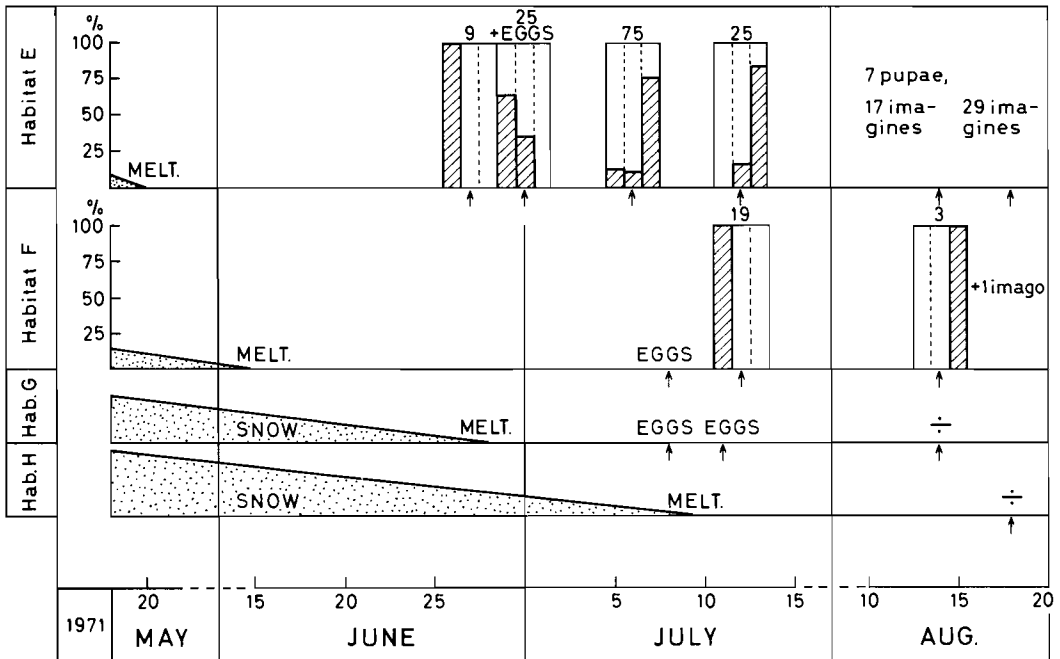


Fig. 6. Development of *M. collaris* in four habitats (E-H), with snow melt at different dates. Explanation as in Fig. 4.

delayed in some habitats compared with others, and that there is a close correlation between the developmental stage of a given population and the date for snow melt in the habitat. Habitats melting off more than approximately one month later than the earliest snow-free *S. herbacea* habitats, are probably only to a small degree, or not at all, used by the species.

For a more precise picture of the use of *S. herbacea* habitats with snow melt at different dates, an attempt was made to estimate the density of *M. collaris* in different habitats; relative measurements of densities were judged sufficiently. It was found that the percentage of leaves with feeding marks from larvae or imagines would be useful. In the habitats used by *M. collaris*, no other animals making similar feeding marks were present in such high densities as to disturb the method. A very few larvae of Hymenoptera Symphyta may occur, or larvae of a small lepidopteran, probably Tortricidae. The

lepidopteran larvae may in a few cases be locally abundant, but the leaves on which they have eaten are covered with fine threads spun by the larvae and are therefore easily identified. One or two more Chrysomelid species occur in the study area, but they are exceedingly rare.

This relative method of measuring density has the advantage that the density can be measured quickly in all habitats in the autumn. Direct measurements are more laborious, as the larvae may sometimes be difficult to find. Furthermore, direct measurements should always be made at similar points in the life cycle, and this means that each population has to be followed closely.

Some preliminary counts were made in 1970. In a snow bed with snow melt late in the summer, only 2% of 1,000 leaves had been fed upon by larvae or imagines of *M. collaris*. In another snow bed melting earlier, the percentage based on 400 leaves was 11. It was also observed that very locally, up to 100% of the leaves could be eaten, leaving a brown spot in the field.

As the imagines have a feeding period during the autumn, the best method was judged to be a count of only those leaves which had been fed upon by larvae. The percentage would then be an indirect measure of the number of larvae developed in the habitat, assuming similar mortality in the habitats.

Fig. 7 shows feeding marks made by larvae in each of the three instars, and of imagines. Feeding marks made by larvae can be distinguished from those of imagines, as larvae eat by making holes in the leaf, while imagines eat from the edge. On a closer view, each instar is also relatively characteristic. First instar larvae avoid even the smallest nerves in the leaf, while the second and third instar cut larger and larger nerves. Larvae of the two first instars do not eat all layers of the leaf, while the third instar larvae penetrate all layers.

No distinction was made between feeding marks from the different larval instars during the counting of leaves in the field. Furthermore, rather than counting single leaves, the unit chosen was the two (or sometimes three) leaves resulting from one bud. Thus the percentage of such shoots with holes in one or more of the leaves was



Fig. 7. Leaves of *S. herbacea*, showing feeding pattern of first instar larvae (lower row), second instar larvae (second lower row), third instar larvae (second row from top), and of imagines (upper row). Larvae make holes while imagines eat from the edge.

counted. The countings were made in August, when the larval development in the habitats was completed.

Fig. 8 shows that in habitats where snow melt occurs very early, e.g. in the last part of May, up to 100% of the shoots had been fed upon by larvae. The data from each of the four habitats in Fig. 8 A are based upon 5–10 squares of 30 × 30 cm each, covering altogether about 500–1,500 shoots. In Figs 8 B–11 each plot represents the number of shoots with larval feeding marks, as a percentage of the total number of shoots within random 15 × 15 cm squares. The mean number of shoots per 15 × 15 cm square, based on 81 squares from habitats used by *M. collaris*, is 68, SD being 38. From Fig. 8, it is evident that there is a gradual and strong decrease in the density of *M. collaris* larvae between the earliest snow free suitable habitats and those which were last taken into use.

The habitats with known dates for snow melt described in Figs. 6 and 8 are partly local habitats of a few square metres containing *S. herbacea*, and partly certain points in *S. herbacea* snow-bed gradients. Both fig-

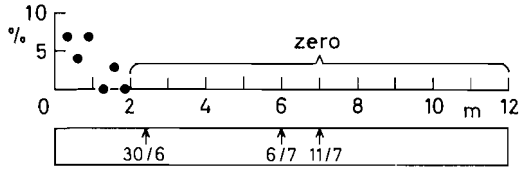


Fig. 9. Percentage of *S. herbacea* shoots being fed upon by larvae of *M. collaris* along a 12 m long gradient of a *S. herbacea* community in a snow bed, different parts melting off at different dates (bottom of figure). Gentle slope facing NE, 1972. In this gradient, even the outer parts melt rather late. Explanation in text.

ures, however, containing data from 1971 and 1972, have one feature in common; only habitats where snow melts before the beginning of July are used by *M. collaris* larvae.

This last point is interesting, because in large parts of the *S. herbacea* zone in the snow beds, containing almost monocultures of the food plant, snow melts rather late. To what extent are these monocultures actually used by *M. collaris*?

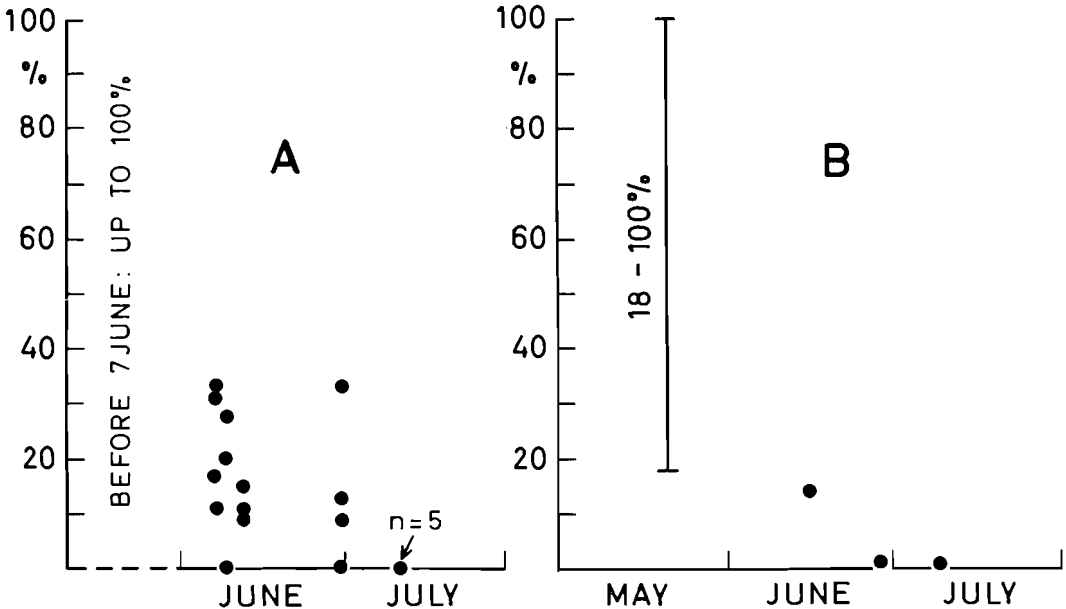


Fig. 8. Percentage of *S. herbacea* shoots being fed upon by larvae of *M. collaris* in habitats with snow melt at different dates. Explanation in text. A: Data from 1971. B: Data from 1972. As indicated by the vertical line, the whole gradient from 18 to 100% might be found in May.

Figs. 9–11 show the degree of larval feeding along the whole *S. herbacea* gradient in four different snow beds, each belt of *S. herbacea* being 7–12 m broad (measured along the ground).

In *S. herbacea* belts where even the outer parts melt rather late, only the very outer fringe is used, and the larval density here is small (Fig. 9). In gradients where the outer part melts somewhat earlier, e.g. some weeks before the beginning of July, the larval density may be very high in the outer part, and all shoots may be fed upon by larvae (Fig. 10). However, the density drops rapidly, and several metres of the zone are not used. As in Figs. 6 and 8, the beginning of July represents the limit for the colonisation of snow beds by *M. collaris*. Fig. 11 gives the same picture of feeding intensity in a *S. herbacea* zone, even though dates for melting are lacking for this habitat.

The snow beds from which the data in Figs. 9–11 are taken are roughly representa-

tive of the Finse area. Without doubt the *S. herbacea* habitats associated with snow beds cover larger areas in the neighbourhood of Finse than the *S. herbacea* habitats occurring more randomly and locally outside the snow beds. This means that only a fraction of the 'potential' *M. collaris* habitats are actually used by the species, the limit being set by the date of snow melt.

The pupal stage

The young pupa has a light yellow colour, but it becomes nearly black at the end of this stage. The pupae are rather well concealed in the habitat and may be difficult to find; they are very strongly attached to the leaf, or any other object from which they hang down. The larvae have a fastening organ on their hind part, probably similar to a sucker. With this organ the fully grown larvae fasten themselves to an object, head down. During the following ecdysis, the larval exuvium is not totally separated from

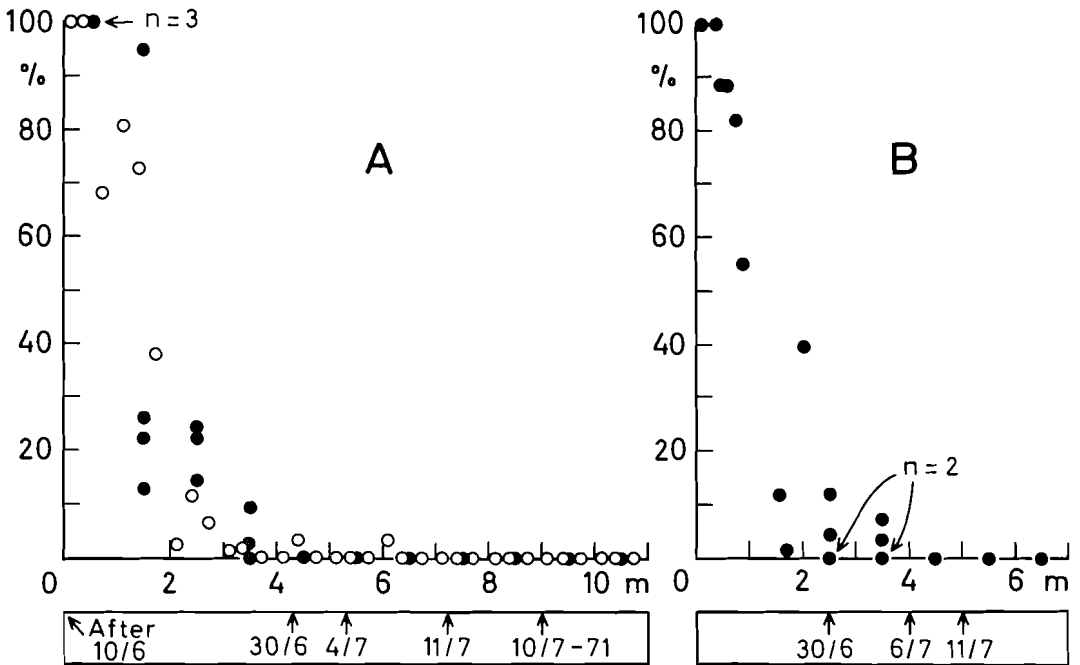


Fig. 10. Percentage of *S. herbacea* shoots being fed upon by larvae of *M. collaris* along two gradients of *S. herbacea* community, 11 and 7 m long. Both gradients are parts of snow beds. Dates for snow melt at different points of the gradients are given at the bottom of the figures. A: Slope facing W, 1:3.2. Data of snow melt are from 1972, except one from 1971. Dots: 1971, open circles from 1972. B: Slope facing E, 1:1.7. All plots are from 1971, while dates for snow melt are taken from 1972.

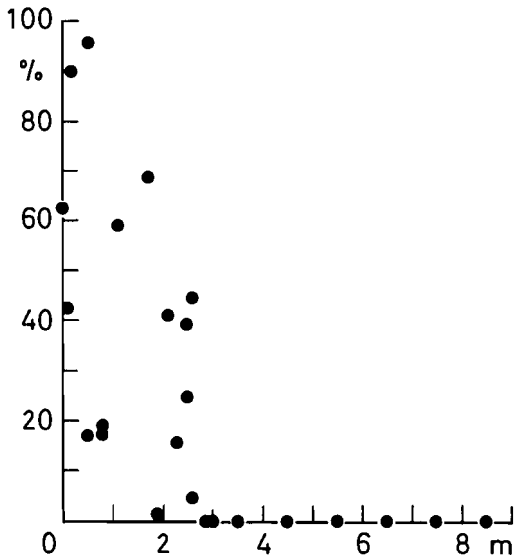


Fig. 11. Percentage of *S. herbacea* shoots being fed upon by larvae of *M. collaris* along a 9 m long gradient of *S. herbacea* community in a snow bed. Dates for snow melt along the gradient are missing, but the outer parts melt rather early. Slope facing NE, 1:2.9. Data from 1971. Explanation in text.

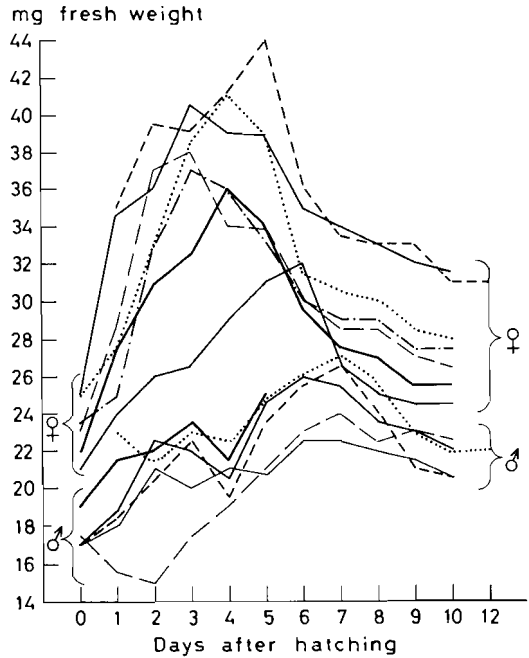


Fig. 12. Daily changes at 20–25°C in weight of newly hatched imagines of *M. collaris*, showing individual curves for six males and seven females.

the pupa. The hind part of the pupa keeps contact with the larval exuvium, and after ecdysis it is not possible to separate the pupa from it. The pupa is thus fastened by means of the larval organ.

At 20°C the pupal stage lasts five days. In natural habitats this time is probably at least doubled.

The imaginal stage

Data from Figs. 4 and 6 indicate that the major part of the imagines hatch during the first three weeks of August. This means that the total development takes about two months.

The newly hatched animals can be distinguished from the old population by their shining, almost metallic blue-green elytra. During overwintering the shiny appearance is strongly reduced, and the colour becomes more dull and dark.

The changes in weight during the feeding period after hatching have been studied over 12 days in a laboratory culture at 20–25°C (Fig. 12). Although the animals have not developed in the field, but at temperatures

around 20°C, the pattern of weight changes in the newly hatched imagines will give an indication of the intensity of feeding within a population in the field before hibernation.

