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NORSK ENTOMOLOGISK FORENING

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Contribution from the Norwegian IBP/PT-UM sections

Quantitative and Qualitative Investigations of the Invertebrate Fauna under Stones (the Hypolithion) in Some Alpine Habitats at Finse, South Norway

SIGMUND HÅGVAR & EIVIND ÖSTBYE

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In five alpine habitats (1220-1350 m a.s.l.) at Finse, South Norway, the invertebrate fauna under stones was studied qualitatively and quantitatively during the summers of 1969 and 1970. The stone cover of the ground varied from less than 5% to about 30%, and the majority of stones could be turned by hand. Typical soil animals, and Collembola and Acarina were not collected. The data are compared with quantitative quick trap collections from litter and vegetation between stones in three habitats at Stigstuv (approx. 36 km from Finse, 1210-1240 m a.s.l.). In the comparisons, Oligochaeta, Collembola, and Acarina are excluded. The hypolithic fauna is very rich, containing about the same orders, and to a certain extent the same families, as found in litter and vegetation. In the hypolithic communities, Araneida dominate in number (52-99%), while Araneida never make up as much as 50% of the individuals between stones. The density of invertebrates between stones at Stigstuv may be more than ten times higher than under stones at Finse. However, the density of Araneida under stones was almost as high as between stones. The mean weight of hypolithion ranged from 66 to 157 mg per m^2 of stones turned. Araneida seemed to prefer stones that covered about 400 cm^2 of the ground. When the energy flow of a habitat is estimated, the hypolithion has to be included.

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Very little work has been done on the quantity and quality of the invertebrates living under stones, and their role in the ecosystems. Schönborn (1961) uses the term 'hypolithion' for this fauna. He groups the fauna into three vertical layers: fauna living on the under surface of the stone, fauna living on the litter surface, and fauna present in the litter layer. If the litter layer is wanting under the stone, then the second (and last) group of animals are those living on the true soil surface.

The hypolithion always has a characteristic species composition in a given area (Schönborn 1961), and the fauna is also very uniform on a world basis (Tischler 1955). In high mountains above the timber line, the hypolithic habitats become especially important, because of the favourable and relatively constant microclimatic conditions, compared with most other habitats in this region (Mani 1968). The importance of stones for invertebrates has also been investigated by Brundin (1934), Cole (1946), and Balogh (1958), and the rich hypolithion in high mountains has been stressed by Kühnelt (1970). After several years of experience it is felt that this faunal component is of great importance in Norwegian mountain areas.

At Finse the lower hypolithic layer of Schönborn (1961) is lacking. All the major plant communities in the study area contain varying degrees of stone cover. The hypolithion of five different plant communities has been investigated.

This paper is part of an analysis of a high

mountain ecosystem being carried out under the leadership of the second author. The authors shared the planning of this study and the sampling of the material. The treatment of the data and the main task of writing is the responsibility of the first author.

STUDY AREA

The study area at Finse is located in the north-western part of the Hardangervidda mountain plateau (60°36′ N – 7°30′ E) and consists of five habitats situated in the mid-alpine region in the area between the Finsevatn lake (1214 m a.s.l.) and the Blåisen glacier (1390 m a.s.l.), one of the largest outlets of the Hardangerjökulen glacier. They form parts of a north-sloped succession gradient, going from recently free-laid ground in front of the glacier to the presumed climax community of this area. A fully detailed description of the geomorphology, pedology, and plant cover of the study area will appear elsewhere. Therefore only a brief description of the plant cover of the habitats under study will be given here.

A. The pioneer community. The first habitat is characterized by a pioneer vegetation (in the text referred to as the pioneer community), located 800 m from the glacier at an altitude of 1350 m. The habitat is situated in a north-faced slope in a landscape formed by young moraines, not more than about 200 years old. Stones cover approximately 30 % of the habitat, most of which can be turned by hand. The soil is relatively dry. The dominant plants are *Salix herbacea, Stereocaulon* sp., and mosses. Also typical, but less dominating, are the following plants: *Empetrum hermaphroditum, Polygonum viviparum, Oxyria digyna,* and *Cetraria nivalis.* The plant cover is not continuous, and is strikingly sparser than in the lower habitats. This habitat has several characteristics that would place it in the transition zone between the mid- and high-alpine regions in this area.

B. The eutrophic meadow. The second habitat, an eutrophic meadow, is located approximately one km from the glacier at an altitude of 1300 m. The area is relatively flat, and stones and barren rocks cover about 10 % of the surface. Some boulders are present in a small part of the area. Most of the hypolithic area is covered by stones which can be turned by hand. The soil has a high humidity, and there are tussocks in some places. The dominant plants are mosses, and *Carex* sp. *Polygonum viviparum* and *Salix herbacea* are also common.

C. The oligotrophic dry heath. The next habitat represents oligotrophic dry heath communities located approximately 2.5 km from the glacier at 1230 m a.s.l. This study area is relatively flat. Most of the stone cover is represented by boulders, and only a smaller part of the hypolithic area is covered by stones which can be turned by hand. Altogether stones cover 5–10 % of the habitat. *Cladonia rangiferina, Cl. silvatica,* and *Carex bigelowii* dominate, but mosses and *Empetrum hermaphroditum* are also common.

D. The snow bed. This site can be characterized as a *Salix herbacea*–snow bed, situated on a north-faced slope, approximately 2.6 km from the glacier at an altitude of 1220 m. In this type of habitat there are large snow accumulations during winter. A distinct solifluction occurs during the melting period. Stones cover 15–20 % of the habitat, and most of them can be turned by hand. *Salix herbacea* and mosses dominate the flora.

E. The tussock area. The last habitat is an area with an extensive tussock formation (in the text referred to as the tussock area), situated approximately 3 km from the glacier at an altitude of 1220 m. A striking feature of this flat area is that the cavities between the tussocks are usually filled with water during the spring flood or after heavy rains. Some boulders and bare rock are present. There are very few smaller stones which can be turned by hand. The total area covered by stones is less than 5 % of the habitat. *Carex* sp., mosses. *Salix herbacea, Anthoxanthum odoratum,* and *Deschampsia flexuosa* are dominating plants.