Fig. 12 shows that in both sexes there is first an increase in weight, which seems to stabilize later at a considerably lower level than the maximum weight achieved. Females achieve their maximum weight (mean value 38.4 mg) after 3–6 days (mean value 4), and during this period the initial weight is increased by about 75%. Males increase their weight more slowly, and the increase in several specimens is disrupted by one or more drops in weight. The maximum weight of males (mean value 25.2 mg) is achieved after 6–7 days (mean value 6.5) at this temperature, the increase being about 50%. It is not clear why the weight of both sexes is so much reduced after reaching the maximum value. Perhaps the development of the genitalia needs a strong feeding period in the earliest days, the animals then later becoming more inactive, in preparation for hibernation. It is, however, astonishing if the animals

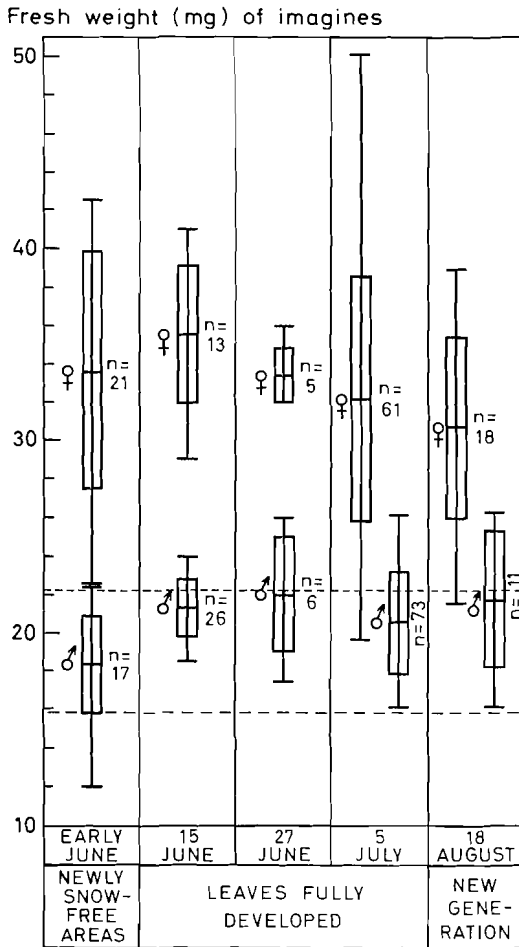


Fig. 13. Changes in fresh weight of males and females of *M. collaris* from the time of snow melt, through the first period when the leaves of *S. herbacea* are fully developed, to the appearance of the new generation in August. Mean values are given, together with SD (block) and maximum and minimum values. n = number of specimens. Lower broken horizontal line shows mean weight of newly hatched males, and upper broken horizontal line mean weight of newly hatched females.

start hibernation with no more extra fat reserves than indicated by the values around which the weights of females and males seem to stabilize, given at the end of Fig. 12.

In the field the imagines may use about one month for this feeding. In the middle of September the first snow usually falls, or else the temperature becomes too low to allow for much feeding.

Fig. 13 illustrates the changes in weight of adults during the main part of the snow-free period. For comparison, the mean weights of newly hatched males and females are indicated by broken horizontal lines. These last values are taken from cultures bred at 20° C. However, since the growth curve during the larval stages for culture animals corresponds closely to that of field larvae, it must also be anticipated that the weights of newly hatched imagines from cultures correspond well with those of newly hatched field animals.

If we first look at the weights in the population which has hibernated, it is evident that the highest mean weight of females is achieved in the main egg-producing period (mid-June). A similar picture, perhaps a little delayed, is achieved for males. Fig. 13 also shows that both sexes maintain throughout the summer a weight considerably higher than the weight of newly hatched animals.

The weights of females and males of the new generation, measured 18 August, show that at this point the weight of the animals in question has already increased markedly. This observation corresponds well with the strong feeding activity recorded immediately after hatching in Fig. 12.

Most imagines probably live for more than 12 months. Of 20 animals (10 pairs) kept isolated in a cage under natural conditions from 16 June, when hibernation was just finished, 17 were still alive 8 July the same year. Of 25 other animals collected and isolated 13 July, 20 were alive on 8 August the same year. Whether imagines can hibernate a second time is unknown.

The ♂/♀ ratio is close to 1. A sample collected near the snow border 16 June 1971 contained 20 females and 17 males. Another sample collected 5 July 1972 contained 62 females and 75 males.

DENSITY OF IMAGINES AND LARVAE

The general distribution of *M. collaris* populations in the field depends wholly on the distribution pattern of habitats containing a certain cover of *S. herbacea*, and the snow-melt date. Apart from the general coverage mentioned for snow beds in the Finse area, no further efforts have been made to estimate

the coverage of suitable *M. collaris* habitats in the field. The following data concern the densities within the local habitats used.

Imagines

The most clumped distribution of imagines is found during the time when the snow in their habitats is melting. At this time the animals often gather close to the snow border, and some animals are also found on the snow. Densities of around 50 animals per m² at the snow border are not uncommon in the habitats with the earliest snow melt. The density may exceed 100 per m², and smaller groups can be found where the animals climb upon each other. Later the animals spread, so that the distribution becomes more uniform.

16 June 1971 the density was measured in a habitat from which the snow had just melted, and where the imagines had spread after their concentration during melting. The site chosen is thought to be a typical *M. collaris* habitat, and probably most animals belong to populations having similar densities. In a field covering 2 × 5 m, 111 imagines were recorded, resulting in a mean density of 11 per m². For the counting, the area was divided into 40 squares, each 0.5 × 0.5 m. Only 6 squares contained no animals. The maximum number per square was 14. The leaves were not developed in the habitat at this time, and the animals were in the copulation/egg-laying phase.

In another newly snow-free habitat where snow melt was later, the mean density on 30 June 1971 was found to be 3 individuals per m². This value was based upon 30 random squares, each 30 × 30 cm.

Larvae

Determination of larval density is more complicated, partly due to their uneven distribution caused by the eggs being laid in groups, partly to the fact that larvae may be difficult to observe and also because the density will change as development proceeds due to mortality and a certain migration.

The absolute upper limit for the number of larvae able to develop per m² habitat can be calculated from the primary production of *S. herbacea* leaves and the food requirements of the larvae. Such total defoliation seems to occur locally every year. Multi-

plying the number of shoots per m² (about 3,000) with the number of leaves per shoot (mostly 2 in the larval period), and with the mean fresh weight of one leaf (about 15 mg, mean of 30 leaves), we obtain 90,000 mg leaves per m². Mean consumption per larva is 93.5 mg (*S. Hågvar in manus*). This gives a maximum density of roughly 960 larvae per m², assuming no mortality. Actually, the larvae do not eat the whole leaf, as most of the leaf nerves remain. Furthermore, the leaves are not usually fully developed when the larvae commence eating, and parts of the leaves may die as a result of feeding on other parts. Therefore a somewhat lower maximum value must be anticipated in the field.

In an experiment, where 24 larvae from one egg clutch were developed at 20° C, living on natural habitat (earth with growing *S. herbacea* plants), the larvae defoliated 154 shoots, which means that larvae from 20 egg clutches, or about 480 larvae, would defoliate 1 m².

The above-mentioned 'normal' density of 11 imagines per m² will produce 11 egg batches per m², assuming that each female lays two batches. With a mean of 23 eggs per batch, this gives a maximum of about 250 larvae hatching per m² under normal conditions. Mortality will, however, reduce this number more or less during development.

In another habitat with snow melt somewhat later than the most preferred habitats, 145 random squares of 30 × 30 cm were investigated 7 July 1970 for the presence or absence of larvae. Minimum distance between each square was 1 m, and the whole area covered roughly 100 m². Instar I and II dominated, and at this point in development the larval colonies were well aggregated. 52 % of the squares contained at least one larval colony, giving a minimum of about one colony per 30 × 60 cm, or about 5.6 colonies per m², corresponding to a minimum larval density of 129 per m² soon after egg hatching.

As a conclusion, the number of larvae developing per m² may locally reach 4–500, but in the main areas of the species the number of larvae hatched will be around 250 per m². From this value, the density drops successively to zero in habitats where snow melt is later in the season.

DECIMATING FACTORS

Both imagines and larvae may be attacked by a fungus. The body swells, and the inner parts are completely filled by hyphae, producing a spongy consistency. The direction of the hyphae is mainly from the alimentary canal outwards to the body wall. Only a short time after death (about 1–2 days at 20° C) the hyphae penetrate the cuticula and create a dense cover around the whole animal. Since the attack seems to start around the alimentary canal, it is reasonable to believe that the fungus is ingested together with food. The sickness is not spontaneously infectious, since other larvae and imagines living in the same culture may not be visibly attacked, even when the dead animal is not taken away. Eight imagines kept and fed in close contact with two dead imagines covered with hyphae, showed no signs of sickness after eight days.

Fungus-enveloped, dead larvae and imagines were found both in the field and in laboratory cultures. The larvae killed were mostly large specimens of instar III. This may indicate a long incubation period. In some field populations with a rather high density, several dead larvae might be found. Most of the dead animals observed were found in the field, or in cultures containing animals taken from the field. In most cultures of larvae and imagines bred at 20° C from eggs, mortality was close to zero.

Whether the fungus actually causes death, or whether it only attacks the dead animals, has not been studied in detail. However, since the hyphae cover the animal only 1–2 days after death and penetrate the body from the inside, it seems most probable that death is caused by the fungus.

In some cases the larval growth stops; the animal becomes dark and shorter, but may still live for several days. Dissection could not reveal any specific reason, and parasites were not found.

Neither from eggs, larvae, pupae nor imagines were any parasitic insects hatched, even though large numbers were kept and studied in cultures during four summer seasons.

During very strong rain, parts of the habitats of *M. collaris* may be temporarily flooded. Thin layers of snow may also

occasionally cover the vegetation. The animals seemed to survive such conditions fairly well in the field. Larvae of instar III sink in water and very soon become motionless. They survive at least four hours under water at 20° C. One larva kept in water for ten hours, however, did not survive.

Predation by birds probably plays no important role as a decimating factor. The most common insect feeding bird in the area is the meadow pipit (*Anthus pratensis* (L.)) (Lien et al. 1974). An investigation of the stomach content of 88 adults from the whole snow-free season, and of 16 nestlings, showed that imagines and larvae of *M. collaris* were only very rarely eaten, and always in small quantities (S. Hågvar & E. Østbye in manus).

FOOD PREFERENCES

Larvae and imagines have similar food preferences. They prefer leaves of the genus *Salix* sp., and in cultures, leaves both from bush-formed *Salix* species and from the creeping *S. herbacea*. Imagines which were given a choice between *S. herbacea* and *S. lapponum* L. ate 2.5 times as much of the latter species as the former.

When deprived of *Salix* sp., both larvae and imagines may feed in *Polygonum viviparum* L. Larvae may to a very slight extent eat *Oxyria digyna* (L.), but imagines did not touch this species. Neither larvae nor imagines ate any of the following species when *Salix* sp. were unavailable: *Polytrichum* sp., *Alchemilla alpina* L., *Rubus chamaemorus* L., *Carex* sp. and *Taraxacum* sp. It seems that in the field only *S. herbacea* and perhaps to a certain extent *S. polaris* Wahlenb. are eaten.

Bush-formed *Salix*-species, especially *S. lapponum*, are not uncommon in the study area. However, *M. collaris* does not utilize these plants, even though the preference for those leaves may be greater than for *S. herbacea*. Imagines were never observed on bushes of *Salix* sp., and larvae only once (6 July 1970). The actual *S. lapponum* plant was only 12 cm high. Up to 4 cm, 93 % of the leaves were eaten upon (n = 165); from 4–8 cm 81 % (n = 132); and above 8 cm 54 % (n = 41). Evidently the larvae prefer to keep

close to the ground, even though it would not take them long to climb to the top.

Three times a couple of larvae were placed on bushes of *Salix lapponum* about 40 cm above the ground. However, in all cases most animals either fell or walked down after a few hours or a few days. This happened both under strong wind and almost calm weather conditions. Two larvae were found dead on the bush after 2.5 days, after a windy, warm night. Both were dry and seemed to have died because of dehydration. Perhaps *M. collaris* is unable to survive wind in bushes above the timber line. Besides the problem of dehydration, the strong movements of the bushes during wind may make it difficult to walk and feed without falling.

CLIMATIC CONDITIONS

Wind speeds, measured at different levels at about the same time for a *S. herbacea* community and a 20 cm high *S. lapponum* stand are depicted in Fig. 14. The *S. lapponum* cover was not very dense, and the two wind profiles do not differ to any great extent. However, the wind speeds measured on the upper surface of the *S. herbacea* cover and among the leaves of *S. herbacea* (0.4 and 0.16 m/s) are considerably lower than those measured at 5, 10 and 20 cm above ground in the *S. lapponum* bushes (1.4, 1.9 and 3.3 m/s). Obviously *S. herbacea* offers a much better habitat for species wishing to avoid wind than *S. lapponum* and other bush-forming *Salix* species.

As for temperature, the *S. herbacea* community achieves quite high temperatures even after a short time in sunshine. More than 40° C have been measured with a shaded thermocouple on the litter surface. Very few other habitats in the alpine region reach such high temperatures.

The temperature preference of imagines and third instar larvae was studied in a gradient ranging from about -2 to 42° C. At temperatures below 20° C, the relative humidity was 80–100%, at higher temperatures somewhat lower. The experiments were started by placing animals from the field in the middle of the gradient.

Two experiments with imagines showed

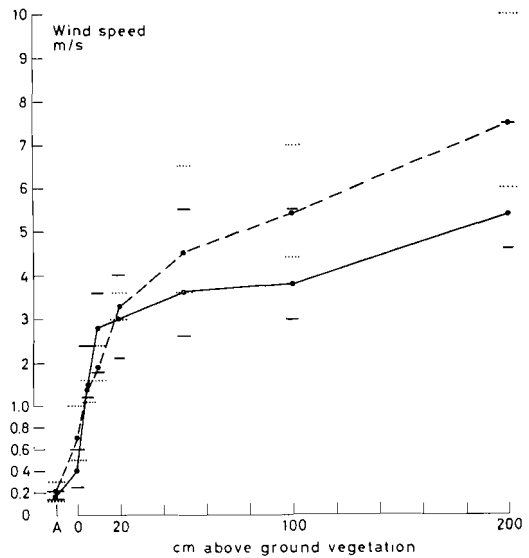


Fig. 14. Wind speeds at different levels above ground vegetation in a *S. herbacea* community (solid line) and in a 20 cm high *S. lapponum* community (broken line). Mean values are depicted together with maximum and minimum values recorded for about one minute (small horizontal lines for *S. herbacea* community and horizontal rows of dots for *S. lapponum* community). A = among leaves of *S. herbacea* and among moss plants, respectively.

that most specimens ($n = 20$) tended to prefer temperatures between 0° and 15° C. This range roughly corresponds to the temperature range in their habitat when cloudy (which is the normal condition at Finse). However, some individuals might also stay for a long time at much higher temperatures, exceeding 30° C.

Larvae of instar III ($n = 10$) did not show any special temperature preference at all during two experiments, moving along the whole range from 8–36° C.

Some simple tests of humidity preferences were performed with imagines. However, the results did not indicate any special range of preference.

The animals evidently have a strong positive phototropism. Animals kept in petri-dishes near a window always congregated towards the window. Of 117 animals placed in a petri dish which was half covered with black paper, 79% were found in the light

half after one hour, and 81 % after 2 hours. Even though the petri dish was placed far from any window, the animals concentrated in that part of the light half which was turned towards the nearest window.

ACTIVITY AND BEHAVIOUR

A characteristic feature for both imagines and larvae is that even short periods of favourable weather (e.g. a short period of sunshine on a cold day) are used for different activities, e.g. feeding, copulation, or egg-laying. It is therefore an advantage for the species that its habitat is quickly warmed by the sun. At 20° C, the egg laying (of one batch) takes about 10 minutes, and copulation may also occur quite spontaneously. Both in larvae and imagines, feeding occurs very effectively once started.

When a female deposits eggs, she moves her abdomen slowly from side to side, and moves a little forwards each time, so that the eggs are placed in parallel, transverse rows behind her. During egg-laying, the female does not react to smaller irritations, not even to other imagines climbing over her.

In one case a female was seen feeding on eggs, but this probably happens very rarely.

Even though imagines possess fully developed wings, they have never been observed flying. If flight occurs at all, it must be quite exceptional.

Larvae and imagines are active at temperatures close to zero, and imagines can walk long distances on the snow surface. Evidently the species is well adapted to survive long periods of cold weather.

Copulation occurs from soon after snow melt for a period of several weeks, and each pair (observed in cultures) may copulate several times, often every day during several succeeding days. It seems that the 'copulation instinct' is very strongly developed in males. This obviously ensures both an effective use of the fleeting favourable weather conditions, and a high fertility of the species in general. It is the general impression that most females lay eggs. All egg batches from cultures, or gathered from the field, were fertilized.

When irritated mechanically, the larva secretes 9 drops of liquid along each side of

the body, protruding from the top of pleural processes. After a few seconds those drops which have not achieved contact with another medium are withdrawn. This reaction can be repeated several times by new irritations. It is reasonable to believe that the fluid acts in a repellent way to predators, both to birds, and to predatory invertebrates strolling through the habitat (e.g. Carabidae, Opiliones, and Araneida). A mechanism against predators is especially important for species like *M. collaris* which occur in 'colonies', often with high densities.

CALORIC AND WATER CONTENT

Table IV shows no significant difference between the caloric content of male and female imagines collected very soon after snow melt, nor between different dry weight groups within each sex (t-test). After hibernation, the fat content is evidently on the same level in all animals. The mean caloric value after a feeding period is somewhat higher (5685 cal/g), (Hågvar & Østbye 1974).

The water content immediately after hibernation is related to dry weight in different ways in males and females (Fig. 15). Males show the typical decline in water percentage with increasing dry weight, which has been

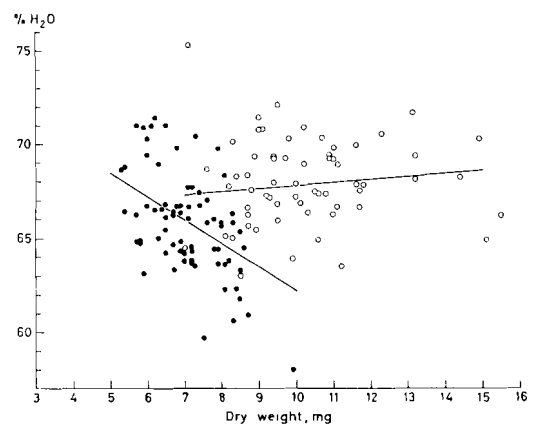


Fig. 15. Water percentage of *M. collaris* imagines, plotted against dry weight. Dots: males, open circles: females. Regression lines for males and females are given. The animals were collected soon after snow melt.

found in all other coleopterous species investigated at Finse (Hågvar & Østbye 1974), while the mean water percentage of females is quite constant. The variation around both regression lines is, however, great.

Earlier investigations (e. g. Skar, Hagen & Østbye 1972, Hågvar & Østbye 1974) have indicated that a correlation exists between a high fat (and caloric) content, and a low water percentage in animal tissue. This is, however, not the case with *M. collaris* males immediately after hibernation. Evidently the water percent in some cases may decrease with increasing dry weight, without any corresponding increase in caloric content.

The water percentage in pupae of *Zygaena exulans* Hochw. (Lep.) at Finse decreases with increasing dry weight (Hågvar & Østbye 1974). Pupae of *M. collaris*, however, show the opposite picture (Fig. 16).

DISCUSSION

M. collaris is found in Middle and North Europe, and in Siberia (Strand 1944). The species occurs both in alpine habitats and below the timber line down to sea level. Different species of *Salix* sp. seem to be the overall feeding preference. In Denmark *M. collaris* occurs mainly on *S. repens* L. (Hansen 1927), which is only 10 cm high. The tendency to stay near the ground may be a general feature of the species.

M. collaris is obviously not exclusively

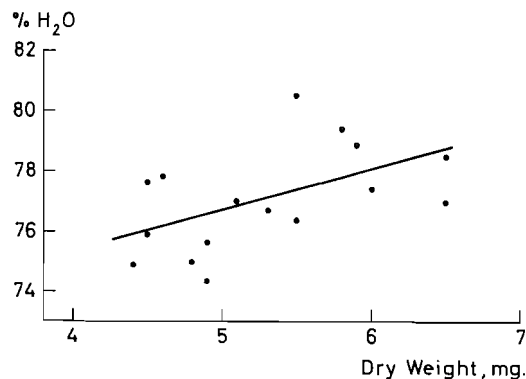


Fig. 16. Relation between water percent and dry weight in pupae of *M. collaris*.

adapted for alpine habitats, being a more 'all-round' species. As stated by Mani (1968) and others, the number of insect species decreases markedly with increasing altitude, and most species occurring in lowlands are not found above the timber line. The question therefore arises: What makes *M. collaris* so successful in alpine habitats?

A main factor regulating the number of herbivore insect species above the timber line is the limited number of host plant species.

As for *M. collaris*, however, one of its favourite host plants occurs in alpine conditions in great amounts, even to a large extent forming almost monocultures. As other invertebrates feeding on *S. herbacea* consume only a very small part of the primary production, *M. collaris* in this respect meets no competition. Together with the ability to survive the alpine climate, the good feeding conditions explain the presence and high densities of the species.

A common mode of adaptation to cold alpine and arctic conditions is to extend the life cycle over two or more years (Downes 1962, Mani 1968). *M. collaris*, however, fulfils its life cycle during the few snow-free months of the mid-alpine region. It seems that this ability can be explained through a combination of the following factors.

In spring, imagines become active immediately after snow melt; they feed on the unopened shoots of *S. herbacea* which have a much higher caloric content than leaves (Hågvar in manus). The eggs are laid after a short time, and during a short period. All eggs are deposited in those parts of the *S. herbacea* habitats which melt off so early that development can be fulfilled during the snow-free period. The larvae, which in first instar are unable to feed on unopened shoots, hatch soon after the leaves have developed. During the early melting period, imagines tend to aggregate along the snow border, being positively phototrophic. This ensures effective copulation within the populations. The larvae grow fast and have an unusually high assimilation efficiency (Hågvar in manus). The number of instars is low, which means few ecdyses and few interruptions in the feeding activity. Both larvae and imagines react spontaneously to even short periods of favourable weather, and they may also be active at temperatures close to 0° C. Clima-

cally the habitat is characterized by consistently low wind speeds and by high temperatures in sunshine. *M. collaris* tolerate such wide changes in temperature.

Because of the short summer, *M. collaris* depends on using those *S. herbacea* habitats where snow melt is early. Some imagines still hatch as late as the beginning of September. An extensive migration activity, especially by imagines of the new generation in late summer, would have resulted in only a part of the population hibernating in the early snow-free areas where eggs have to be laid soon after melting. The non-use of wings is therefore a good adaptation to alpine conditions. The new generation appears within the same area where the eggs were laid, and hibernation occurs here also.

Having considered several factors which evidently make the species successful in alpine habitats, it is also clear that strong ecological limitations exist. The major areas containing almost monocultures of the host plant are not available for the species. In this respect the one-year life cycle is the limiting factor, as a change to a two- or three-year life cycle would allow the species to colonize far greater areas than colonized at present. The bush-formed *Salix* species occurring in the area, which represent a favourite food source in the laboratory, are not used in the field, probably because of wind.

Very little of the total green primary production of *S. herbacea* is consumed by other species. Therefore, the major part of what is left by *M. collaris* is channelled directly through the decompositors' food chain. *S. herbacea* communities often contain a well-developed litter layer, but dead leaves may in many habitats be blown away. In a *S. herbacea* community where snow melt is so late that it was not used by *M. collaris*, and where in some parts there was a well-developed litter layer, the density of Collembola and Acarina was rather high. However, the number of larger invertebrate species developing in the area, and their total density, was very low. The only invertebrates which might to any extent feed directly on *S. herbacea* were *Otiorrhynchus dubius* Ström (Col., Curculionidae) and a few larvae of Lepidoptera and Hymenoptera Symphyta (Hågvar, Melåen & Østbye 1974). Feeding marks on the leaves could scarcely be seen. It seems

therefore that if *M. collaris* had been absent from alpine communities, close to 100 % of the total green production of *S. herbacea* would have been consumed directly by decompositors. Evidently *M. collaris* has occupied a very open niche, although only imperfectly.

Among the restricted number of coleopterous species occurring in alpine habitats, Chrysomelid species are not typical (Mani 1968). Whether this can be explained mainly by the limited number of host plant species or by abiotic factors is difficult to determine.

Small-rodent cycles are very pronounced in the Finse area. During peak years the vegetation may be strongly destroyed, even in *S. herbacea* communities. It is highly probable that this affects both the overwintering population of *M. collaris* and the primary production of *S. herbacea*. Closer investigations are needed to state whether the population changes of *M. collaris* follow the small-rodent cycles.

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On the ecology and distribution of *Chaoborus* (Chaoboridae, Diptera) from the Upper Romerike District, south-east Norway

DAG HONGVE

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The occurrence of *Chaoborus* was investigated in 28 lakes. Two species were found, *C. flavicans* in 16 lakes and *C. obscuripes* in four. Larvae were usually pelagic in meromictic lakes and in lakes with a total hypolimnetic oxygen deficit. In these, the larvae remain in the oxygen-free hypolimnion during the day.

Some factors which may affect distribution are discussed. The O₂ concentration of hypolimnion was the only one of importance. A negative correlation was found between the density of other zooplankton organisms and *Chaoborus* larvae. For the first time, larvae of *C. obscuripes* were discovered in lakes deeper than 5 m. In these lakes they are never benthic.

Dag Hongve, Department of Limnology, University of Oslo, P. O. Box 1027 Blindern, Oslo 3, Norway.

The transparent larvae of the Chaoboridae, which are the only true planktonic insects, have been an interesting field of investigation for many freshwater biologists and invertebrate physiologists (see Roth & Parma 1970). Many investigations have been carried out on populations in single lakes, while some publications have also considered distribution over larger areas in relation to habitat factors (e.g. Parma 1969, Pope et al. 1973). The paper of Nilssen (1974) summarizes the present knowledge of the distribution of *Chaoborus* in Norway.

The most common species in Norway, and the only ones present in the study area, are *Chaoborus flavicans* (Meigen) and *C. obscuripes* (v.d. Wulp). The study area is situated in Romerike district (Akershus county, south-east Norway). Geographical coordinates about 60° 10' N, 11° 10' E. It is a relatively flat area covered by forest and farmland. It contains 28 kettle lakes and tarns of different sizes and depths (Table I and Fig. 1). These lakes are

well suited for investigations of the relationships between the distribution of species and habitat factors.

MATERIAL AND METHODS

The *Chaoborus* larvae were mainly collected by means of a plankton net with opening 0.05 m² and mesh width 335 µm. This was always lowered to less than half a metre from the bottom at the deepest point of the lake and then elevated to the surface with a constant speed of about 0.5 m/s. Samples were taken in each lake once or twice during summer 1972 and six times, at regular intervals, during 1973.

During sampling the coarse net did not clog and sampled much better than finer ones. This method may be considered as semi-quantitative, permitting comparison in time and between different lakes. The depth distri-

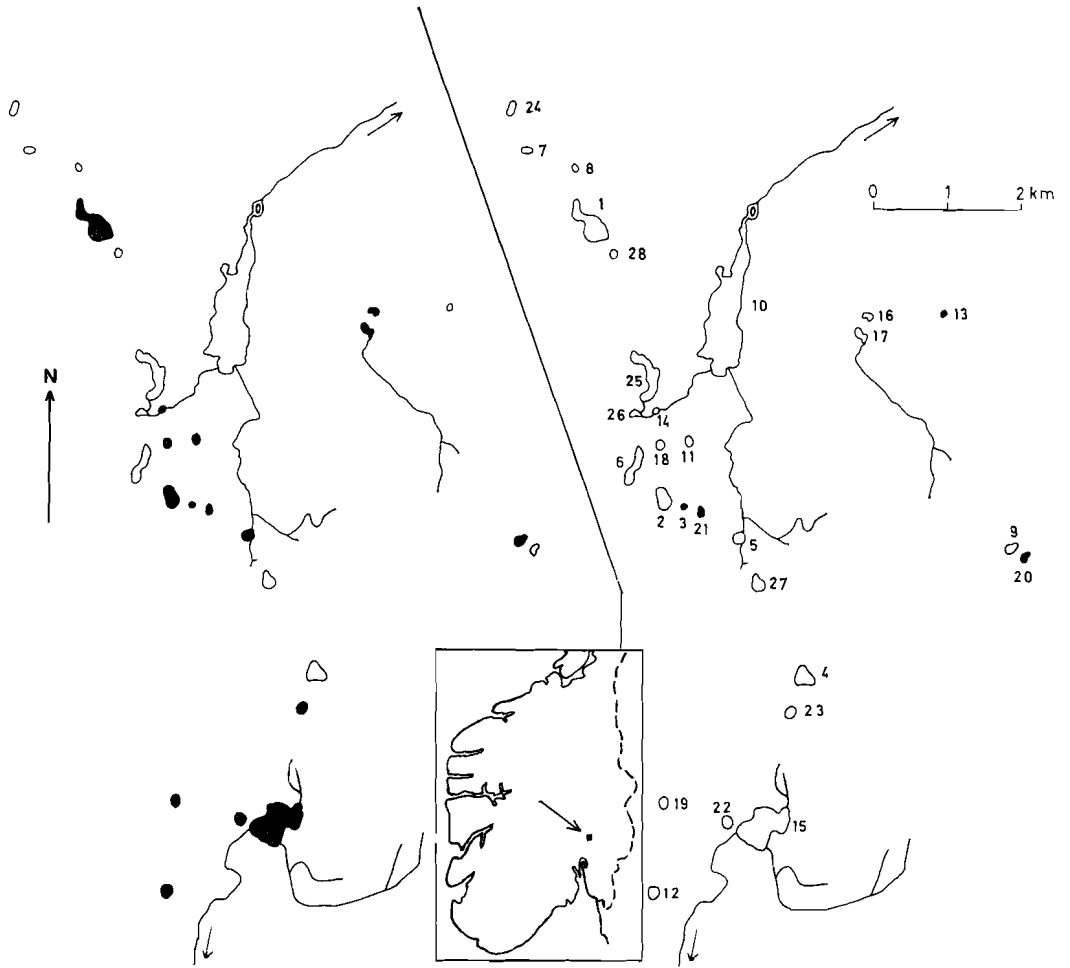


Fig. 1. Location of the investigated lakes and occurrence of *Chaoborus*. Left: *C. flavicans* (black), right: *C. obscuripes* (black).

bution of the larvae was investigated once in three lakes by means a Schindler sampler of volume 48 l. Samples were taken for each metre depth and filtered through a net with mesh width 90 μ m. To obtain a true picture of population densities, more laborious methods of collection, using water and bottom samplers, would have been necessary. Recording of larval occurrence can, however, be carried out solely by means of a plankton net. Since the early larval instars are planktonic (Parma 1971a), these will be taken when sampling at the appropriate time of the year. When the topography of the bottom of the lakes is known, sampling at the deepest points will also give the greatest probability

of obtaining the later instars. This is the case especially in meromictic lakes, where they are to a large extent pelagic throughout the larval period. Also in lakes which are oxygenated throughout, larvae have been observed in the deeper strata during daytime (Jónasson 1972). Bottom samples have only been taken in two of the lakes (Nos. 1 and 15), where a 200 cm² Ekman grab was used. The samples were taken at various depths, but no larvae were found when the material was filtered. A total of about 4300 larvae were collected, 4000 of which were taken by means of the plankton net. The species were identified after Sæther (1972). In some cases the instars were also determined after Parma (1971b).

Table I. Some important characteristics of the lakes. Hydrographical values are means for six investigations during 1973.

No.	Name	Area (ha)	Depth (m)	KMnO ₄ consump- tion (mg/l)	κ ₁₈ μS/cm	pH	Ca (mg/l)	time of total O ₂ depletion	Chaoborus	
									flavicans	obscuripes
1	Aurtjern	12.4	16.5	8.7	30	6.5	4.1	permanent	x	
2	Bakketjern	2.3	14.5	19.0	70	6.9	14.8	permanent	x	
3	Vesle Bakketjern	0.3	9.5	118.	27	4.4	1.3	permanent	x	x
4	Bonntjern	4.6	9.0	15.4	54	6.9	10.2			
5	Dagsjøen	2.0	7.0	8.5	203	7.4	41.4	summer/winter	x	
6	Danielsetertjern	4.8	5.5	11.6	132	7.3	27.8			
7	Flatnertjernet	1.0	5.0	9.6	13	4.4	0.5			
8	Fugletjernet	0.6	1.5	13.3	12	5.4	0.9			
9	Gråvtjern	1.7	7.0	35.1	58	6.8	10.3	permanent	x	
10	Hersjøen	64.0	16.5	5.2	186	7.6	35.9	summer/winter		
11	Katt-tjern	1.3	13.5	13.6	16	5.6	0.9	summer/winter	x	
12	Ljøgodttjern	2.4	16.0	12.0	76	6.9	12.3	permanent	x	
13	Majorsetertjern	0.1	6.5	18.1	19	5.5	1.8	summer/winter		x
14	Mjøntjern	0.6	8.5	5.8	238	7.5	49.1	summer/winter	x	
15	Nordbytjernet	26.4	23.5	10.0	175	7.2	32.1	permanent	x	
16	Nordkulpen	0.5	3.0	49.8	34	5.8	4.2	summer	x	
17	Sandtjernet	1.5	7.0	58.6	37	5.5	4.6	summer/winter	x	
18	Skråttjern	0.9	11.5	14.9	102	7.1	22.4	permanent	x	
19	Skånetjern	1.1	5.5	57.2	64	6.7	10.0	summer/winter	x	
20	Sofrødtjern	1.0	3.0	27.0	31	6.3	4.0			x
21	Stormåsan	0.9	5.5	56.4	17	4.2	0.3	summer	x	x
22	Svarttjern	2.2	10.5	5.1	183	7.1	34.6	winter	x	
23	Svenskestutjern	2.2	17.0	5.3	14	5.2	0.8	summer	x	
24	Sørmotjernet	1.6	5.0	19.4	14	4.6	0.5			
25	Transjøen	9.3	22.0	5.4	271	7.7	55.3	permanent		
26	Vesletjern	0.8	4.0	5.6	279	7.6	55.1			
27	Vilbergjtjern	2.4	17.0	11.3	13	5.6	0.9	permanent		
28	Vollsnepputten	0.8	4.0	12.5	17	6.0	1.3	winter		

The length of the larvae was measured under a dissecting microscope.

Hydrographical investigations were carried out for at least one year in all the lakes. In 1973 samples from different depths over the deepest point were taken six times at regular intervals. The values in Table I are arithmetical means of all the samples taken from the circulating parts of the lakes during 1973.

DEPTH DISTRIBUTION AND LARVAL GROWTH

The classical pattern of migration for *Chaoborus* larvae is an ascent to the limnetic zone in the evening and a descent to the bottom in the morning, although several authors have also reported different patterns of migration (see Sæther 1972). They may thus be pelagic in all or greater parts of their larval period. There are also differences between the larval instars. The two first ones

are unaffected by light and may be permanently present in the epilimnion, whilst the two last ones are migratory (Teraguchi & Northcote 1966, Parma 1971a). The results of the present investigation show that within the area all instars may be pelagic during the day, largely dependent on the oxygen conditions near the bottom.

Chaoborus flavicans was found in 16 of the lakes (Tables I and II), seven of which are meromictic; in six of the meromictic lakes *C. flavicans* was found in every net haul but one. In the others, occurrence varied with changing oxygen conditions. Most records are from August, when oxygen concentrations in the hypolimnions are at a minimum. In this month, larvae were found in seven other lakes, six of which had a complete oxygen deficit in the bottom strata. By means of a transparent water sampler, used for hydrographical investigations, large larval densities were often observed in the anaerobic stratum of the meromictic lakes. It is probable that

Table II. *Chaoborus flavicans*. No. of specimens in net hauls 1972 - 1973.

Lake	Date intervals											total
	3 Jun 11 Jul	26 Jun 22 Jul	4 Jan 22 Jan	19 Mar 4 Apr	7 May 24 May	12 Aug 21 Aug	15 Oct 25 Oct	4 Dec 18 Dec				
1		1	0	0	0	0	0	0	0	1		
2		3	11	4	6	5	4	10	43			
3		26	1	3	6	11	3	5	55			
5		11	0	0	0	8	0	0	19			
9		35	15	10	1	12	1	15	90			
11		313	0	0	0	0	1	0	314			
12		220	196	334	98	211	19	112	1190			
14		229	1	0	1	110	0	0	341			
15		1	1	3	1	1	1	0	8			
16			1	0	0	9	0	1	11			
17	60	70	8	4	43	115	16	60	376			
18		92	22	34	1	12	3	8	173			
19		3	1	0	1	2	0	0	9			
21		5	1	3	5	20	0	0	34			
22		0	0	0	0	0	1	0	1			
23	0	0	0	0	1	0	0	0	1			
total	60	1009	258	395	162	521	49	211	2666			

C. flavicans has a diurnal migration between the monimolimnion and epilimnion in these lakes. The depth distribution of *C. flavicans* during the day (3 July 1974) in two meromictic lakes is shown in Fig. 2.

Ljøgdottjern (lake No. 12) is an iron meromictic, eutrophic clearwater lake, where the greatest concentration of larvae (mainly fourth instar) was in the upper part of the monimolimnion. Some larvae occurred down to the bottom where the concentration of iron was more than 70 mg/l (Fig. 2). Vesle Bakketjern (lake No. 3) is the most humic influenced of the investigated lakes. Water colour in terms of mg Pt/l is usually about 120, and Secchi disc transparency 1.5 m. In this lake, where light conditions are very poor, the greatest density of larvae (mainly third instar) was at 3 m.