The percentage of the different stone sizes in the four habitats where the stone coverage exceeded more than 5 % is shown in Fig. 1.

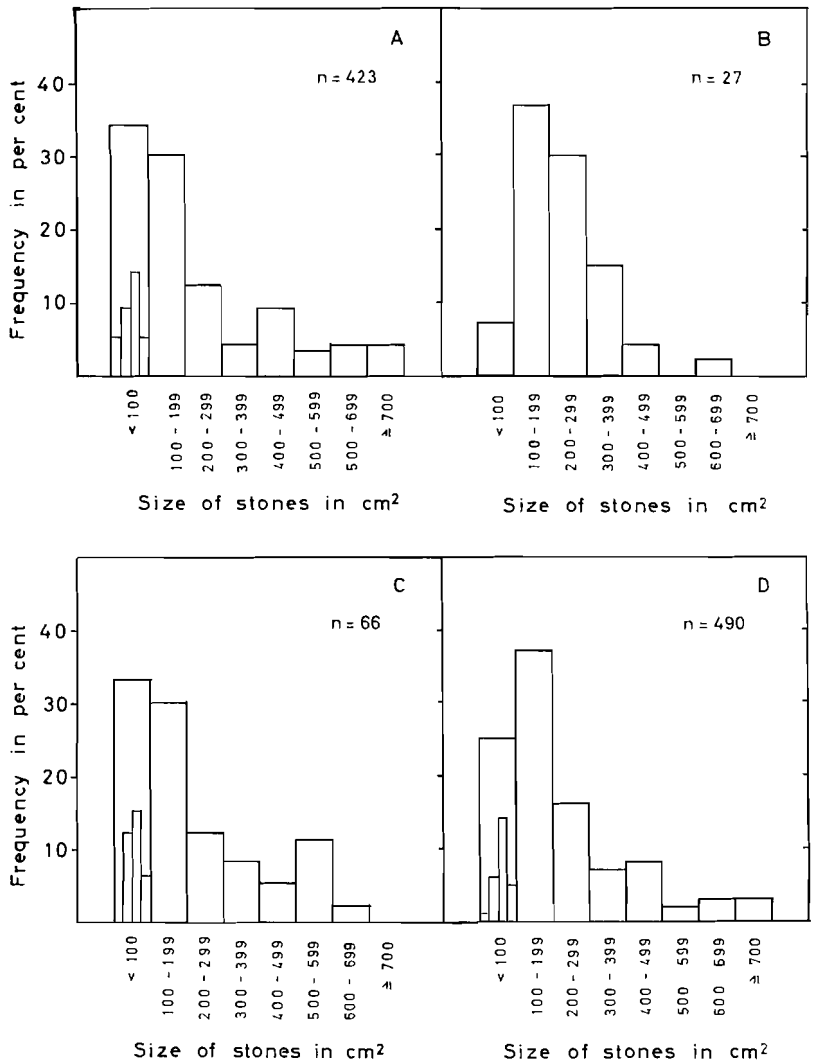


Fig. 1. The percentage of the different stone sizes in the four habitats where the stone cover exceeded more than 5%. In three habitats (A, C, and D), where the number of stones measured is high, more detailed size frequences are given for stones less than 100 cm². These groups are: < 25 cm², 25-49 cm², 50-74 cm² and 75-99 cm². A = Pioneer community, B = Eutrophic meadow, C = Oligotrophic dry heath community, D = *Salix herbacea*–snow bed. n. = number of stones.

MATERIAL AND METHODS

The collecting consisted of overturning the stones so that all animals on the exposed soil surface, and on the under side of the stone, could be collected as quickly as possible. Collembola and Acarina were not collected, because these very minute animals are very difficult to see. They also disappear quickly. But in most cases their presence was noted. The other invertebrates were collected with forceps and aspirator. This is a very painstaking and time-consuming effort, and several investigators were used to enable us to have a sample large enough for statistical treatment. The animals were counted and weighed and classified to order or family immediately after collecting. Typical soil animals, like Oligochaeta and tipulid larvae, were excluded from the material.

Each collection consisted of a number of

Table I. Total number of arthropods collected (excluding Collembola and Acarina), the number of stones overturned, and the size of the sample areas within which the hypolithion has been investigated

Habitat	Pioneer community	Eutrophic meadow	Oligotrophic dry heath	Snow bed	Tussock area	Total
Number of arthropods collected	324	661	53	361	32	1431
Number of stones turned	641	642	97	618	38	2036
Investigated area in m^2 (of the plant community)	58	450	425	153	250	1336

samples, taken at random in a given habitat. Each sample consisted of all animals (except Collembola and Acarina) found under all stones within a given area. During most of 1969, units of 1×1 were used in habitats where the stone cover was especially high, and units of 5×5 m where the density of stones was lower. However, in habitats where the stone cover was scarce, this method gave only very small amounts of material. We therefore chose a new unit, which consisted of all animals from a total area of 0.5 m^2 of overturned stones. This unit was used in September 1969 and in the summer of 1970.

In the sampling area, two parallel lines were extended 1–2 metres apart, and all the stones that could be overturned by hand were successively removed in this trip. The area covered by each stone was measured. When 0.5 m^2 of stones had been overturned, the total area investigated was measured. By this method not only the density of animals under stones per m^2 of habitat was found, but also the density per m^2 of stone cover. Animals associated with deep-lying, or very large stones are not included in this survey. The total material of animals, the number of stones overturned, and the size of the areas investigated is shown in Table I.

The samples were taken in the summers of 1969 (10–16 July, 4–8 August, and 6–7 September) and 1970 (14 July and 11–12 August). Each sampling lasted several hours. All were taken within the time interval 1030 to about 1900 hrs. The collections could not be taken during similar weather conditions, partly because the weather is usually very unstable at Finse. The weather conditions were, however, recorded during each collection in standard meteorological height at the field station. (Most of the data about wind in 1969 are taken from Slirå meteorological station situated 1300 m a.s.l., 5 km west of Finse.) Also data about the weather on the preceding day at Finse are given, as this may have affected the colonization of the hypolithic spaces by accidental visitors.