Chaoborus obscuripes, which occurred in four of the lakes (Tables I and III), has often been observed to have another depth distribution. Large larvae have been observed several times from the boat as they swim just beneath the surface on sunny days. The depth distribu-

Table III. *Chaoborus obscuripes*. No. of specimens in net hauls 1972 - 1973.

Lake	Date intervals											total
	30 Jun 4 Jul	15 Jan 22 Jan	26 Mar 5 Apr	7 May 14 May	5 Aug 21 Aug	22 Oct 29 Oct	12 Dec 18 Dec					
3	22	8	1	2	19	0	11	63				
13	97	2	9	6	23	14	7	159				
20			3		22			25				
21	89	3	0	2	2			96				
total	208	14	13	10	66	14	18	343				

tion of *C. obscuripes* in two lakes is also shown in Fig. 2. In Vesle Bakketjern the main occurrence was from the surface down to 1 m, where largely fourth instar larvae were present. Thus, the two *Chaoborus* species were inhabiting different strata of the lake during the day. In Majorsetertjern, which is much less humic influenced, the main occurrence was at 4 m (third instar larvae). Larvae have also often been observed here near the surface, and their absence may have been caused by an abundance of dytiscid larvae.

From Table IV it can be seen that larvae of *C. flavicans* in all stages of development longer than 5 mm occur in the plankton throughout the year, but most plentiful are fourth instar larvae about 11 mm long. During the summer smaller specimens are mostly present. The major part of fourth instar larvae then constitute the new year's generation, reaching a length of 9 to 10 mm. The two first instars are only found during the summer. The first 3 mm long larvae of the new generation were found on 26 June. This agrees with the findings of Hirvenoja (1960) in Finland and of Parma (1971a) in the Netherlands, whereas Jónasson (1972) in Denmark found that hatching of eggs first occurred in August.

The emergence and oviposition of *C. obscuripes* starts earlier in the year than that of *C. flavicans*. In June/July 1972 none of the

Table IV. Percentage distribution of length (mm) of *Chaoborus flavicans* larvae in net hauls 1972 - 1973.

Date	Length												
	2	3	4	5	6	7	8	9	10	11	12	13	
26 Jun - 31 Jul		2.2	7.5	33.0	18.6	13.6	6.3	5.8	8.3	4.0	0.5	0.2	
4 Jan - 22 Jan				0.8	6.6	4.3	5.4	1.2	15.0	49.2	17.1	0.4	
19 Mar - 4 Apr					2.8	2.0	1.3	1.8	15.2	50.6	23.0	3.3	
7 May - 24 May						11.0	1.8	0.6	11.7	48.5	25.8	0.6	
12 Aug - 21 Aug	0.4	5.4	4.8	8.4	5.6	3.3	8.6	21.3	27.8	13.6	0.8		
15 Oct - 25 Oct				2.0	10.2	28.6	10.2	2.0	8.2	24.5	14.3		
4 Dec - 18 Dec				0.5	3.8	15.6	10.0	2.8	10.9	40.3	15.6		

Table V. Percentage distribution of length (mm) of *Chaoborus obscuripes* larvae in net hauls 1972 - 1973.

Date	Length														
	3	4	5	6	7	8	9	10	11	12	13	14	15		
30 Jun - 4 Jul		9.1	49.3	19.1	20.6	1.4	0.5								
15 Jan - 22 Jan								7.1	14.3	21.4	57.1				
26 Mar - 5 Apr							15.4	7.7	7.7	15.4	38.5	15.4			
7 May - 14 May			10.0				20.0	20.0	30.0	20.0					
5 Aug - 21 Aug	3.1	1.6	3.1	1.6	1.6		4.4	26.6	40.6	17.2	3.1				
22 Oct - 25 Oct						7.1					21.4	42.9	28.6		
12 Dec - 18 Dec						16.7	5.6	16.7	5.6	22.2	33.3				

former year's generation were found (Table V). The same was the case when the depth distribution was investigated on 2 July 1974. In Vesle Bakketjern fourth instar larvae were the only ones present in December 1973, but as early as 24 May 1974 only first instar larvae could be found.

The total picture obtained after the study of the net samples indicates the following life-cycle patterns:

Chaoborus flavicans is univoltine. Hatching of eggs occurs during the summer months and the larvae go through the first two limnetic instars in the same summer. In the autumn most larvae have reached the fourth instar. In the late autumn, when the oxygen conditions are generally good, the larvae are mostly benthic during the day. With a few exceptions, pelagic larvae are then only found in the meromictic lakes or lakes which have still not attained full circulation.

During the winter, as oxygen conditions become poorer in the ice-covered lakes, greater numbers of larvae become pelagic. In the spring, partial circulation improves the oxygen conditions and fewer pelagic individuals are found. Pupation and emergence takes place during a long period in the summer.

Chaoborus obscuripes has more or less the same life-cycle pattern as *C. flavicans*, except that emergence and oviposition takes place earlier in the year. The larvae also seem to be permanently pelagic in lakes with hypolimnetic oxygen deficit.

DISTRIBUTION OF CHAOBORUS LARVAE IN RELATION TO SELECTED HABITAT FACTORS

The larvae of *Chaoborus* have been found in a wide variety of aquatic habitats and are

considered as rather euryecious species (Parma 1969, Sæther 1972, Nilssen 1974). Most authors consider the chemical conditions of the lake waters to be unimportant in determining distribution, whilst stratification and hypolimnetic O₂ deficit (Stahl 1966) and zooplankton density (Parma 1969, Sæther 1972) are considered as essential factors. It has been stated that the densest populations occur in dystrophic and eutrophic lakes.

In such localities the above-mentioned factors may become extreme. As mentioned by Nilssen (1974), neither these nor other parameters such as Secchi disc transparency, humic influence, and predation pressure can be considered separately, since they are to a great extent interrelated. A further analysis of the importance of the individual factors can only be done in a system where these parameters are as independent as possible. Such a well-suited system is found in the aggregation of kettle lakes in the Romerike district. The investigated area contains a broad spectrum of ionic composition, humic influence, stratification and O₂ deficit, zooplankton density, and predation pressure. In this area most of these factors are unusually independent due to the special features of the lakes such as small surface areas, greatly varying depths in relation to surface areas, and different groundwater influence.

Chemistry

The present observations agree fully with the assumptions of Parma (1969) and Sæther (1972) that the lakes' chemistry is unimportant in distribution. In Fig. 3 the distribution of the two *Chaoborus* species in relation to total electrolyte content of the lake waters is shown. Similar figures would have shown that the distribution is independent of the

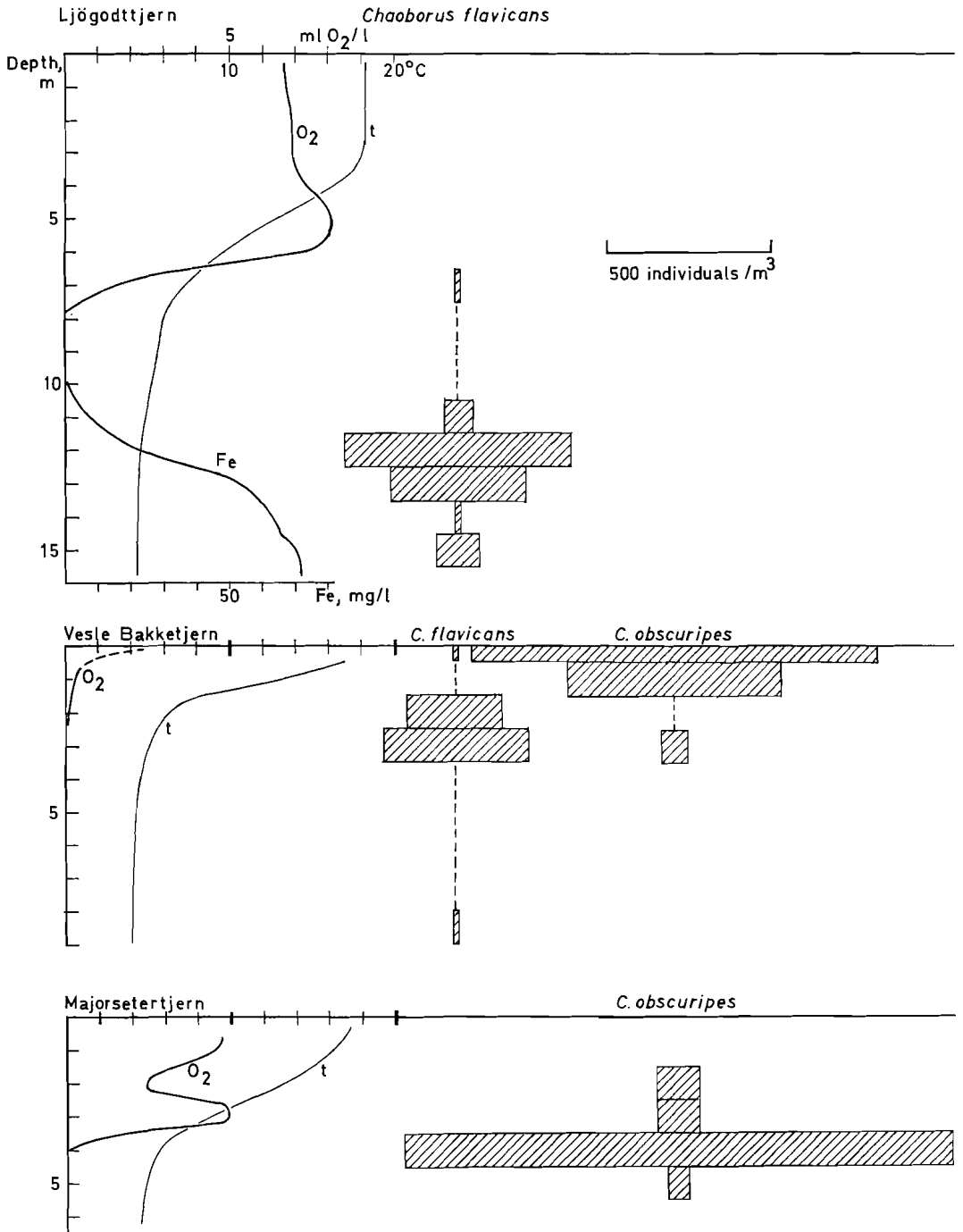


Fig. 2. Depth distribution of pelagic *Chaoborus* larvae around noon on 3 July 1974.

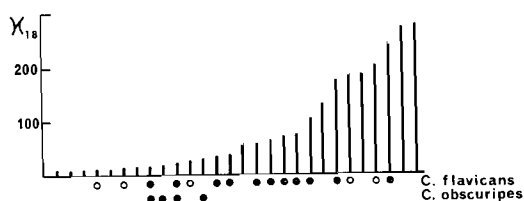


Fig. 3. Distribution of *Chaoborus* larvae in relation to total electrolyte content of lake waters. Black circles: rich occurrence, open circles: minor occurrence. Each column represents one lake.

concentration of any of the major constituents of the lake waters.

Humic content

The degree of dystrophy can be expressed as the concentration of humic substances in the water and measured as consumed $KMnO_4$. In Fig. 4 the distribution of *Chaoborus* is related to increasing $KMnO_4$ consumption. The larvae have been found throughout the entire spectrum of humic-influenced lakes. Although most records are from lakes with high humic contents, this relationship must not be seen separately, since the lakes with highest humic contents also tend to be the ones most liable to become anaerobic in the hypolimnion.

Hypolimnetic O₂ deficit

Frey (1964) regarded *Chaoborus* larvae as indicators of lakes with greatly reduced oxygen concentration in their deep waters, and Stahl (1966) related the distribution and density of *Chaoborus* populations to stratification and hypolimnetical O_2 deficit. In the present case, distribution seems to be even better correlated with the degree of O_2 deficit (Table VI) than with humic content.

A second method which has been used for expressing the same relationship (Stahl 1966

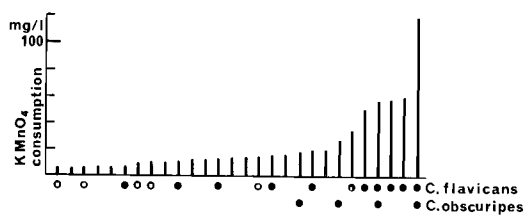


Fig. 4. Distribution of *Chaoborus* larvae in relation to $KMnO_4$ consumption. Symbols as in Fig. 3.

and Nilssen 1974) is to see in which of the three lake classes of Hutchinson (1957), based on stratification, the larvae occur. These two former authors added two classes, one for meromictic lakes and one for pools. A scheme based on these classes is set up in Table VII. (Strictly speaking this is not quite correct since most of the holomictic lakes in the district are not dimictic as presupposed by Hutchinson, but only have full circulation in the autumn.)

There is also a good correlation between lake category and *Chaoborus* occurrence. This indicates that the larvae prefer thermally stratified lakes with a hypolimnetical O_2 deficit.

Predation

A negative relationship between *Chaoborus* density and the occurrence of fish has been clearly shown by Pope et al. (1973). In contrast no such relationship seems to exist in *C. flavicans* in the present case (Table VIII). This is probably a consequence of the total hypolimnetical O_2 deficit which is present during all or most of the year in the lakes

Table VI. Distribution of *Chaoborus* in relation to time of total hypolimnetical O_2 deficit.

	Time of total O_2 deficit				
	permanent	winter summer	summer	winter	never
Total no. of lakes	9	7	3	2	7
Lakes with <i>C. flavicans</i>	7	5	3	1	0
Lakes with <i>C. obscuripes</i>	1	1	1	0	1
Total no. of lakes with <i>Chaoborus</i>	7	6	3	1	1

Table VII. Distribution of *Chaoborus* in different lake classes. I: thermally stratified, bottom temperature near 4 C, II: thermally stratified, bottom temperature well above 4 C, III: unstratified, M: meromictic, P: pond.

	Lake class				
	I	II	III	M	P
Total no. of lakes	2	9	7	9	1
Lakes with <i>C. flavicans</i>	2	6	1	7	0
Lakes with <i>C. obscuripes</i>	0	2	1	1	0
Total no. of lakes with <i>Chaoborus</i>	2	7	2	7	0

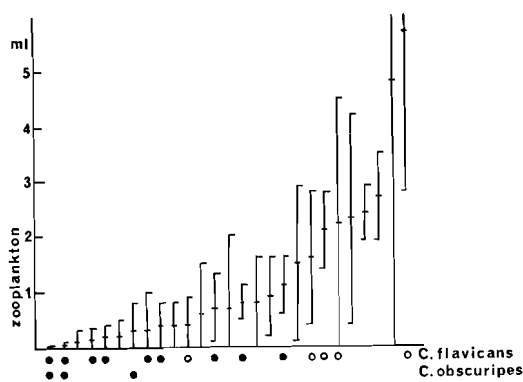


Fig. 5. Distribution of *Chaoborus* larvae in relation to wet volume of zooplankton in net hauls. Mean values and standard deviations of zooplankton volume are given for each lake. Other symbols as in Fig. 3.

in winter. It is also probable that the densest *Chaoborus* populations in Romerike have other food items among the zoobenthos.

Among the factors discussed, stratification and hypolimnetical O_2 deficit are the only ones which influence the distribution of *Chaoborus*. Nevertheless, *Chaoborus* is found in all classes of lakes, including unstratified ones. This shows the great ecological plasticity and tolerance of the species.

The total lack of larvae in some lakes should therefore be ascribed rather to emergence and oviposition than to conditions affecting the survival of the larvae.

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Energy budget of a population of adult *Carabodes labyrinthicus* (Mich.) (Acari, Oribatei)

ANDREAS L. STEIGEN, TORSTEIN SOLHØY & GÖRAN GYLLENBERG

Steigen, A. L., Solhøy, T. & Gyllenberg, G. 1975. Energy budget of a population of adult *Carabodes labyrinthicus* (Mich.) (Acari, Oribatei). *Norw. J. Ent.* 22, 59–61.

Ingestion, assimilation, and egestion rates of the oribatid mite *Carabodes labyrinthicus* (Mich.) collected on a lichen heath at Stigstuv, Hardangervidda 1225 m a.s.l. were investigated at 10°C using ¹⁴C technique. Average individual ingestion rate was 0.45 cal/day × 10⁻³. Assimilation and egestion rates were 0.18 and 0.27 cal/day × 10⁻³ respectively. Estimated consumption of the field population during the snow-free period in 1972 was 186 cal/m². Corresponding assimilation and egestion rates were 75 and 111 cal/m² respectively. The A/C index for the population was 0.40. Results compiled from other authors were in concordance with the results obtained for *C. labyrinthicus*.

Andreas L. Steigen & Torstein Solhøy, Zoological Museum, Dept. of Animal Ecology, University of Bergen, N-5014 Bergen-Univ., Norway.

Göran Gyllenberg, Dept. of Zoology, University of Helsinki, Helsinki, Finland.

Most information on the feeding and feeding activity of oribatid mites is qualitative; only a few quantitative measurements of ingestion, assimilation, and egestion have so far been made. The most recent studies are those by Luxton (1972) on *Damaeus clavipes* (Herm.), and by Webb & Elmes (1972) on *Steganacarus magnus* (Nic.).

MATERIALS AND METHODS

Adult specimens of *Carabodes labyrinthicus* (Mich.) were collected during July 1972 on a lichen heath at Stigstuv, Hardangervidda 1225 m a.s.l. (60° 18' N.L., 7° 40' E.). A description of the study area was given by Solhøy (1972).

C. labyrinthicus is the most abundant oribatid species at the site. The average biomass of adults is about 40% of the total biomass of mites in the lichen and litter layers. The species is tolerant to relatively dry conditions and high temperatures. On the lichen heath it was almost exclusively found in the litter and the lower part of the lichen carpet.

In the laboratory, the mites were fed on fungal hyphae labelled with ¹⁴C at a constant temperature of 10°C. The hyphae had been made radioactive by being grown on fresh cucumber leaves that had been exposed to ¹⁴CO₂-treated atmosphere for five days.

¹⁴C was used because uptake of the other possible isotope, ³²P, seems to be strongly biased in relation to the amount of food required by the animals (see also Webb & Elmes 1972). On the other hand, ¹⁴C isotopes have a rather low beta energy and must be counted in a liquid scintillation counter. This makes it impossible to measure the radioactivity in a living animal.

After the animals had been fed for three days on the radioactive hyphae, a sample was taken and radioactivity measured. The remaining animals were transferred to non-radioactive food and the decrease in body radioactivity was measured on samples taken at intervals.

According to values given by Hanssen et al. (1973), the average calorific content of hyphae is 4.5 cal/mg dw.

Calories consumed, assimilated, and egested

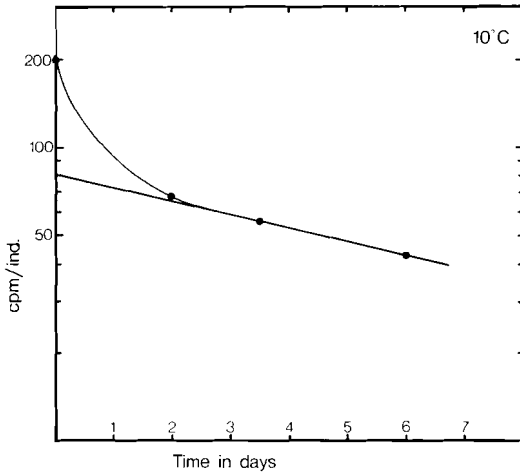


Fig. 1. Radioisotope elimination curve for adult *Carabodes labyrinthicus* (Mich.) from Hardangervidda.

by each animal/day have been calculated, assuming that the animal preferentially does not digest nutrients of particularly high or low calorific content. All calculations are based on dry weights.

RESULTS

The results of the experiment are shown in Table I and plotted in Fig. 1. From this graph the amount of ¹⁴C assimilated by the animals was extrapolated. At the time t₀ the assimilated fraction was 40% of the ingested material. The radioactivity of the hyphae was 661,000 cpm (counts per minute). Trophic rates obtained from the laboratory experiments are given in Table II.

In 1970 the mean density of adults on the lichen heath was 3450 individuals/m², equiv-

Table I. Radioactivity of adult *Carabodes labyrinthicus* (Mich.) following three days feeding on radioactive hyphae.

Days on non-radioactive food	n	Dry weight in µg \bar{X}	Total radio-activity cpm	cpm/animal	cpm/µg dw
0	35	7.17	6.917	198	27.6
2	20	7.21	1.360	68	9.4
3	21	6.94	1.243	59	8.5
6	19	6.70	826	43	6.5

Table II. Ingestion-, assimilation-, and egestion rates obtained for *C. labyrinthicus* from laboratory experiments carried out at 10°C.

	µg/anim. per day	% of total dw of anim.	Cal./day x 10 ⁻³
Ingestion rate	0.1	1.4	0.45
Assimilation rate	0.04	0.6	0.18
Egestion rate	0.06	0.8	0.27

alent to a dry weight of 26.2 mg. The soil surface was unfrozen for about 120 days, and the mean litter temperature in this period was 9.8°C.

In Table III the consumption (C), assimilation (A) and egestion (FU) rates and A/C ratio for this time-interval are shown.

DISCUSSION

Our laboratory measurements of consumption rates correspond with estimates given by other authors (Table IV). The consumption rates expressed as a percentage of dry body weight vary from 1.5 to 9.0 at different temperatures. Exceptions are those of Kowal (1969) and Engelmann (1961) which are rather high. Taking the different temperatures into consideration, our results for *C. labyrinthicus* agree with values for unspecified *Carabodidae* given by MacBrayer & Reichle (1971). Some of the differences in the results may be due to the great variation in methods applied (cf. footnote to Table IV).

The A/C ratio for *C. labyrinthicus* is a little lower than most values in Table IV, but is within the range that could be expected for a mycophagous animal. For herbivorous animals, Van Hook (1971) gives an index of 0.41, and the same value was obtained for the homopteran *Neophilaenus lineatus* (L.) by Hinton (1971).

Table III. Consumption (C), assimilation (A), egestion (FU) and A/C ratio for a population of *C. labyrinthicus* in the four month period of unfrozen soil surface on the lichen heath in 1970. Feeding experiments were carried out at 10 °C.

C	186 cal/m ² /year
A	75 »
FU	111 »
A/C	0.40

Table IV. Compilation of consumption and assimilation rates of oribatid mites.

Species	Temp. °C	Consumption % of dry body weight/day	A/C ratio	Author
<i>Steganacarus magnus</i> (Nic.)	5	1.5 a	0.50	Murphy 1953
"	18	2.0 b	0.12	Berthet 1964
"	18	3.2 c	0.47	Webb & Elmes 1972
Several species	20	1.7-9.0 d	-	MacBrayer & Reichle 1971
"Carabodidae"	20	2.5 d	-	"
<i>Carabodes labyrinthicus</i> (Mich.)	10	1.4 e	0.41	Present study
<i>Damaeus clavipes</i> (Herm.)	15	9.0 c	0.60	Luxton 1972
<i>Cultroribula juncta</i> (Mich.)	20	25.0 f		Kowal 1969
Several species	25	40.0 e	0.20	Engelmann 1961

a: gravimetric methods, b: ^{35}S isotope, c: ^{32}P isotope, d: ^{137}Cs isotope, e: ^{14}C isotope, f: ^{45}Ca isotope.

It is reasonable to assume that consumption is temperature dependent, but this has not yet been clearly shown for oribatid mites. If consumption varies fairly linearly, a good approximation to field conditions is obtained by using the seasonal mean temperature during the feeding experiments. We therefore chose a constant temperature of 10°C throughout the feeding period.

The errors which may be involved in transferring laboratory data to field conditions have been thoroughly considered by Macfadyen (1967) and Petruszewicz & Macfadyen (1970).

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Notes on the Pseudoscorpiones of Norway

FINN ERIK KLAUSEN

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A list of twelve species of Pseudoscorpiones is presented from different localities in the provinces of Hordaland and Vestfold. Three of the species are new to Norway: *Allochernes dubius* (Cambr.), *Allochernes wideri* (C. L. Koch), and *Toxochernes panzeri* (C. L. Koch). Brief notes on distribution and habitat are given.

Finn Erik Klausen, Zoological Museum, University of Bergen, N-5014 Bergen, Norway.

This material has been collected during the years 1970–1974 from different localities in the western and south-eastern parts of Norway, mainly in the counties of Hordaland and Vestfold. It comprises 337 specimens of 12 different species, three of them new to the country. The material is deposited at the Zoological Museum, University of Bergen.

Since Ellingsen's publications (Ellingsen 1897, 1901, 1903), no investigations have been carried out on the Norwegian pseudoscorpion fauna. His work was mainly concentrated in the Oslofjord region. Knowledge of the fauna is therefore scanty and insufficient, and almost nothing can be said on the distribution of Norwegian species.

The specimens in the present collection were partly picked by hand, partly sieved and extracted in Tullgren funnel. A lot of the collecting was from trees, mostly from inside hollow trunks of *Quercus robur*.

The letters and numerals given in brackets in the following text refer to the UTM coordinate system.

Chthonius ischnocheles (Hermann 1804)

HOy: Botanical gardens, Bergen (32V KN 974004). 7 Sept. 1974, 1 ♀, 18 Sept. 1974, 1 juv. In greenhouse.

Neobisium carcinoides (Hermann 1804)

HOy: Møkster, Austevoll (32V KM 823646). 24 June 1973, 1 ♂, 19 June 1974, 1 ♀. Storumsvågen, Os (32V LM 008750). 19 Feb. 1971, 2 ♀♀, 5 juv. Halhjem, Os (32V LM 024733). 7 Oct. 1973, 5 ♀♀, 5 ♂♂, 6 juv., 8 March 1974, 5 ♀♀, 2 ♂♂, 11 juv., 16 June 1974, 1 ♀, 3 ♂♂. Bjørnen, Os (32V LM 029726). 3 Nov. 1793, 3 ♀♀, 10 ♂♂, 21 juv., Ånuglo, Tysnes (32V LM 170480). 13 May 1970, 3 ♀♀, 4 ♂♂, 3 juv., 23 May 1970, 1 ♂. HOi: Lio, Kvinnherad (32V LM 225482). 12 May 1970, 1 ♀, 1 ♂. 13 May 1971, 1 ♀, 1 juv. Jemtelandsvatn, Kvinnherad (32V LM 375424). 14 May 1970, 6 ♀♀, 4 ♂♂, 2 juv. Staffvatn, Kvinnherad (32V LM 368413). 14 May 1970, 2 ♀♀, 2 ♂♂. Tråvikåsen, Kvinnherad (32V LM 218575). 23 May 1974, 3 ♀♀, 3 ♂♂, 5 juv. Dalen,

Varaldsøy, Kvinnherad (32V LM 329654). 11 May 1971, 2 ♀♀, 2 ♂♂. Murabotn, Kvinnherad (32V LM 3553). 19 May 1971, 3 ♂♂. Innstranda skole, Kvam (32V LM 417837). 10 Sept. 1974, 1 juv. Øyjordsvann, Røyrvik, Kvam (32V LM 408850). 10 Sept. 1974, 2 ♀♀, 3 ♂♂, 29 juv. Tørrvikbygd, Kvam (32V LM 430893). 10 Sept. 1974, 1 ♂, 3 juv. Ytstheim, Kvam (32V LM 453911). 10 Sept. 1974, 1 juv. Kvamskogen, Kvam (32V LM 340972). 10 Sept. 1974, 4 ♀♀, 2 ♂♂, 4 juv. Kvanndal, Granvin (32V LN 685055). 29 Sept. 1972, 1 ♂. VE: Gullkronen, Sem (32V NL 786728). 17 July 1974, 4 juv. Gullkronen, Sem (32V NL 788730). 28 Sept. 1974, 2 juv. Langvann, Ramnes (32V NL 682804). 25 Sept. 1974, 1 ♀, 2 juv. Borrevann, Borre (32V NL 822853). 26 Sept. 1974, 2 ♀♀.

Microbisium brevifemoratum (Ellingsen 1903)
HOy: Halhjem, Os (32V LM 024733). 8 March 1974, 3 ♀♀, 13 juv. In sphagnum bog with *Myrica gale*, *Calluna vulgaris*, *Erica* sp. and *Rhacomitrium lanuginosum*.

Microcreagris strandi (Ellingsen 1901)
HOi: Murabotn, Kvinnherad (32V LM 3553). 19 May 1971, 1 juv.

Cheiridium museorum (Leach 1817)
HOi: Avlsgården, Rosendal, Kvinnherad (32V LM 340539). 21 Aug. 1974, 1 ♀. Indoors. SFy: Halsvik, Gulen (32V KN 883518). 20 Nov. 1974, 1 juv. From litter in a wharfside shed.

Pselaphochernes scorpioides (Hermann 1804)
HOy: Botanical gardens, Bergen (32V KN 974004). 15 June 1974, 2 ♀♀. In compost heap. HOi: Dalen, Varaldsøy, Kvinnherad (32V LM 329654). 11 May 1971, 2 ♀♀, 4 ♂♂. Inside hollow trunk of *Quercus*. VE: Borrevann, Borre (32V NL 822853). 26 Sept. 1974, 1 ♀, 2 ♂♂. Inside hollow trunk of *Populus tremula*.

Allochernes dubius (Cambridge 1892)
HOy: Halhjem, Os (32V LM 024733). 7 Oct. 1973, 1 ♂. 16 June 1974, 4 ♀♀, 1 ♂, 1 juv. Ground level in pine forest with *Calluna vulgaris*, *Vaccinium* spp., *Empetrum nigrum*, *Pteridium aquilinum*, *Sphagnum* sp. and *Hylocomium splendens*. HOi: Innstranda skole, Røyrvik, Kvam (32V LM 417837). 10 Sept.

1974, 1 ♀. Inside hollow trunk of *Quercus*. VE: Gullkronen, Sem (32V NL 786728). 17 July 1974, 1 ♀. At ground level in deciduous forest with *Quercus*, *Fagus* and *Ulmus*.

Allochernes wideri (C. L. Koch 1843)
VE: Borrevann, Borre (32V NL 822853). 26 Sept. 1974, 10 ♀♀, 2 ♂♂, 17 juv. Inside hollow trunk of *Quercus*. 3 ♀♀, 2 ♂♂. In squirrel's nest in *Quercus*. Gullkronen, Sem (32V NL 788730). 28 Sept. 1974, 1 ♀. Inside hollow trunk of *Quercus*.

Toxochernes panzeri (C. L. Koch 1837)
VE: Borrevann, Borre (32V NL 822853). 26 Sept. 1974, 7 ♀♀, 4 ♂♂, 23 juv. Inside hollow trunk of *Populus tremula*. 1 juv. Inside hollow trunk of *Tilia* sp. AK: Asker kirke, Asker (32V NM 807351). 27 Sept. 1974, 1 juv. Inside hollow trunk of *Fraxinus excelsior*.

Toxochernes nigrimanus (Ellingsen 1897)
VE: Akersmyra, Sem (32V NL 762711). 12 April 1974, 1 juv. Under bark on a stump of coniferous tree.

Chernes cimicoides (Fabricius 1793)
HOi: Ytstheim, Kvam (32V LM 453911). 10 Sept. 1974, 1 ♀, 2 ♂♂, 12 juv. In nest of *Formica rufa* inside hollow trunk of *Quercus*. VE: Borrevann, Borre (32V NL 822853). 26 Sept. 1974, 1 juv. Inside hollow trunk of *Populus tremula*.

Chelifer cancroides (Linné 1758)
HOy: Mannsverk, Bergen (32V KM 996962). 23 May 1973, 1 ♂. Indoors. Solheimsgt., Bergen (32V KM 982992). 17 Sept. 1974, 2 ♀♀, 10 ♂♂, 2 juv. In bakery.

DISCUSSION

The majority of the collection consists of the common species *Neobisium carcinoides*. I consider it unnecessary to give more detailed information about this species apart from indication of locality. The species seems to be present in almost every kind of forest or open country habitat up to the subalpine region, as long as humidity is not too low.

The single specimen of *Microcreagris strandi* is an interesting find. This species was described by Ellingsen on three speci-

mens found in Hallingdal. Three more specimens were later found in Suldal (Ellingsen 1901, 1903). The only other record is from Karelen in Finland (Kaisila 1949). Kaisila presumed it to be endemic in Fennoscandia.

The following species are new to Norway: *Allochernes dubius*, *Allochernes wideri* and *Toxochernes panzeri*.

Lohmander (1939) gave in his work a list of 12 (13) species taken in Norway. In his opinion Ellingsen's *Chernes phaleratus* could either be *A. wideri* or *A. dubius* (Ellingsen 1897). As this is not yet confirmed the two species must be regarded as new to Norway.

A. wideri and *A. dubius* are both distributed nearly all over Europe (Beier 1963). In Sweden, Finland, Denmark, and the Latvian countries *A. wideri* has almost exclusively been taken either from old oaks or in the nests of ants (Lohmander 1939, Kaisila 1949). My own records from oaks fall neatly in line with this.

A. dubius is commonly looked upon as a ground species, with habitat ranging from the acid soil of pine forests to the neutral and base-rich conditions in deciduous forests, with preference for the last (Lohmander 1939, Beier 1963). Two of my records are from the ground layer of pine forest. The other two are from oak forest, one of them from the litter inside a hollow trunk.

T. panzeri is distributed in central and northern Europe up to England, Denmark, and southern Sweden. It is usually considered a synantrophic species, but can likewise be found in hollow trees and leaf litter away from man (Beier 1963). One of my records is from the hollow trunk of an old aspen, where it was found together with *Chernes*

cimicoides and *Pselaphochernes scorpioides*. Several other interesting groups were represented, including pauropods, proturs, and the diplopod *Polyxenus lagurus*. Lohmander also noted that *T. panzeri* is often found together with other species of pseudoscorpions (Lohmander 1939).

I have so far not been able to collect *A. wideri* and *T. panzeri* in the western parts of Norway. Further investigations will show if these two are more common in the eastern than western parts of the country.

ACKNOWLEDGEMENTS

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Aggregation pheromone in the bark beetle *Ips duplicatus* (Sahlberg)

ALF BAKKE

Bakke, Alf, 1975. Aggregation pheromone in the bark beetle *Ips duplicatus* (Sahlberg). *Norw. J. Ent.* 22, 67-69.

Gas chromatographic analysis indicates that the males of *Ips duplicatus* (Sahlberg), when initiating galleries or when exposed for 48 hrs to myrcene vapour, have in their hindgut a compound with the retention time of ipsdienol (2-methyl-6-methylene-2,7-octadien-4-ol). In field tests, flying beetles responded to synthetic ipsdienol.

Alf Bakke, Norwegian Forest Research Institute, N-1432 AS-NLH, Norway.

When bark beetles attack and colonize standing trees or newly cut logs they respond to aggregating pheromones produced by pioneer beetles. This has been described for species of the genera *Dendroctonus*, *Ips*, *Scolytus*, and *Gnathotrichus*. Three terpene alcohols, 2-methyl-6-methylene-2,7-octadien-4-ol (ipsdienol), 2-methyl-6-methylene-7-octen-4-ol (ipsenol) and *cis*-verbenol were identified in *Ips paraconfusus* Lanier (Silverstein et al. 1966). These compounds and *trans*-verbenol are present in various combinations in several *Ips* species (Vité et al. 1972). Monoterpenes of the host trees' oleoresin serve as precursors of the pheromones (Vité et al. 1972, Hughes 1973, 1974, Vité et al. 1974).

This paper deals with the pheromones of *Ips duplicatus* (Sahlberg), a bark beetle associated mostly with standing trees of Norway Spruce (*Picea abies*) in Eurasia. The population of this species seems to increase with increasing densities of *Ips typographus* (L.) after stormfellings in spruce forests. The beetle colonizes the top section of the tree,

whereas the sympatric species *Ips typographus* concentrates on the rest of the trunk.

The results were obtained as part of a project where *Ips typographus* was the main subject for investigation. The paper reports the presence of ipsdienol as an aggregating pheromone in *Ips duplicatus*.

MATERIALS AND METHODS

Beetles were collected at Eidskog, Hedmark county, in South Norway. Some were taken when they emerged in autumn and kept under natural conditions until the following spring. Others were extricated in May from initial galleries in vertical arranged tops of newly cut trees and stored in dry ice.

For gas chromatographic analysis, the hindgut of beetles was transferred to a 0.5 ml centrifuge tube held in dry ice (Vité et al. 1972). The guts were crushed, the tubes sealed with septums and heated in boiling water. Air samples with the volatiles were with-

drawn with a syringe and then analysed by gas chromatography (glc).