The weather during the samplings is given in this way: temperature range, mm rain, degree of cloudiness, and the maximum strength of wind in Beaufort. The data from the preceding day are given in this way: minimum temperature the night preceding the day of sampling, maximum temperature the preceding day, mm rain in all 24 hrs of the preceding day, cloudiness in the light part of the day, and the maximum strength of wind in all 24 hrs. (Data about rain on the sampling date before the sampling are given in brackets.)

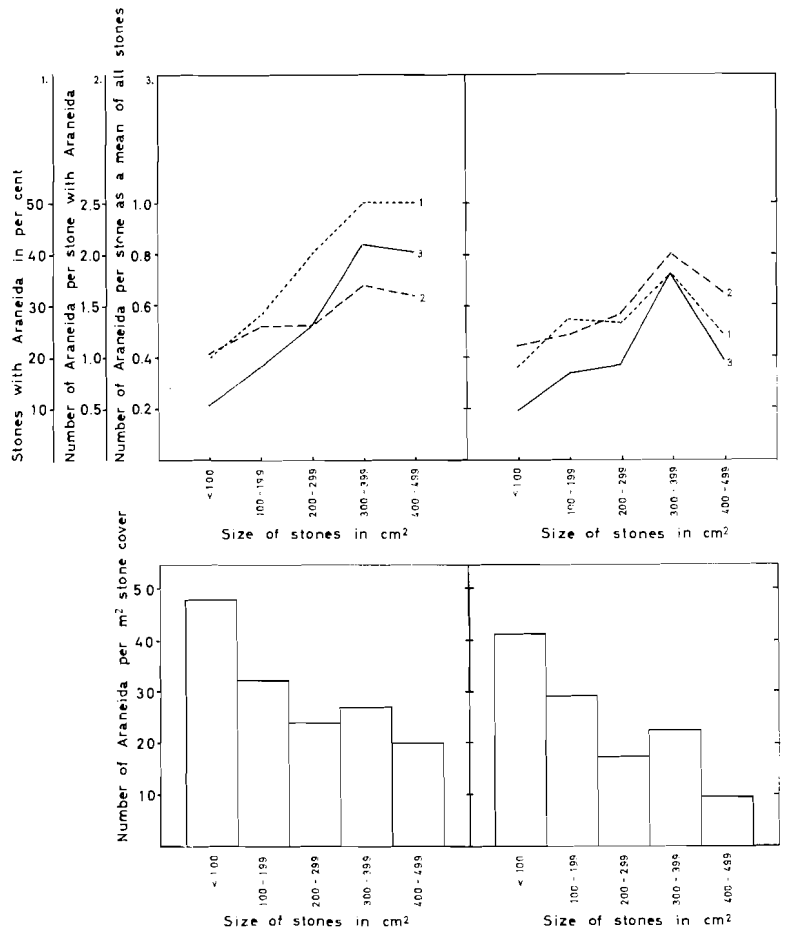
July 1969. (Oligotrophic dry heath 10 July and 16 July.) 10 July: 8–10, 0, partly cloudy, 3. Preceding day: 4.5, 9.5, 0, partly cloudy, 4. 16 July: 17–19, 0, clear, 1. Preceding day: 5, 12, 0, (0.3 mm at 02), clear, 1.

Aug. 1969. (Pioneer community 4 Aug., eutrophic meadow 5 Aug., oligotrophic dry heath and tussock area 7 Aug., snow bed 8 Aug.) The weather was very stable in this period, and the following data apply for all samplings: 16.5–19.5, 0, partly cloudy-clear, 4. General for the preceding day: 7.5–8.5, 16.5–19.5, 3 mm. 6 Aug. at 19–20, partly cloudy-clear, 4.

Sept. 1969. (Snow bed 6 Sept. and 7 Sept.) 6 Sept.: 6–7.5, 0, partly cloudy, about 3. Preced-

Table II. The monthly mean temperature and the monthly precipitation for the sampling months of 1969 and 1970, and the monthly standard normals for Slirå. Further information about recording localities are given in the text

	Monthly mean temp. (°C)			Monthly precipitation (mm)		
	July	Aug.	Sept.	July	Aug.	Sept.
1969	6.5	10.6	3.6	101	22	149
1970	5.5	7.8	2.9	180	51	138
Monthly Standard Normals	7.3	7.0	3.3	100	168	99



Number of stones overturned	141	117	42	12	26	83	137	42	14	21
Number of stones with Araneida	28	33	17	6	13	15	37	11	5	5
Number of Araneida found	29	42	22	10	21	16	45	15	10	8
Area in m² of stones overturned	0.6057	1.3305	0.9105	0.3750	1.0600	0.3900	1.5425	0.8925	0.4650	0.8450

Fig. 2. Density of Araneida under stones at different stone sizes. Four different ways of expressing the density is explained to the left in the figure. Left: Pioneer community 11 Aug. 1970. Right: *Salix herbacea*- snow bed 12 Aug. 1970.

ing day: 5, 8, 1.5, cloudy, 5. 7 Sept.: 5–6, 0, cloudy, about 3. Preceding day: –0.5, 8, 0.3, partly cloudy, about 3.

July 1970. (Pioneer community and eutrophic meadow 14 July.) 6–9, 0, changing, 2. Preceding day: 3,7, 6.6 mm until at 19, (1.9 mm 13 July 1900 – 14 July 0700), 2.