The glc analyses were performed with a Varian model 1400, equipped with a flame ionization detector. Polar and non-polar columns were used. The first was a 300×0.15

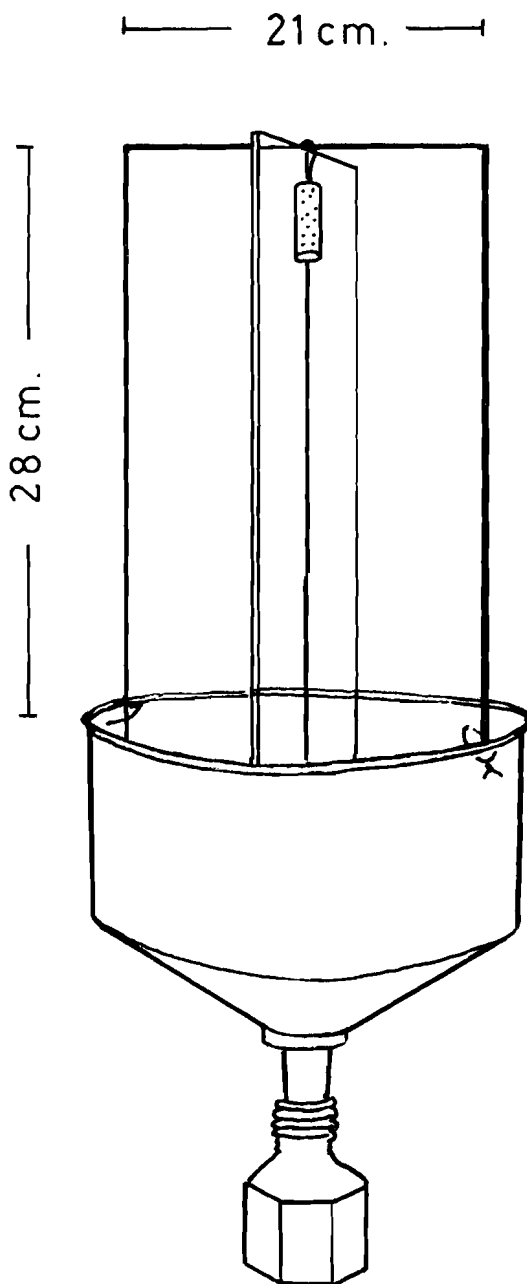


Fig. 1. The plexiglas trap model.

Table I. Number of *Ips duplicatus* trapped in response to synthetic ipsdienol and to fresh cut bolts. The trapping period was 1 day and the figures are the results of 5 days trapping during the period 11 May to 21 May.

	Ipsdienol	Fresh bolt	No bait
Five-day total	274	3	1
Range of daily trappings	24-85	0-2	

cm glass column packed with 15% FFAP on Varaport 30, 80/100 mesh, nitrogen being used as carrier gas. The column temperature was 135°C . The non-polar column was 300×0.15 cm glass column packed with 20% Apiezon L. on Chromowax DMCS 60/80 mesh. The column temperature was 120°C .

Field tests were conducted at a field station in Eidskog, Hedmark county in May 1974, with synthetic ipsdienol prepared at the Department of Chemistry, University of Oslo. The attraction of the beetles to ipsdienol was recorded as the number of beetles caught in plexiglas traps supplied with a perforated tube containing the pheromone (Fig. 1).

RESULTS

Males of *Ips duplicatus* initiating galleries in Norway spruce contained in their hindguts a compound with a glc retention time identical to synthetic ipsdienol. This result was obtained on two different columns. The compound was not present in female hindguts.

When overwintering male beetles, taken into laboratory temperature (22°C) and kept in *Sphagnum* moss for 10 days, were exposed to vapour of myrcene for 48 hrs, their hindgut contained a compound with retention time of synthetic ipsdienol. In field tests flying beetles responded to synthetic ipsdienol (Table I). The sex ratio of 50 beetles was 1.2 ♀ to 1 ♂.

Under field conditions, the following compounds were tested without obtaining a positive response: *trans*-verbenol, *cis*-verbenol, verbenone, ispenol, α -pinene, β -pinene, myrcene, limonene, linalool, myrtenol, and *trans*-pinocarveol.

DISCUSSION

GLC analyses of hindguts of *Ips duplicatus* indicate that ipsdienol (2-methyl-6-methylene-2,7-octadien-4-ol) is present as a major compound in the male beetles during initiation of the gallery. The response of flying beetles to synthetic ipsdienol also indicates that this compound is a major aggregating pheromone for the species. Because *Ips typographus* was the main subject for the field test, no traps were baited with *Ips duplicatus* boring in fresh bolts. Therefore, no comparison can be made with the effect of naturally produced attractants.

When tested alone, no response was obtained to the oleoresin compounds of the host tree or to the other pheromones known from beetles of the genus *Ips*. Whether or not some of those compounds, combined with ipsdienol, will increase the attraction, was not tested. An increased flight response to a combination of two or more compounds has been observed in other *Ips* species (Wood et al. 1968, Renwick & Vité 1972).

Hopping (1963) examined the external morphological characteristics of the North American *Ips* species, and divided the members of the genus into 10 groups. He also suggested the relationship of some species from Eurasia to such groups. *Ips duplicatus* is placed in group IV. All the species in group IV in which the pheromones have been studied are characterized by their high ipsdienol content and lack of ipsenol (Vité et al. 1972).

Hughes (1974) has demonstrated that *Ips. avulsus* Eichh. produce ipsdienol, and *Ips paraconfusus* Lanier produce ipsenol and ipsdienol upon simple exposure to myrcene vapours. Other *Ips* species have to feed for a brief period in the host tree before they are able to metabolize myrcene to pheromones.

This study indicates that the mechanism of pheromone production in *Ips duplicatus* is similar to that of *Ips avulsus*, which further supports the close relationship of these two species as members of *Ips* group IV in the system of Hopping (1963).

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Norwegian stoneflies. III. Field studies on ecological factors influencing distribution

ALBERT LILLEHAMMER

Lillehammer, A. 1975. Norwegian stoneflies. III. Field studies on ecological factors influencing distribution. *Norw. J. Ent.* 22, 71–80.

Studies on stonefly association at different habitats were carried out in a stream and lake. Habitats which had great variations in the substratum of stones and gravel held the highest number of species. However, where the amount of allochthonous matter was greatest, the number of specimens was also highest even if the substratum consisted of fine sand. Species such as *Capnopsis schilleri* seemed to prefer places with fine sand and silting, *Capnia atra* places with a dense layer of stones, while *Nemoura avicularis* and *Leuctra hippopus* were most numerous at habitats with much allochthonous matter, even if there was fine sand in the substratum. Different temperatures seemed to have a great influence on stonefly development, but the photoperiod was probably less important for the species in this study.

A. Lillehammer, Zoological Museum, University of Oslo, Sars gt. 1, Oslo 5, Norway.

The amount of allochthonous matter originating from trees and bushes along streams has been mentioned as one of the factors influencing distribution of stoneflies (Lillehammer 1974b). Other important factors discussed were the composition of the substratum and differences in temperature.

To understand the distribution of the Norwegian stonefly fauna, special studies on environmental dependence had to be carried out, first in the field and then in the laboratory.

The primary aim of this work was to study the species association on different substrata in a stream to determine which substratum supported the highest number of species and to what degree the amount of allochthonous matter influenced the stonefly association, especially substratum consisting mainly of fine sand.

The second aim was to study substratum preference, the influence of allochthonous matter in a lake, and stonefly association in areas with different wave exposure.

Further emergence differences were studied

in streams occurring in areas with the same photoperiod, but which had differences in temperature. Finally, the duration of emergence from a single habitat was investigated to obtain information about possible variation in nymphal growth and the presence of adults within the same habitat.

The connection between substratum and species occurrence has been discussed by several authors, such as Brinck (1949), Macan & Maudsley (1969), Hynes (1970), and Ulfstrand (1967, 1968).

Several authors, including Nelson & Scott (1962), Hynes (1963, 1970) and Minshall (1968), have stressed the importance of allochthonous matter in stream ecosystems. The importance of herbivorous stoneflies in the breakdown of leaves and the production of detritus was mentioned by Wallace & Woodall (1970).

The importance of water temperature as an ecological factor has been studied and discussed by several authors such as Hynes (1941, 1961), Brinck (1949), Gledhill (1960), Khoo (1964, 1968a, b), Langford (1971), Ne-



Fig. 1. The stream Leirelva with high water level in spring time.

beker (1971), Thibault (1971), Brittain (1975) and Harper (1973).

Substratum and the amount of allochthonous matter are closely linked to speed of current. However, studies of this factor were not made. The relationship between current speed and particle size was discussed by Hynes (1970) and Nielsen (1950), and Schmitz (1961) presented tables giving the speed of flow required to move mineral particles of different sizes. However, the usefulness of these tables to ascertain stream velocity is limited, as they are both approximations and because current speed is very variable in Norwegian streams and difficult to measure. This is illustrated in Figs. 1 and 2, which show the water level in Leirelva, Fagernes, during spring and summer. Also, sand and gravel frequently persist among large stones in a large number of Norwegian streams which are highly turbulent.

The dependence of stoneflies upon speed of current is therefore difficult to ascertain in the field. Many of them live much of their life sheltered down in the substratum. Bournaud (1963) stressed that cryptic habitats are characteristic of most stream insects. They occur in what appears to be swift water, but may not be exposed to it.

SUBSTRATUM AND ALLOCHTHONOUS MATTER

The study of the relationship between the stonefly association, the composition of the substratum and the amount of allochthonous matter was carried out in the stream Sæterbekken, Bærum (area 2.1 Oslofjord and surroundings) and in the lake Øvre Heimdalen (area 4) (Lillehammer 1974b).

Sæterbekken

Habitats and methods

The study was carried out at five habitats during March 1970, 1971 and 1972. One sample series was also taken in October 1972. In March and October, 17 species of stonefly could be taken, as only the hiemal species *Leuctra fusca*, *L. digitata*, and *Amphinemura standfussi* have their growth during the summer months and are thus too small to be taken at these times.

The habitats were quite different: Habitats 1, 2 and 3 were riffles, 4 and 5 pools. Habitat 1 had a dense, deep layer of stones; the diameter on the stones was from 15 cm and down to gravel. Habitat 2 had a single, but dense, layer of stones on gravel; the size of the stones was nearly the same as at habitat 1. Habitat 3 had scattered stones on gravel; the size of the stones was from 2–6 cm.

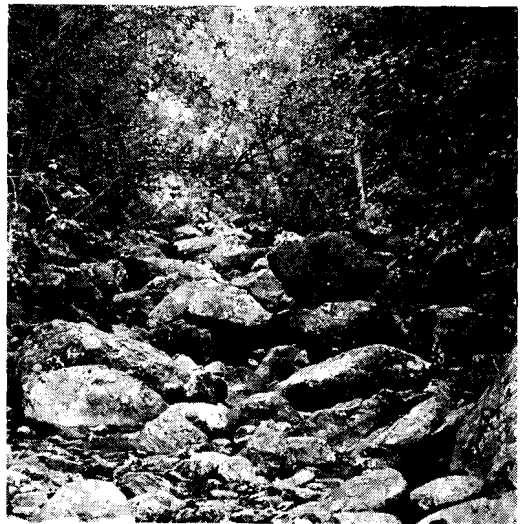


Fig. 2. The same locality as in Fig. 1 of Leirelva at summer time and low water level.

Table 1. The frequency of occurrence of stonefly species at habitats 1 to 5, in Sæterbekken, Bærum.
+ signifies less than one percent.

Species	Habitats				
	1	2	3	4	5
<i>Diura nanseni</i>	1	3	7		
<i>Isoperla difformis</i>	1				+
<i>Isoperla grammatica</i>	3	3			
<i>Siphonoperla burmeisteri</i>	1			6	+
<i>Brachyptera risi</i>	36	4	12		
<i>Taeniopteryx nebulosa</i>	+	15	+		
<i>Amphinemura borealis</i>			2		
<i>Amphinemura sulciollis</i>	8	6	15		1
<i>Nemoura avicularis</i>	+		2		7
<i>Nemoura cinerea</i>	+	13			+
<i>Nemoura flexuosa</i>	4	4			+
<i>Protonemura meyeri</i>	2	3	5		
<i>Capnia atra</i>	1				
<i>Capnia bifrons</i>	22	9	42		2
<i>Capnopsis schilleri</i>	14	65	7	94	80
<i>Leuctra hippopus</i>	6				8
<i>Leuctra nigra</i>	+				
Number of species	16	10	9	2	9

Habitat 4 had fine sand without stones and almost no allochthonous matter, while habitat 5 had fine sand without stones and large amounts of allochthonous matter.

A Surber sampler with a frame of 30 × 30 cm and a net of 530 μ was used. This method was chosen because it is most convenient for quantitative sampling of substrata ranging from fine sand to a dense layer of stones. The method (Surber 1937) has been used by several authors and its limitations were discussed by Hynes (1970b).

Results and discussion

The material consists of 1141 nymphs taken at the five stations. The results are shown in Table I. The total number of species taken was 17, of which 16 were present in habitat 1, where there is a dense layer of stones. In habitat 2, the number of species had fallen to ten, the same as for habitat 3. In habitat 4, where there is only fine sand, only two species were taken. At station 5, where there are large amounts of leaves and twigs over the fine sand, there were nine species.

The substratum rich in stones supported the highest number of species, while the fine sand area had least. This agrees in general with Egglisshaw & Mackay (1967) and Armitage et al. (1974), though in

their case there seemed to be less substratum differences. Habitat 5 with large amounts of allochthonous material supported a high number of species, even though the substratum consisted of fine sand. This habitat had also by far the highest number of specimens (676), indicating that food is an extremely important factor. The second highest was habitat 1 with 37% of this total, followed by habitat 2 with 14%, habitat 3 with 9%, and habitat 4 with 7%. The high number of specimens in habitat 5 was mainly due to the abundance of one species, *Capnopsis schilleri*.

The species concerned showed large variations in their frequency at different stations. The Capniids dominated the investigated area, with *Capnopsis schilleri* and *Capnia bifrons* being the most common species. *Capnopsis schilleri* was taken at all stations, and completely dominated on sandy substrata. This may be due to a particular substratum preference which will be dealt with further in experimental work in the laboratory. *Capnia bifrons* had the highest number of specimens and dominated in habitat 3, where there were scattered small stones on gravel, i.e. typically unstable substratum. *Siphonoperla burmeisteri* was taken both on substrata of stones and of fine sand. It also seems clear that *B. risi* prefers stony substrata and is absent on solely sandy substrata. This agrees with Madsen's (1969) findings. *Diura nanseni* is also absent where the substratum is fine sand. Ulfstrand (1967) stated that this species avoided silt, which could be the reason why *D. nanseni* is absent, although potential prey animals are most numerous there. *Taeniopteryx nebulosa*, *Protonemura meyeri*, *Amphinemura borealis*, *Leuctra nigra*, *Capnia atra*, and *Isoperla grammatica* are also absent on fine sand. They are, however, more or less rare species in this part of the stream. Two of these species, *T. nebulosa* and *A. borealis*, are common in silted localities in other streams (Lillehammer 1974b). The species *A. sulciollis*, *N. avicularis*, *Siphonoperla burmeisteri*, *C. schilleri*, *N. flexuosa*, *Leuctra hippopus*, *Capnia bifrons*, and *Isoperla difformis* have been taken on sandy substrata where there were large amounts of allochthonous matter. Two of them, *N. avicularis* and *L. hippopus*, had their highest incidence at this station.

There are variations from year to year both

in the number of species and in their frequency. For example, the number of species taken in March 1970, 1971, and 1972 at station 1 was 11, 10, and 4, respectively. The frequency of *B. risi* was 41%, 33%, and 67%, while for *C. bifrons* it was 3%, 18%, and 28% in the three years.

Øvre Heimdalsvatn

Habitats and methods

In 1971 and 1972, studies of the fauna association in shallow water at Øvre Heimdalsvatn were carried out. A high number of stonefly adults (16 species) was recorded from the banks of the lake. Ten of these were also taken as nymphs in the lake, and therefore at least ten species inhabit the lake during their nymphal life.

In shallow waters, there are large variations in substratum from fine sand to a dense layer of stones, which are mostly small where the bottom is unstable and larger where the bottom is stable. Some parts are also heavily wind exposed, while others are sheltered, the amount of allochthonous matter being greatest in the sheltered bays. A major distinction in the lake is between the area around the inlet, where sand and gravel predominate together with much allochthonous material, and the area around the outlet, where stony substrata with highly variable stone size and less allochthonous matter predominate.

In connection with IBP research in 1972, 20 stations were selected and sampled monthly from ice break-up at the beginning of June until ice formation at the beginning of October. Twelve stations were used in the present analysis. Frequency analyses were carried out to compare the inlet/outlet areas and wind-exposed/sheltered areas.

Sampling of the stony substrata in Øvre Heimdalsvatn was accomplished by a combination of two sampling techniques, both time based. Firstly, for a period of 3 min, stones were picked up from the bottom by hand and placed in plastic bowls on the lake side. At the same time as the individual stones were picked up, a net was swept underneath to obtain those faunal elements that swim away when disturbed. This technique was used by Macan & Madsley (1969). The second method was a 'kick' technique modified from its use in running water studies (Frost et al. 1970), whereby for a 3 min period the substratum was disturbed by kicking while a net was passed forwards and backwards over the area. The net used was triangular, with sides 36 cm and netting with 15 meshes/cm. Both methods were used twice, thus providing four samples at each station. Subsequent studies have shown that depending on the exact nature of the substratum, the area covered by the four samples varied between about 4 and 5 m². Both methods are

Table II. The number of specimens of the species taken in different parts of the lake Øvre Heimdalsvatn. The number of samples at each station is 15, taken in June, July, August and September.

		<i>Diura bicaudata</i>	<i>Nemoura avicularis</i>	<i>Nemoura cinerea</i>	<i>Nemurella picteti</i>	<i>Capnia atra</i>	<i>Amphinemura standfussi</i>	<i>Isonemura obscura</i>	<i>Leuctra fusca</i>	<i>Leuctra hippopus</i>	<i>Nemoura</i> sp.
Outlet,	4 stations	89	31	63	1	40	3	2	1	1	5
Inlet,	4 "	68	68	48	96	2	6				1
Sheltered bays,	2 "	37	63	22	4	3	3	1			1
Exposed areas,	2 "	170	3	18		1					
The total number of specimens		364	165	151	101	46	12	3	1	1	7

at best semiquantitative, but together they give a usable comparison of frequency occurrence in different parts of the lake.

Results and discussion

The total number of Plecopteran nymphs taken in Øvre Heimdalsvatn during this investigation was 851, and the number of species nine. The results are given in Table II.

The highest number of specimens occurred in the inlet area, where numbers were about 20% higher than in the outlet. The part of the fauna dependent upon allochthonous matter for food also constituted a higher percentage of the total numbers in the inlet area than the outlet area (76% compared with 62%), the herbivorous species in the outlet area constituting only 62% of the number in the inlet area. The number of species was, however, higher in the outlet area; nine compared with six species in the inlet area.

In the exposed areas, with small amounts of allochthonous matter, there was a higher number of specimens than in sheltered bays which were rich in allochthonous matter. However, this was largely due to the carnivorous *Dura bicaudata* constituting 88% of the total fauna. In contrast, herbivorous stonefly fauna of exposed areas made up only 23% of the herbivorous fauna of sheltered bays. There were seven species in the sheltered areas and four in the exposed areas.

The dominant herbivorous species in exposed areas was *N. cinerea*, one of the species which goes highest up in the mountains where there is little allochthonous matter, while the

dominant species in sheltered areas was *N. avicularis*.

Capnia atra was taken mainly in the outlet area of the lake and seemed to be most common on stony substrata.

TEMPERATURE

The relationship between emergence and temperature was studied in area 1 (Southern Hordaland and Northern Rogaland) and in Sæterbekken, Bærum. The duration of emergence was studied in Øvre Heimdalen. The three areas are described by Lillehammer (1974b).

Emergence and temperature

Various species display quite large differences in emergence time at different latitudes (Brinck 1949). That a species generally emerges later at higher altitudes than at lower ones has been shown by several authors such as Dodds & Hirshaw (1925), Nebeker & Gaufin (1967), Nebeker (1971), Kownacka (1971), and Ikomonow (1973). In such cases, temperature differences were stated to be the most important factor; in this connection Hales & Gaufin (1971) showed large differences between species.

Fig. 3 shows different emergence of *Leuctra hippopus* in some localities at different altitudes. The Isterfoss population, which also differs morphologically from other populations (Lillehammer 1974a), shows marked divergence with a marked early emergence. In contrast, the Storbekken population shows late emergence. These differences seem to be

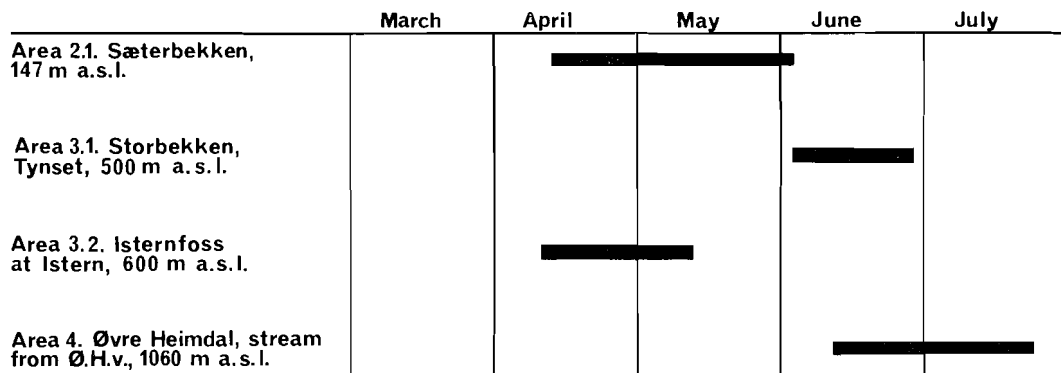


Fig. 3. The first day of emergence and the presence of adults of *Leuctra hippopus* in localities from different altitudes. The number of specimens taken at each locality varied between 50 and 200.

Table III. Registered water temperature (°C) at five streams in area 1, South Hordaland and North Rogaland.

Date	Streams				
	1	2	3	4	5
28 Apr. 66	11	3	2	1.5	
15 June 66	15	14	7	5.0	3.0
28 May 67	12		4	1.0	
10 July 67	16	12	6	6.5	3.0
3 Sept. 67	12.5	10.5	9	7.0	6.0
28 May 70	16	12	4.5	3.5	1.0
Mean	14.9	10.3	5.4	3.6	3.3

connected with the special thermal conditions of the streams.

The Isterfoss population occurs in a short stream (about 200 m long) which is isolated between two lakes, Lake Ister and Lake Galten. The stream is only a prolonged outlet and follows the thermal conditions of the lake. The result is a later cooling in autumn, and an early break-up of the ice in the spring. Specimens from the Isterfoss population were also reared in laboratory to see if they were ecologically different from other populations (Lillehammer 1975).

Further recording of emergence was carried out in North Rogaland and South Hordaland in different streams with marked differences in temperature ranges (Table III), thereafter in a single stream, Sæterbekken,

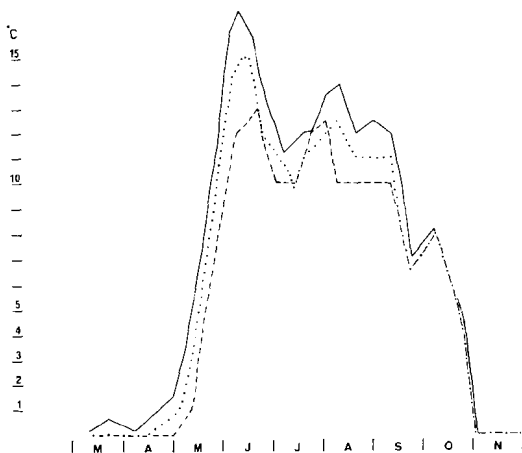


Fig. 4. The water temperature at three stations of Sæterbekken, measured in 1970 and 1971 (from Lillehammer 1974b).

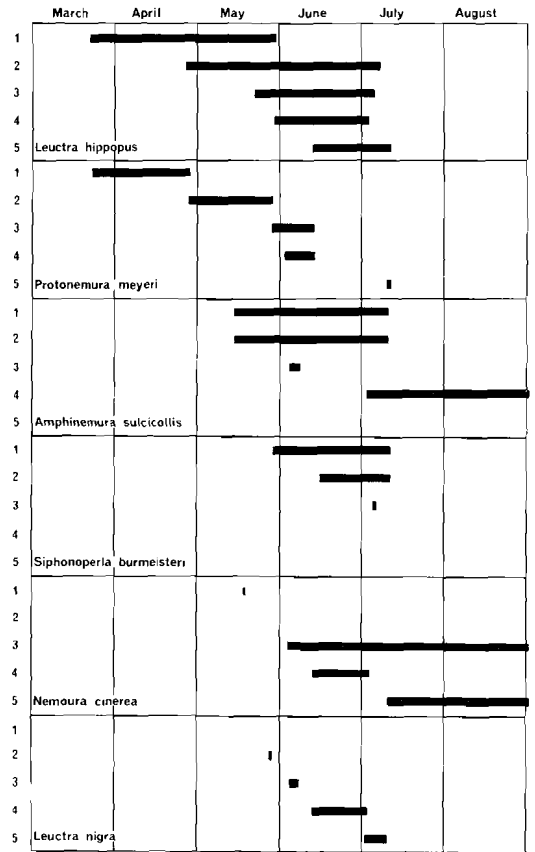


Fig. 5. The first day of emergence and the presence of adults of six species in five streams in Rogaland and South Hordaland.

Bærum, where there were also marked differences in the temperature ranges at different stations (Fig. 4). The streams and stations are the same as used in the horizontal and vertical distribution gradients (Lillehammer 1974b).

Fig. 5 shows the first day of emergence and the presence of adults of *Amphinemura sulcicollis*, *Leuctra hippopus*, *L. nigra*, *Nemoura cinerea*, *Protonemura meyeri*, and *Siphonoperla burmeisteri* in five streams in North Rogaland and South Hordaland. Records cover the whole period 1965–1970. All six species showed earlier emergence in the coastal areas than in central and inner areas. There is a good correlation between the recorded differences in temperature and time of emergence (Fig. 5 and Table III). The differences between the first records of emergence at the coastal stream 1 and the

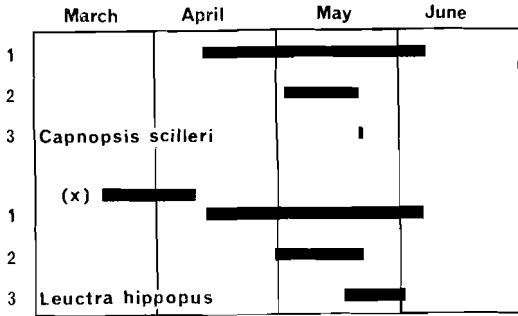


Fig. 6. The first day of emergence and the presence of adults of *L. hippopus* and *C. schilleri* at three stations in Sæterbekken, Bærum in 1970. (X) The same data for *L. hippopus* from a spring emptying into Sæterbekken. The spring maintained 2–3° C during the winter.

high altitude stream 5 were 76 days for *Leuctra hippopus* and 96 days for *Protoneura meyeri*. The differences in the duration of adult specimens recorded present at the same stream seem to depend on abundance. At streams where the species is abundant, adults have been taken over a long period and number as many as 100–200 specimens.

In streams where the species is rare and only recorded for a few days, the material only consists of 5–15 specimens.

Within the same locality there are often large differences in emergence from year to year. The largest difference was recorded in Halvfjordingsvatn at about 900 m a.s.l. (loc. 41 in Lillehammer 1974a). In this area there are great climatical variations from year to year. In 1967 snowfall was heavy; in combination with a cool summer, this resulted in a situation where the ice on the lake had not completely disappeared by the beginning of September, and in fact hardly disappeared at all that year. In 1969 there was less snow, the summer was warm, and the ice had broken up and disappeared by the beginning of July. *Diura bicaudata* emerged mainly during the first half of July in 1969, while in 1967 emergence did not take place before the end of August and the beginning of September. This indicates that emergence in this species follows climatical variations.

An example of emergence following a rise in temperature at three stations was recorded in Sæterbekken. The first emergence of *Leuctra hippopus* and *Capnopsis schilleri* occurred parallel with the rise in temperature

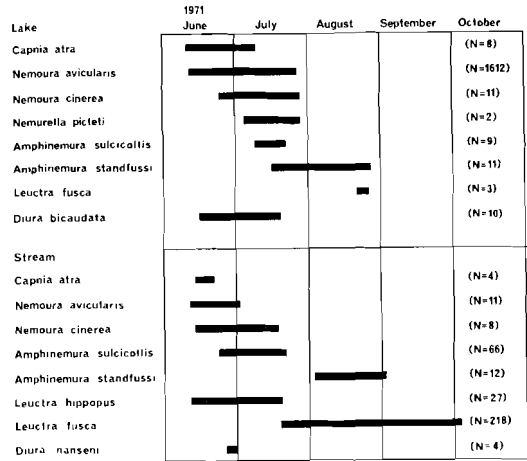


Fig. 7. The emergence of 8 species recorded in lake Øvre Heimdalsvann and 8 species in the stream from the lake in 1971.

during the spring of 1970 (Figs. 4, 6). It was also shown that specimens living in an open spring which maintains 2–3° C during the winter had an emergence which was much earlier than in a stream which is frozen during the winter and where the temperature is around 0° C. As for the record in Rogaland, the differences in the duration of specimens recorded present at the same station seemed to be connected with the abundance of the species. *Capnopsis schilleri* were only common at station 1 where about 250 specimens were taken. *Leuctra hippopus*, however, were taken in great numbers at all three stations (from 62–125 specimens).

Table IV. Registrations of the duration of females present at certain habitats. (S) = stream, (L) = lake.

Species	Locality	Females present, days
<i>Diura bicaudata</i>	Øvre Heimdalsvatn L.	43
<i>D. nanseni</i>	Elgjuvet, Sauda S.	35
<i>Amphinemura standfussi</i>	Øvre Heimdalsvatn S.	41
<i>A. sulcicollis</i>	" S.	61
<i>Nemoura avicularis</i>	" L.	38
<i>N. cinerea</i>	" L.	72
<i>Nemurella picteti</i>	" L.	70
<i>Capnia atra</i>	Østerbekken, Bærum S.	40
<i>C. bifrons</i>	Sæterbekken, " S.	52
<i>C. pygmaea</i>	Nordelva, Sauda S.	64
<i>Capnopsis schilleri</i>	Sæterbekken, Bærum S.	61
<i>Leuctra digitata</i>	" " S.	39
<i>L. fusca</i>	Øvre Heimdalsvatn S.	75
<i>L. hippopus</i>	Byrkjelandsb. Sveio S.	67
<i>L. nigra</i>	Sæterbekken, Bærum S.	71

Duration of emergence

Adult females of several species were present at the same locality for a long period (Table IV). This led to a recording of the duration of emergence from a defined area. A long flight period in a single stream is well known in some species (Thomas 1969, Nebeker 1971). The temperature in a single stream may be different as shown in Fig. 4, and temperature differences may produce differences in emergence as shown above. To eliminate this factor, emergence was studied at the same locality, both in a stream and a lake. The lake Øvre Heimdalsvatn and the outlet stream were chosen. Three emergence traps were used, two in the lake and one in the outlet stream. The traps were described by Davies (1950) and first used in Norwegian running water by Raastad (1974). The traps were placed at the water's edge and occupied one metre of the shore line. The sides below water were covered by nylon netting, thus preventing imagines entering from the land side. The traps were emptied daily from ice break-up at the beginning of June until ice formation in October.

The species were recorded and the results are shown in Fig. 7. The material consisted of 2016 specimens. The dominating species were *Nemoura avicularis* and *Leuctra fusca*. The emergence period often had a duration of three weeks or more. In one case, that of *Leuctra fusca*, emergence occurred for more than two months, indicating marked differences in growth. In the species which are common and taken in large number, the recorded length of the emergence is certainly near the true values, while in rare species which are only taken in small numbers, the values are minimum. There were marked differences between the lake and the stream, some species emerging earlier from the stream than from the lake and vice versa.

CONCLUSION

Studies from Sæterbekken stream and Øvre Heimdalsvatn lake showed that in both ecosystems the highest number of species were recorded in habitats with a dense layer of stones of different size, and the highest number of specimens in habitats with much allochthonous matter, even though the sub-

stratum consisted of fine sand to a large extent.

In both the lake and the stream, *Nemoura avicularis* was most common on fine substrata containing much allochthonous matter. *Capnia atra* was only taken in parts of Sæterbekken which had a dense layer of stones, and in the lake the species was most common on the same substrata. In the case of *C. atra*, this indicates a substratum preference, while for *N. avicularis* it seems to be more a combination of food and substratum.

The studies also demonstrated that *Capnopsis schilleri* was common in streams where the substratum consisted mainly of fine sand and much allochthonous matter, but it was not taken in the lake although it is common in the same area (Lillehammer 1974b). Also *Capnia bifrons* was common in Sæterbekken stream, but absent in the Øvre Heimdalsvatn lake, although it is fairly common in the Heimdalsvatn area.

The reason for the high number of herbivorous specimens in the inlet area of Øvre Heimdalsvatn may be the higher amounts of allochthonous matter, while the high number of species in the outlet area may be connected with the dense layer of stones mixed with gravel providing a greater variety of habitats. The situation is parallel with that in Sæterbekken (Table I), where the pool with fine sand substratum and large amounts of allochthonous matter contained the highest number of specimens, while the habitat with a dense layer of stones supported the highest number of species.

The results from both these investigations indicate the importance of allochthonous matter in a stream and a lake ecosystem where Plecoptera species are present and form an important part of the total fauna. This certainly influences species distribution and will therefore be dealt with in laboratory studies where the relationship between substratum, temperature, and food will be studied in selected species (Lillehammer 1975).

Comparison of emergence periods in streams with different temperature ranges indicates that the time of emergence is closely bound to the temperature regime. Gledhill (1960) came to the same conclusion in a study of emergence in two English streams. Photoperiod seems to be less important in this connection, since all stations in area 1

are situated at the same latitude and within a radius of 90 km, and thus have the same photoperiod. However, Elvang & Madsen (1973) seem to accept photoperiod as a regulating factor for the emergence of *Taeniopteryx nebulosa*. Nebeker (1971) has shown that an increase in temperature in streams brings emergence forward. The much earlier emergence of *Leuctra hippopus* in the spring which is 2–3° above the temperature in the nearby stream, Sæterbekken, also indicates this. Thibault (1971) observed large differences in the emergence of stoneflies between some English and French streams; he considered them to be caused by differences in temperature regime. In contrast, Langford (1971) mentioned that heated water in the River Severn did not seem to have any significant effect on the distribution and ecology of the seven species of Ephemeroptera and one stonefly studied.

The present studies indicate that the photoperiod seems to be less important for the species involved here. The development of stoneflies is certainly bound to certain temperature intervals, and this might influence distribution. If the species needs a certain total of warm degrees to complete its life cycle within a year, it must either absent itself from the areas with a lower annual temperature or revert to a semivoltine life cycle. However, the range in the emergence of individual species in the same locality might not only be bound to temperature, but also be connected to differences in food consumption.

In one of the local populations of *Leuctra hippopus* (at Isterfoss) the temperature seems to isolate the population from the rest of the species in the surroundings; this produces an early emergence. Since the Isterfoss population is different in some morphological characters as well, specimens from this population will be studied in laboratory and the results will be published by Lillehammer (1975).

Emergence at the same locality seemed to be of long duration in some species. This indicates differences in growth of the nymphs and/or in the length of the incubation period of the eggs.

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Short Communications

Three species of spiders (Aranea) new to Norway

ERLING HAUGE

Centromerus prudens (Cbr.), *C. aequalis* (Westr.) and *Pholcomma gibbum* (Westr.) (Aranea) are reported for the first time from Norway.

Erling Hauge, Zoological Museum, University of Bergen, N-5014 Bergen-Univ., Norway.

When examining a small collection of spiders collected by T. Solhøy in the counties of Telemark and Aust-Agder, I identified two species of the family Linyphiidae and one species of the family Theridiidae, which must be reckoned as new to Norway. The species are:

Centromerus prudens (Cbr.)

One ♀ was found 9 September 1973 at AAY: Birkenes, 2 km E of Myklebostad. The habitat was a light forest on a slope facing south. I also have one unpublished record of this species (in preparation) from western Norway. Here, one ♂ was at HOy: Austerheim, north of Bergen, in a pitfall trap in a *Calluna* heath between 6 November and 8 December 1972.