Aug. 1970. (Pioneer community 11 Aug. and snow bed 12 Aug.) 11 Aug.: 5.5–8.5, 0.4, partly cloudy, 3. Precedingday: 4.8, 2.5, (0.3 mm

Table III. Number and fresh weight (in brackets) for each group of invertebrates collected under stones in per cent of the total material (Collembola and Acarina excluded)

	Pioneer community			Eutrophic meadow		Oligotrophic dry heath		Snow bed community			Tussock area
	Aug. 69	July 70	Aug. 70	Aug. 69	July 70	July 69	Aug. 69	Aug. 69	Sep. 69	Aug. 70	Aug. 69
Araneida	75	75 (20)	83 (42)	86 (33)	82 (22)	52 (32)	80 (61)	90 (50)	99 (77)	82 (28)	69 (11)
Opiliones											
Mitopus morio	2	3 (6)	1 (15)	3 (31)	4 (48)	6 (13)	5 (37)	2 (26)	1 (22)	3 (35)	12 (86)
Homoptera											
Aphidoidea	5		2 (1)								
Coccoidea						3 (< 1)					6 (2)
Cicadoidea						6 (< 1)					
Heteroptera, larvae						3 (< 1)					
Diptera, adult											
Bibionidae	3			1 (4)				1 (1)			
Tipulidae										4 (4)	
Other	6		6 (4)	< 1 (< 1)	4 (< 1)	3 (< 1)		4 (< 1)		2 (< 1)	
Lepidoptera, adult										1 (1)	
Lepidoptera, larvae	3			< 1 (2)		3 (7)					
Coleoptera, adult											
Byrrhidae		3 (36)				3 (16)				1 (10)	
Carabidae	3	2 (9)	1 (4)	4 (23)	3 (20)			4 (22)		1 (1)	
Chrysomelidae						3 (12)					
Curculionidae			2 (30)	< 1 (2)						1 (5)	
Staphylinidae		5 (1)	1 (1)	2 (1)	4 (2)	6 (1)	5 (< 1)				12 (1)
Coleoptera, larvae	2		1 (2)	3 (4)	1 (8)	9 (16)	10 (2)			1 (1)	
Hymenoptera, adult		5 (1)	3 (< 1)	1 (< 1)	3 (1)	3 (3)					
Hymenoptera, larvae		2 (27)								1 (7)	
Insecta, larvae	2	6 (< 1)	2 (1)							3 (2)	
Insecta, pupae			1 (1)							4 (6)	
Total number	64	65	195	585	76	33	20	107	116	138	32
Total weight (mg)	363	304	669	2285	315	274	118	365	209	790	300

at 00–04), cloudy, 3. 12 Aug.: 9–10.5, 0, mainly cloudy, 1. Preceding day: 2.5, 8.5, 0.8, partly cloudy, 2.

Table II gives the monthly mean temperature, the monthly precipitation for the sampling months of 1969 and 1970, and the monthly standard normals (Bruun 1962, Det norske meteorologiske institutt 1949, 1971). Until October 1969 the observations were taken at Slirå meteorological station. Later observations were taken at Finse meteorological station, 1220 m a.s.l. The monthly precipitation for July and September, and the monthly mean temperature for July 1969 were taken at the Zoological Station, Finse, 1210 m a.s.l. July was cold both years, August warm and very dry, and September very rainy both years.

RESULTS

The composition of the total invertebrate material found under stones (except Collembola and Acarina) is presented in Table III. For each collection the number and fresh weight of each aminal group are given in per cent. The total number and weight of the animals are given at the bottom of the Table. The number and fresh weight per m^2 of each habitat and per m^2 of stones turned are given in Tables IV-V. The mean and the standard error of the mean together with the number of samples are given as a result of 5–14 samples, mostly 10. Because Araneida is a dominant group they have been treated separately.

In Fig. 2 are shown some relationships between stone sizes and densities of Araneida in two samples from the pioneer community and the snow bed, where the greatest number of stones were investigated. The factors related to stone size are: per cent of stones with Araneida, number of Araneida per stone with Araneida found underneath, number of Araneida per stone as a mean of all stones turned, and number of Araneida per m^2 of stone cover.

DISCUSSION

Occurrence of Collembola and Acarina

As mentioned earlier, Collembola and Acarina were not collected, but in most cases it was noted if these groups were observed under the stone or not. In August 1970, Collembola were observed under 51 % of the stones in the pioneer community, and under 35 % of the stones in the snow bed. The corresponding numbers for Acarina were 14 and 19 %. These numbers are minimal, because Collembola and Acarina

Table IV. Total number and weight of arthropods (except Collembola and Acarina) and Araneida under stones, per m^2 habitat

Habitat	Date	No. of samples	All arthropods		Araneida	
			No. of animals[1]	Weight (mg)[1]	No. of animals[1]	Weight (mg)[1]
Pioneer community	Aug. 69	10	6.40±1.24	36.25±17.97	4.80±1.14	
	Aug. 70	13	5.90±1.01	11.98± 2.93	4.94±0.95	6.74±1.77
Eutrophic meadow	Aug. 69	9	2.61±1.10	10.19± 5.57	2.23±0.92	3.39±1.40
Oligotrophic dry heath	July 69	7[2]	0.22±0.08	1.83± 1.12	0.12±0.06	0.58±0.47
	Aug. 69	10	0.08±0.02	0.48± 0.24	0.06±0.02	0.29±0.15
Snow bed community	Aug. 69	10	2.70±0.47	9.11± 2.58	2.43±0.43	4.60±0.82
	Sep. 69	5	3.50±1.53	6.68± 3.12	3.48±1.52	5.22±2.41
	Aug. 70	10	4.00±0.58	25.68± 4.34	3.14±0.60	6.45±1.68
Tussock area	Aug. 69	10	0.12±0.05	1.21± 0.73	0.08±0.04	0.13±0.08

[1] Mean ± standard error (S.E.)
[2] Weight: 6 samples.

Table V. Total number and weight of arthropods (except Collembola and Acarina) and Araneida under stones, per m² of stones overturned

Habitat	Date	No. of samples	All arthropods		Araneida	
			No. of animals[1]	Weight (mg)[1]	No. of animals[1]	Weight (mg)[1]
Pioneer community	Aug. 70	14	26.99± 3.16	65.50±20.77	22.39± 2.67	27.64± 3.80
Snow bed community	Sep. 69	5	41.12± 5.46	73.86±23.95	40.78± 5.38	57.46± 8.40
	Aug. 70	10	26.50± 4.41	157.10±24.98	21.89± 4.45	42.50±11.68

[1] Mean ± standard error (S.E.).

are very difficult to observe. These two animal groups were probably present under the great majority of the stones turned, perhaps under all of them. They may be highly important to the energy flow in the under stone communities, both as decomposers, predators, and as a source of food for other animals.

Composition and density of hypolithion

The hypolithic fauna is very rich (Table III), and the list of orders and families is very similar to that from quick trap collections from the vegetation and litter in three habitas at Stigstuv, approx. 36 km from Finse, at a level of 1210–1240 m a.s.l. (Kauri et al. 1969, Solhöy, pers. comm.).

The habitats investigated at Finse and Stigstuv are not quite similar. It may, however, be of interest to compare the quantitative hypolithic data from Finse with the quantitative data from between stones at Stigstuv. In the hypolithic communities, Araneida dominates the number of invertebrates in every collection (Table III). This is in contrast to the quick trap results (Kauri et al. 1969, Solhöy, pers. comm.). When Collembola, Acarina, and Oligochaeta are excluded from the quick trap material, Araneida never make up as much as 50 % of the total number. Most often, Hemiptera or Thysanoptera are the groups that are best represented.

The densities of invertebrates under stones per m² of stones turned at Finse (Table V) are lower than the densities measured per m² between stones in three habitats at Stigstuv at the same time of year (Solhöy, pers. comm., data from August and September 1969, except Oligochaeta, Collembola, and Acarina). The mean values from Finse range from 27 to 41, while the mean values from Stigstuv range from 130 to 263 in oligotrophic lichen heath, from 162 to 296 in eutrophic mire, and from 462 to 648 in eutrophic dry meadow. However, the mean density of Araneida (Table V) is almost as high under stones at Finse (22 to 41 per m² of stone cover) as between stones at Stigstuv (mean values ranging from 10 to 81 in oligotrophic lichen heath, from 52 to 81 in eutrophic mire, and from 38 to 48 in eutrophic dry meadow).

Because Araneida are predators, they may participate in many food chains, and play a great role in the total energy flow picture. Very often eggs of Araneida were found under stones, indicating that this habitat is more or less permanent for the whole life cycle.

Regarding the density of hypolithion, per m² of plant community, the values are quite dependent on the stone cover (Table IV). The pioneer community, eutrophic meadow, and snow bed all have a relatively high stone cover and a rich hypolithion, while the oligotrophic dry heath and the tussock area are poor in stones and hypolithion. (See 'Study area' for the degree of stone cover.)

Weight of hypolithion

The mean values for the total hypolithion (except Collembola and Acarina) range from 65.5 to 157.1 mg per m² of stones turned (Table V), and from 0.48 to 36.3 mg per m² of habitat (Table IV). Araneida do not dominate

so much in weight (Tables IV-V) as they do in number (Table III). Comparable data of the invertebrate fauna in litter and vegetation are wanting.

The importance of stone size

Schönborn (1961) reports that the best stones for hypolithic communities have an area ranging from 100 to 400 cm^2, and a thickness of about 10 cm or less. Other stones have a hypolithion poorer both in species number and density. Mani (1968) gives the same area for optimal stones, but mentions an optimal thickness of about 20 cm. Kühnelt (1970) regarded the best stones to have a diameter of 10 to 30 cm.

Since invertebrates are usually very sensitive to microclimate, it is obvious that only stones with a favourable microclimatic in the hypolithic space are used. Under very small stones, the humidity easily becomes too low, and the space is limited. Temperature under these small stones shows both large diurnal and annual variations. Very big stones are often situated deep in the soil, with little, or no hypolithic space. The space under medium-sized stones has a relatively constant, and high humidity. The hypolithic space is often well developed and can easily be found. Furthermore, the temperature is very stable. In the day, mainly the upper part of the stone is warmed, and during night this heat is released and delays the cooling of the hypolithic space.

In this study, the density of hypolithic Araneida from two habitats has been correlated with stone size (Fig. 2). The results are very similar in both cases, indicating some general principles. The percentage of stones with Araneida increases with an increase in stone area up to 400 cm^2 (curve No. 1). This might be explained by the fact that the percentage of stones having a suitable microclimate in the hypolithic space increases with increase in stone size up to 400 cm^2. The increasing number of Araneida per stone with Araneida up to 400 cm^2 (curve No. 2) can be explained by the increasing hypolithic area when stone size increases. The number of Araneida per stone, as a mean of all stones, also increases up to 400 cm^2 (curve No. 3). This curve is a combination of data from the two other curves. Curve No. 3 is more similar to curve No. 1 than it is to No. 2, because the changes in per cent of the values are greatest in curve No. 1.

When a certain stone size is reached (here about 400 cm^2) the percentage of favourable stones, the number of Araneida per stone with Araneida, and the number per stone as a mean of all stones do not show further increase. As already indicated, this may be explained by a less favourable microclimate, and a poorer hypolithic space, which is also difficult to colonize. The optimal stone size for Araneida in this investigation (about 400 cm^2) is in accordance with the data given by Schönborn (1961), Mani (1968) and Kühnelt (1970). The thickness of the stones is also an important factor, but has not been measured here.

With increasing stone size, the number of Araneida per m^2 of stone cover decreases (lower part of Fig. 2). It has no effect that the number of Araneida per stone increases with increasing stone size (up to about 400 cm^2), because the number of stones to cover 1 m^2 is so much greater at a smaller stone size. This tells us that if we are going to calculate the density of hypolithic animals in a given habitat, it is not enough to know the stone cover percentage; we also have to take the size of the stones into consideration.

FINAL REMARKS

The hypolithion is a mixture of species that are dependent upon this habitat for their life cycle or parts thereof, and species that are accidental visitors (Balogh 1958). The composition of the fauna will therefore change during the year, and it will also depend on the time of the day and the weather conditions (Cole 1946).

Both the quick trap samples and the hypolithic samples were collected during the day, and only samples collected at the same time of year are used in the comparison of the two methods. To study the effect of the weather factors alone, it is necessary to make repeated collections (in different places) in the same habitat within a few days, at the same time of

the day, and during different weather conditions. This has not been done in the present study. The aim of this survey is to give a picture of the composition and density of the hypolithic fauna in different habitats at different times of the year, during the weather conditions described.