C. aequalis (Westr.)

One ♂ 5 September 1973 at AAY: Tvedestrand, 200 m west of Nedrejordet, in the foena of a deciduous forest on a slide facing south with great blocks. One ♀ was found 9 September 1973 at AAi: Bygland, in a forest on a slope facing south-southwest with mostly lindens mixed with some hazels. One ♀ was also found 9 September 1973 at AAY: Birkenes, together with the specimen of *C. prudens*.

Pholcomma gibbum (Westr.)

One ♂ was found 5 September 1973 together with the male of *C. aequalis*. One ♀ 9 September at AAi: Bygland, 1 km south of Frøyenes, in a slide facing east with blocks and deciduous forest with herbs.

Received 20 August 1974

Amara quenselii Schn. (Coleoptera, Carabidae) new to Svalbard

SVEN-AXEL BENGTON, ARNE FJELLBERG & TORSTEIN SOLHØY

In August 1973 a macropterous female, one larva, and fragments of several dead adults of *Amara quenselii* Schn. were collected under stones and among grass beneath a sea-bird cliff at Ossian Sars Mountain in Kongsfjord, West Spitsbergen (78° 56'N, 12° 26'E). It is the first species of Carabidae reported from Svalbard.

S.-A. Bengtson, A. Fjellberg & T. Solhøy, Zoological Museum, N-5014 Bergen-Univ., Norway.

Several fragments of an *Amara* species were found under stones on the steep slope beneath the sea-bird cliffs (mainly *Rissa tridactyla* and *Uria lomvia*) at the Ossian Sars Mountain in Kongsfjorden, West Spitsbergen (78°

56'N, 12° 26'E) on 7 August 1973. The slope has a luxuriant vegetation dominated by *Colpodium vacillans*, *Poa alpigena* f. *viviparum*, *Taraxacum brachyceras*, *Ranunculus pedatifidus*, and *Potentilla rubricaulis*. On 16 Au-

gust one of us (Solhøy) again visited the locality and caught a live specimen of *Amara* under a heap of grass that had been sifted the week before. The specimen was later identified as *Amara quenseli* Schn. (macrop-terous female), which was confirmed by C. H. Lindroth. In addition, a larva of *Amara* was obtained by extracting a sample, taken 7 August, from a modified Tullgren funnel. The identification of the larva to genus was later confirmed by M. L. Luff. Since no other species of *Amara* have been reported from Svalbard, it is likely that the larva belonged to *quenseli*. The presence of a larva of *Amara* strongly suggests that *A. quenseli* breeds in Svalbard and that our female specimen was not just an accidental visitor. The species has a wide distribution in Fennoscandia

(Lindroth 1960), but it is the first record of a carabid beetle from Svalbard.

ACKNOWLEDGEMENTS

We are grateful to Professor C. H. Lindroth, Lund and Dr. L. M. Luff, Newcastle for confirming our identifications of the adult female and larva, respectively. Cand. real. D. O. Øvstedal, Bergen, kindly helped us with the identification of plants.

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Received 16 September 1974

Metrioptera brachyptera (Linné) (Orthoptera, Ensifera) at Sotra, West Norway

TROND ANDERSEN & ARNE FJELLBERG

In September 1974 several specimens of *Metrioptera brachyptera* were caught in a marsh with *Calluna vulgaris* on the island of Sotra, near Bergen. It is the only species of Ensifera reported from the west coast of Norway.

T. Andersen & A. Fjellberg, Zoological Museum, N-5014 Bergen-Univ., Norway.

On 1 September 1974, one female of *M. brachyptera* (L.) was observed in a rather dry marsh with dense cover of *Calluna vulgaris* 1 km west of Fjell Church on the island of Sotra west of Bergen. Two males were caught on a second visit to the locality 13 September, and several were heard singing.

M. brachyptera is the only species of Ensifera that has reached the west coast of Norway and can withstand the humid, atlantic climate. The species was also found by Kvifte (1941) at localities in southern Rogaland.

Otherwise it is found along the coast of eastern Norway (Knaben 1943).

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Received 16 September 1974

Occurrence of *Formica uralensis* Ruzsky (Hymenoptera, Formicidae) in Pasvik, North Norway

ARNE FJELLBERG

The first Norwegian colonies of *Formica uralensis* were discovered on marshes in Pasvik, Finnmark county, summer 1974.

A. Fjellberg, Zoological Museum, N-5014 Bergen-Univ., Norway.

During June and July 1974 several colonies of *Formica uralensis* were discovered on marshes between Vaggatem and Sortbrysttjern in Upper Pasvik, the district of Sør Varanger in Finnmark county. The ant hills were rather small, about 30 cm in diameter, and were situated among scrubs of *Betula nana* and *Ledum palustre* in drier parts of the bogs.

According to Larsson (1943) *F. uralensis* is an eastern species. Until now there have been no Norwegian records (Collingwood 1974), but the species has a wide distribution in Sweden (Forsslund 1957). The occurrence of *F. uralensis* in Finnmark is not surprising, as the area has many faunistical and floristical elements of eastern origin.

Received 16 September 1974

ACKNOWLEDGEMENTS

I am indebted to Dr. C. A. Collingwood, Leeds, for identification of the ants. The field work in Finnmark was supported with a grant from the Nansen Foundation, Oslo.

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Agrilus pratensis Ratz. (Col., Buprestidae) new to Norway

ANDERS BJØRNSTAD & KARL ERIK ZACHARIASSEN

Agrilus pratensis Ratz. is reported new to Norway. The species has been found several times during 1973 and 1974 on leaves of young oaks (*Quercus robur* L.) and willows (*Salix spp.*) near Kragerø in Telemark county.

Anders Bjørnstad, Botanical Garden, University of Oslo, Tøyen, Oslo 5, Norway.
Karl Erik Zachariassen, Institute of Zoophysiology, University of Oslo, Blindern, Oslo 3, Norway.

The genus *Agrilus* Curtis contains a great number of species, of which Lindroth (1960) reports seven found in Norway. The species *A. pratensis* Ratz. (syn. *A. roberti* Chevr.) is, according to Lindroth, found in Finland, in

the southern part of Sweden, and in the northern part of Germany, but has hitherto not been recorded from Norway.

During 1973 and 1974 the species has been found several times by the authors at Berg

Museum near Kragerø in the outer part of Telemark county. Each time it was taken when exposed to the sun on leaves of young oaks (*Quercus robur* L.) or willows (*Salix* spp.) in open mixed deciduous woodland marginal to cultivated fields and close to the sea shore. The collections were made on 11 July 1973 (in great number on leaves of oaks), on 3 June 1974 (one specimen on leaf of oak), and on 6 July 1974 (in number on leaves of willows).

A. pratensis is a rather conspicuous species,

and the fact that it has not previously been found in Norway indicates that further collections in the Kragerø area may add more new species to the Norwegian coleopter fauna.

REFERENCES

Lindroth, C. H. (Ed.) 1960. *Catalogus Coleopterorum Fennoscandiae et Daniae*. 478 pp. Entom. sällsk., Lund.

Received 3 October 1974

Oonops pulcher Templeton, 1835 (Aranea) new to Norway

FINN ERIK KLAUSEN

Oonops pulcher Templeton is recorded from two localities in the county of Hordaland. The whole material consists of 7♀♀, 5♂♂, and 12 juv. At one locality it was taken among stones and grass tussocks, at the other in a *Formica rufa* nest inside the hollow trunk of *Quercus robur*.

Finn Erik Klausen, Zoological Museum, University of Bergen, N-5014 Bergen-Univ., Norway.

During collecting in the county of Hordaland, *Oonops pulcher* Templeton 1835 was taken at two localities.

At Hagavik, Os (UTM: 32V KM 999768), one juvenile was collected 16 October 1973 (leg. T. Andersen) among grass tussocks between stones in a built-up stone wall 5–10 m from the sea shore.

The second time, it was collected by myself at Ytstheim, Kvam (UTM: 32V LM 453911), 10 September 1974. The material consisted of 7♀♀, 5♂♂, and 11 juv. They were all found by sieving litter from a nest of *Formica rufa* and later extracting by Tullgren funnel. The nest was situated at ground level inside the hollow trunk of an old *Quercus robur*. The south-west bent half of the trunk had rotted and broken away, making

a large opening from the ground level up to 2–3 m above this. Other parts of the trunk were investigated, but no specimens were found elsewhere.

The species has up to now not been recorded in Scandinavia. Moreover, it has not yet been found in Denmark. Bonnet's record of it from Denmark in his work (Bonnet 1958, p. 3192) is based on an erroneous identification of *Dysderina loricata* Simon (Brændegård 1965).

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Bonnet, P. 1958. *Bibliographia araneorum*. II:4, 3027–4230. Toulouse.
Brændegård, J. 1965. Danish Spider Fauna I. *Ent Meddr.* 34, 167–171.

Received 8 November 1974

Bokanmeldelser

Gaun, Sven 1974. Blomstertæger. *Danmarks Fauna* 81. 279 pp. Dansk Naturhistorisk Forening, København. Pris D.kr. 40.-.

Det ligg 62 år mellom denne boka om bladtegene (Miridae), og det første bindet om teger i Danmarks Fauna som kom i 1912. Den gongen utgjorde Miridae, eller Capsidae som det då vart kalla, omlag 120 arter. I Gauns bok er naturleg nok hovudvekta i utbreiinga lagt på artene i Danmark (D), men det er også nemnt om artene finns i Sverige (S), Norge (N), Finland (F) og Nord-Tyskland (NT). Bindet omfattar alle til nå kjende arter av bladteger i Skandinavia, og nesten alle i Nord-Tyskland. I alt er omlag 270 arter omtala, og når ein tel opp for dei ulike land får ein følgjande fasit for arter i dei ulike underfamiliene av Miridae:

	D	S	N	F	NT	I alt
Bryocorinae	2	2	2	2	2	2
Deraeocorinae	6	8	4	6	11	11
Dicyphinae	8	9	7	3	12	13
Mirinae	76	83	68	72	90	102
Hallodapinae	2	3	3	3	3	3
Orthotylinae	43	46	28	35	43	56
Phylinae	58	63	39	52	65	82
I alt	195	214	151	173	226	269

Sjølvsagt kan det vere reelle dyregeografiske årsaker til mange av dei skilnader som kjem fram i tabellen, men det er nok ikkje til å kome i frå at vår 'plassering' også kjem av at tegene er lite undersøkt i Norge. Det ser såleis ut til at vi er svakast representert i vanskelege slekter, av *Psallus* og *Orthotylus* er berre 50% av dei oppførde artene nemnde for Norge.

Denne boka kan verte eit viktig hjelpemiddel for å rette på denne situasjonen. Først blir det gitt ein generell omtale av bladtegene som mellom anna omfattar bygning, biologi, fangst og preparering, og korleis ein skal gå fram for identifisering av teger. Den terminologi som er brukt elles i boka blir forklart i dette kapittelet. Den noko kortfatta generelle omtalen av biologien blir supplert med fleire opplysningar om vertplanter etc. i omtalen av kvar art. Dessutan er det sist i boka ei liste over ulike planteslag med opplysningar om kva slag bladteger som ofte er knytta til desse plantene.

Boka er bygd opp slik ein i dag stort sett meiner

det er fylogenetisk naturleg for bladtegene. Det fører ikkje alltid til den praktisk lettaste måte å identifisere materiale på. Det er difor verdfullt at det bak i boka er tatt med ein hjelpetabell som kan føre dei fleste bladteger til slekter eller slektsgrupper. Omtalen er ofte støtta av strekteikningar i teksten, det gjeld i særleg grad for genitalier i vanskelege slekter. Dessutan er det sist i boka 88 klare og karakteristiske imagoteikningar over 82 arter. Her kunne ein nok ynskje ein målestokk lagt inn på teikningane, sjølv om storleiken er oppgitt i teksten.

I det heile er boka eit svært nyttig hjelpemiddel for alle som vil ta for seg bladtegene i Norge, og i Skandinavia. Bladtegene er ei interessant dyregruppe som spelar ei stor rolle i mange biotopar, både som planteetarar og som rovdyr. Det er å vone at boka vil føre til auka kjennskap til bladtegene i Norge.

Gudmund Taksdal

V. B. Wigglesworth, 1974. *Insect Physiology*, 7th. edition. 166 pp. Chapman and Hall, London. Pris £ 1.65.

Wigglesworth's *Insect Physiology* foreligger nå i syvende utgave. Boken er på en måte et sammendrag av den store «Principles of Insect Physiology» av samme forfatter, og har en imponerende trykningshistorie. Den første utgaven ble trykket i 1934, og foruten syv utgaver i vanlig bokform, er «Insect Physiology» utgitt som pocketbok i tre opplag.

Boken gir en kortfattet, men samtidig fyldig og lettlest, introduksjon til insektenes fysiologi. De viktigste sider ved de enkelte organsystemer og deres funksjon blir behandlet på en måte som ikke krever store forhåndskunnskaper. Etter hvert kapittel gis noen få, sentrale litteraturhenvisninger. Den syvende utgaven skiller seg relativt lite fra den foregående. Dette skyldes at det stoff som presenteres er godt dokumentert, og gjenstand for relativt få forandringer. En unntagelse er insektenes hormoner og feromoner, som nå blir behandlet i et eget kapittel.

Boken er velegnet lesning for alle som vil ha en kort og grei oversikt over insektenes fysiologi. Den er utmerket til undervisningsformål, eventuelt som supplerende lesning.

Lauritz Somme

R. Barras. 1974. *The Locust. A Guide for Laboratory Practical Work (Second edition)*. 72 pp. Barry Shurlock, Winchester. Pris £ 1.50.

Noen arter av gresshopper er lette å holde i kulturer, og det gjelder bl. a. de to velkjente «Locusts»; ørkengresshoppe (*Schistocerca gregaria*) og vandregresshoppe (*Locusta migratoria*). I England fins flere biologiske firmaer som dyrker gresshopper for leveranse til skoler og universiteter, om man ikke ønsker å holde sin egen kultur.

Anvendeligheten av disse lett tilgjengelige laboratoriedyr til undervisningsformål er temaet for denne lille boken. Dens viktigste innhold er en samling arbeidsoppgaver innen systematikk, morfologi og fysiologi. Forfatteren fremhever betydningen av at elevene får arbeide med levende materiale, og anledning til å utføre enkle eksperimenter.

Boken er lagt opp slik at den demonstrerer viktige biologiske og entomologiske prinsipper, samt viser detaljer fra insektenes anatomi og fysiologi. Omkring firti forskjellige eksperimenter er beskrevet. De spenner fra enkle studier av temperaturrens effekt på eggens utvikling til mer kompliserte forsøk, som f. eks. elektrisk stimulering av nerver til benenes hoppemusklene.

Etter min mening vil boken være et verdifullt tilskudd til enhver skoles biologiske boksamling. Selv om man ikke ønsker å satse på kulturer av vandregresshoppe eller ørkengresshoppe, gir boken en mengde ideer til arbeidsoppgaver med insekter. Morfologiske studier som kan utføres med fiksert materiale, kan lett tilpasses norske arter, og forsøk som krever levende materiale kan tilpasses gresshopper man kan fange ute.

Lauritz Sømme

J. T. Clark. 1974. *Stick and Leaf Insects*. 65 pp. Barry Shurlock, Winchester. Pris £ 1.50.

I likhet med Barras' bok om gresshopper, som er anmeldt ovenfor, gir boken om vandrende pinner og bladinssekter (orden Phasmida) forslag til arbeidsoppgaver ved undervisning i skoler og universiteter. Enkelte arter av vandrende pinner er meget lette å holde i kulturer, og disse vil stadig gi tilgang på levende materiale. Den indiske vandrende pinne krever minimalt stell, og kan leve på vann og blader av eføy eller liguster.

Representanter for denne orden er ikke spesielt egnet til å vise generelle trekk ved insektenes bygning, men kan heller brukes til å demonstrere visse spesialiseringer. Til dette hører den kamuflerende effekt av kroppens bygning, som fremheves ved dyrenes oppførsel. Når de allikevel føler seg i fare inntar de truende posisjoner, og noen arter kan sende ut en stråle av frastøtende væske fra kjertler i prothorax. Vandrende pinner kan også brukes til å demonstrere autotomi og regenerasjon. Den indiske vandrende pinne, som er det vanligste laboratoriedyr, formerer seg partenogenetisk.

Hvis man ønsker å inkludere stoff av denne type i undervisningen, kan boken anbefales som en grei og oversiktlig håndbok, og vandrende pinner som lettstelte og velegnede laboratoriedyr.

Lauritz Sømme

ERRATA

John E. Brittain: Studies on the lentic Ephemeroptera and Plecoptera of southern Norway. *Norsk ent. Tidsskr.* Vol. 21, No. 2, 1974.

The following corrections should be noted:

p. 135 – in abstract read *standfussi* for *sulcicollis*.

pp. 140/141 – in Table II three plusses (+++) should be inserted under *Capnia atra* for locality 13 (Ø. Heimdalsvn.).

XV International Congress of Entomology

First Announcement

The 15th International Congress of Entomology will be held in the beautiful capital city, Washington, D.C., U.S.A., August 19—27, 1976, under the sponsorship of the National Academy of Sciences and the Entomological Society of America. Sessions will be held in the excellent meeting facilities of the Washington Hilton Hotel. Special events are being planned at national scientific and cultural centers. Two international airports near Washington give direct access from abroad. University housing will be available in addition to hotel facilities.

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Dr. ERNEST C. BAY, *Secretary General*

XV International Congress of Entomology

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Separate sheets should be used for the following: (1) Title page, with the author's name; (2) Abstract not exceeding 11 lines (770 letters and spaces) with the name and full postal address of the author underneath; (3) References; (4) Tables with their headings; (5) Legends to Figures.

In the case of articles submitted in a language other than English, the Abstract, Table headings and Figure legends must be accompanied with an English translation.

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REFERENCES TO LITERATURE

In the text. Brown (1957), Brown & White (1961). If more than two authors, Brown et al. (1963). Multiple references: 'As several authors have reported (Brown 1957, Brown & White 1961, Green et al. 1963)', i.e. chronological order, no commas between names and year.

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Examples:

Løken, A. 1964. Social wasps in Norway (Hymenoptera, Vespidae). *Norsk ent. Tidsskr.* 12, 191-218.

Schwartz, R. J. 1955. *The Complete Dictionary of Abbreviations*. 211 pp., T. Y. Cromwell Co., New York.

Whitman, L. 1951. The arthropod vectors of yellow fever. pp. 229-298 in Strode, K. (ed.) *Yellow Fever*. McGraw-Hill, New York and London.

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