Probably a greater diversity and a higher density would be found on cold, cloudy days, than on warm, sunny days. It is our strong impression from field observations that more hypolithic animals (e. g. Coleoptera and Opiliones) are seen walking free on the ground in good weather, than during bad weather conditions. The data about hypolithion from Finse, although not treating all aspects of the subject, should, however, give an indication of the errors that arise if the hypolithion is neglected during quantitative and qualitative studies of invertebrates above timber line.

In this survey, the soil fauna has not been taken into consideration. It is also possible that the soil fauna under stones may differ from the soil fauna between stones.

When calculating the energy-flow per unit area in a given biotic community, we have to take the fauna living under stones into consideration. In places where the stone cover is high, data from the areas between stones alone are highly insufficient for the calculations.

ACKNOWLEDGEMENTS

We wish to express our gratitude to all who took part in the field work, to Mrs. E. B. Stene for drawing the figures and to R. Wiger, M. Sc., for improving the English. This work is part of the Hardangervidda IBP/PT-UM project.

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Life History Distributions of Geographically Different Populations of *Ephestia cautella* (Walker) (Lep., Phycitidae) in Gradient Environments

NORMA A. DICKER & F. L. WATERHOUSE

Dicker, N. A. & Waterhouse, F. L. 1972. Life history distributions of geographically different populations of *Ephestia cautella* (Walker) (Lep., Phycitidae) in gradient environments. *Norsk ent. Tidsskr. 19*, 11-15.

The distribution of a Laboratory and two imported populations (ex Nigeria and Kenya) of *Ephestia cautella* (Walker) were studied in a controlled gradient environment (temperature ranging from 11.5 °C to 39.5 °C). Adults were found to spend most time in the cool moist regions whereas oviposition and pupation took place in the warmer, drier area of the environment. The field population differed not only between the distributions in the gradient, but also in aspects of their biology. On the whole the Laboratory population was more restricted in its egg and pupal distributions, much slower to develop, and had a lower survival rate than the field populations. The latter appeared to be more favoured in the gradient environment than the former.

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Ephestia cautella (Walker) (Lepidoptera, Phycitidae) is serious pest of stored produce such as dried fruits, oil seeds, and cereals in warm and tropical countries (Burges & Haskins 1965). Infestation by *Ephestia* has throughout the years been an increasing problem (Richards & Thomson 1932) and in the last 10 years it has been further emphasised in such countries as India and Kenya (Tuli & Mookherjee 1963, Graham 1970). *E. cautella* not only causes loss in weight and in nutritive value of produce, but the presence of larvae, frass, and silk also results in considerable spoilage.

Many Laboratory studies on *E. cautella* have been aimed at obtaining information on various aspects of its biology under a number of conditions in which the temperatures and humidities were spatially uniform and stable through time. Such investigations have yielded valuable information, but because the species was restricted at the beginning of its development to a particular condition, it did not have the opportunity to choose suitable conditions for particular stages in its life history. This can only be achieved if a range of conditions is presented to the species simultaneously, i.e. a gradient environment, thereby emphasising the behavioural aspect as shown by Graham (1964, 1965), and Waterhouse, Onyearu & Amos (1971) working with *Tribolium* spp. The purpose of this paper is to determine whether *E. cautella* selects different regions in a temporally stable gradient environment, depending upon the stage in its development. As Burges & Haskins (1965) found differences in the biology of various *E. cautella* populations under constant uniform conditions, opportunity was taken to compare two recently imported field populations with a Laboratory population.

METHODS

Insects

Three *E. cautella* populations were used; a Laboratory population which had been reared at 25 °C and 70 % R. H. for several years, and two specially inported field populations, one from Kano, Nigeria and the other from Nairobi, Kenya.

The moths were cultured in sterilised coarse wheatfeed mixed with glycerine (ratio 5 : 1) in a 7 lb rock jar at about 25 °C and 70 % R. H. As moths deprived of drinking water die early and lay fewer eggs (Norris 1934), a 2.5 × 7.5 cm glass tube filled with water was placed in the culture jar. A piece of muslin inserted into the tube acted as a wick from which the moths could drink. One generation of adults was produced in each culture and used for setting up new ones, the old cultures then being destroyed.

Apparatus

Descriptions of the gradient apparatus and the 90 cm long, moulded perspex troughs have been given by Graham, Onyearu & Waterhouse (1965). In the present study, however, it was necessary to modify the trough lids so that the adults could be introduced without disrupting the stabilised gradient environment. This was achieved by making the centre portion of the lid removable, section by section, whilst the lid as a whole remained on the trough. By sliding the removable sections along the centre of the lid, it was possible to insert the adults at any desired location in the gradient environment. The trough was divided into nine arbitrary regions or compartments, each 10 cm long, in order to facilitate observation.

Temperature measurements were made using thermocouples and a minipotentiometer. The linear temperature gradient ranged from 11.5 °C at floor level in the middle of the coldest compartment (number 1), to 39.5 °C at a similar point in the hottest compartment (number 9), thus giving a gradient steepness of the order 0.3 °C per cm. The concomitant inverse humidity gradient was controlled by using food media previously prepared to a known moisture content (m.c.). All m.c. determinations were carried out using a 'Kaybee' infra-tester.

The food medium used for the oviposition studies was coarse wheatfeed which was ground, sieved (60 mesh B.S.) and then put into a desiccator containing water to condition overnight before it was placed in the troughs. Coarse wheatfeed mixed with glycerine (ratio 5 : 1) was used as the food medium for the developing stages in the gradient.

A number of replicates was carried out for each *E. cautella* population (Laboratory 10, Nigeria 11, Kenya 6). Prior to each test the adults were removed from the cultures and provided with moistened filter paper for drinking, and left two hours. The adults (2–3 days old) were inserted into the centre compartment (5) of the gradient trough. After 48 hours, the number of adults in each region of the trough was carefully noted. Previous experience indicated that not only did the adults have adequate time in which to orientate from their initial central location on the gradient but also sufficient time for oviposition. The adults were then removed by projecting a pooter tube through the central region of the trough lid, and the sex of the adults checked. The complete lid was then removed and the fine wheatfeed taken from each compartment and sieved (60 mesh B.S.) to separate any eggs present, which were then counted. The previously prepared wheatfeed glycerine food medium (50 g) was put into the trough and the eggs returned to its surface in the same compartment region in which they had been laid.

The trough was examined periodically for pupal cocoons which were usually found on the trough floor. Each pupa was carefully removed from its cocoon and placed in a small, pierced gelatine capsule (the hole allowed ventilation) on the surface of the food in its compartment region. This stopped any of the eclosing adults from moving about the gradient. The capsules were inspected daily for adult eclosion.

All the tests were carried out in darkness except for those times when it was necessary to inspect the troughs.

RESULTS

The temperature gradient varied very little through time and was well within the specified limits for the equipment (Graham et. al. 1965). Checks on the fine wheatfeed used as the oviposition medium revealed that its initial m.c. of 12.9 % altered considerably during the first

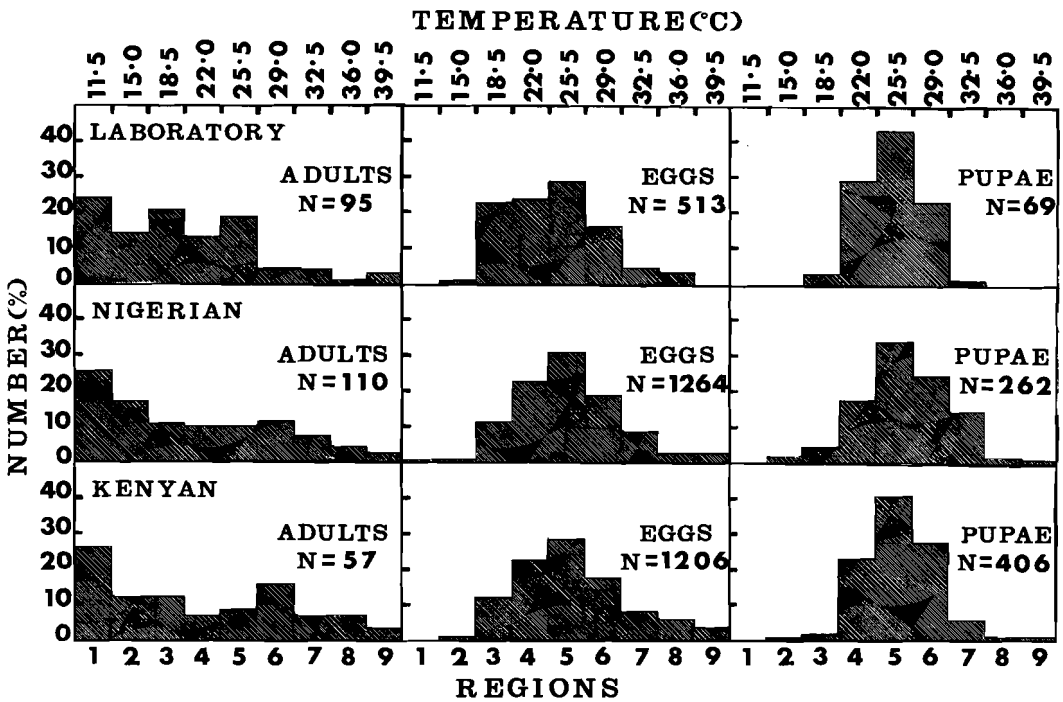

Fig. 1. Histograms (on percentage basis) representing the distribution of adults, eggs, and pupae for three populations of *E. cautella* in a gradient environment. The total numbers (N) of individuals on which the distributions were based are indicated. (See text for further details.)

24 hours becoming damper (about 41 % m.c. at the cold end of the gradient), but altered little thereafter. However alterations in the m.c. of the coarse wheatfeed (initial m.c. 15.6 %) used as food for the developing stages were considerable during the first 14 days, with the hot end (compartment 9) of the gradient reaching 21.1 %, and the cold end (compartments 1 and

Table I. Distribution of adults, eggs and pupae of 3 populations of *E. cautella* together with some details of its biology in a gradient environment

		Population		
		Laboratory	Nigerian	Kenyan
Mean (°C) of distribution ± S.D.	Adults	20.0 ± 7.1	20.7 ± 7.9	21.7 ± 7.8
	Eggs	24.4 ± 4.9	25.8 ± 3.1	26.1 ± 5.4
	Pupae	25.3 ± 2.6	26.9 ± 4.2	26.0 ± 3.4
Egg-adult developmental period (days)	Number	69	268	406
	Mean	37.7	29.5	33.9
	S.E.	1.34	0.34	0.23
	C.V. (%)	28.5	18.6	14.8
Mortality %		86	72	67
Average number of eggs per female per day		9.1	23.6	39.9

2) becoming too damp for analysis; compartment 3, however was about 47 % m.c. Thereafter the changes in m.c. were relatively slight with the hot end of the gradient becoming slightly drier (18.5 %) and the cold end (compartment 3) becoming slightly damper (51.2 %); the extreme cold end of the gradient (compartments 1 and 2) was too damp for assessment.

The number of adults, eggs, and pupae found in the various regions of the gradient troughs have been summed for all replicates of each population and presented on a percentage basis as histograms in Fig. 1.

It can be seen that the distribution of all three adult populations was strongly biased towards the cool, moist regions of the gradient. This was also reflected by the mean positions of the distributions and the theoretically preferred ranges of the adults based on the mean $\pm$ one standard deviation (Table I). None of the differences between the adult distributions were significant. It is noteworthy that there is a vertical temperature gradient in the troughs, and therefore the adult distribution is less reliable in terms of compartmental temperature as adults sometimes settled on the lid and sides of the trough.

The distribution of eggs laid by the Laboratory population was significantly different (χ^2 test) from those of the field population in that it was comparatively restricted in range, with relatively more eggs in the cooler compartments. The field populations differed significantly (χ^2 test) between themselves; proportionately more eggs were laid by the Nigerian population in the middle regions whereas the Kenyan population laid relatively more eggs in the cooler and warmer regions of the gradient.

The pupal distribution of the Laboratory population was again relatively restricted, no pupation occurring in the extreme conditions, and was significantly different (χ^2-test) from that of the Nigerian and Kenyan populations. The field populations were significantly different from each other, the Nigerian population having relatively more pupations in the cooler and warmer ends and less in the middle regions of the gradient.

The average number of eggs laid in the 48 hrs period varied between the three populations. The Laboratory population laid considerably fewer eggs than the field populations although these also differed between themselves (Table I). The mean egg to adult development period varied between the populations with the Laboratory population being far slower to develop than the two field populations. The Nigerian population had a significantly shorter developmental period than the Kenyan population (Table I).

The overall developmental mortality was high, possibly due to the consequences of overcrowding. However it is interesting to note that the mortality of the Laboratory population was significantly higher than the two field populations, which were similar to each other.

The developmental period of the Laboratory population had a markedly higher coefficient of variation than that obtained for the field populations.

DISCUSSION

In the gradient environment the three *E. cautella* populations were able to select conditions most suitable for the development of the particular stages in their life history. Adults favoured the moist, cool regions in the gradient whereas oviposition and pupation occurred mainly in the drier, warmer regions. Thus, although the gradient conditions for the most part might have been unfavourable, only a small area that offered the right conditions was necessary to support their development.

Adults of all three populations responded similarly in that they favoured the cool regions in the gradient environment. All laid their eggs in generally warmer conditions although the actual distribution of their oviposition sites differed in a number of respects. This suggests that adults may have moved from the cooler to the warmer regions in order to oviposit. Support for this view comes from the work of Amos, Waterhouse & Chetham (1968) who studied isolated *E. cautella* adults by means of time lapse photography. They found that a female adult spent periods in the cool region

of a gradient environment (ranging from 17 °C to 32 °C) interspersed with periods of a much shorter duration in the warmer regions where oviposition occurred. The distributions of the pupal sites were generally in warm conditions and in the case of the Laboratory and Nigerian populations they were slightly warmer than that of their oviposition sites. The field populations, although differing between themselves, may have been more strongly favoured over a wider range of conditions than the Laboratory population.

The method of rearing the Laboratory population at uniform and constant conditions over many years has undoubtedly placed selective pressures on the population, and has probably resulted in a tendency towards homozygosity. It can be expected therefore that such a population would be more variable phenotypically in conditions outside the narrow range in which it has been reared (Lerner 1955). Similar results were obtained by Waterhouse & Nowosielski-Slepowron (1964) using *Cathartus quadricollis* Guer. They compared a laboratory population reared for 16 years under uniform conditions with a recently obtained wild population, and showed that the latter had a relatively uniform development over a wider range of conditions than the Laboratory population.

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New Records of Spiders from Norway

E. HAUGE

Hauge, E. 1972. New Records of Spiders from Norway. *Norsk ent. Tidsskr. 19,* 17–18.

In the present paper 4 species of spiders are reported as new to Norway. The species are: *Euryopis flavomaculata* (C. L. Koch), *Gongylidiellum latebricola* (O. P.-Cambr.), *Porrhomma montanum* Jackson, *Silometopus curtus* (Sim.). *Phaulothrix hardyi* (Blw.) and *Diplocephalus permixtus* (O. P.-Cambr.) are new to Western Norway.

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The short list of spiders below is mainly a result of my examination of two collections made in Western Norway by cand. mag. Torstein Solhöy (T.S.) and cand. real. Jon Fjeldså (J.F.). Four species should be regarded as new to the Norwegian fauna. Two species are new to Western Norway.

EURYOPIS FLAVOMACULATA (C. L. Koch).

Locality: HOi: Kvinnherad, Hatlestrand, 200 m SW of Stölen, near the shore of a small eutrophic lake. One male was caught 28 June 1968 (T.S.) by sieving in a thick moss cover. The plant community was dominated by *Comarum palustre, Viola palustre, Cicuta virosa, Myosotis sp., Carex sp.*

According to Tullgren (1949) this species is very common in the southern parts of Sweden, but to my knowledge no records from Norway have been published.

CONGYLIDIELLUM LATEBRICOLA (O. P.-Cambr.).

Two females found 26 June 1968 (T.S.) in the same locality and habitat as *E. flavomaculata.*

The species is, according to Locket & Millidge (1953), widespread throughout the British Isles; on the European continent distributed as far north as to Poland (Wiehle 1960). Larsen & Böggild (1970) have found it north to Kongenshus Hede in Denmark. It is also, according to Roewer (1942), found in northern Europe (Sweden?). Not previously known from Norway.

PORRHOMMA MONTANUM Jackson.

Locality: HOy: Stord, 2 km NE of Leirvik, Mjelkeviki. One female found 18 June 1967 (T.S.) on a SE faced slope dominated by *Allium ursinum,* other plants are *Fraxinus excelsior, Corylus avellana, Sorbus aucuparia, Ilex aquifolium.*

This species is, according to Wiehle (1956), known only from Great Britain and Germany, in Britain at comparatively high altitudes (1000 m) and it is perhaps not surprising to find it in the outermost parts of Western Norway. It should be regarded as new to our fauna.

The *Porrhomma* species are usually not very easy to identify, and this is in particular the case with the present specimen. The epigyne is somewhat obscure, but careful examination gives the impression of two sausage-like, dark bodies, overlayed by two smaller oval dark

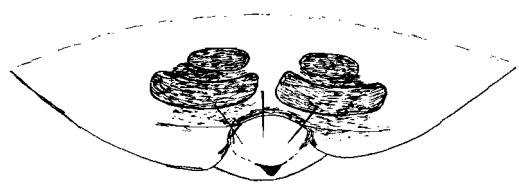

Fig. 1. *Porrhomma montanum* Jackson, ♀ epigyne.

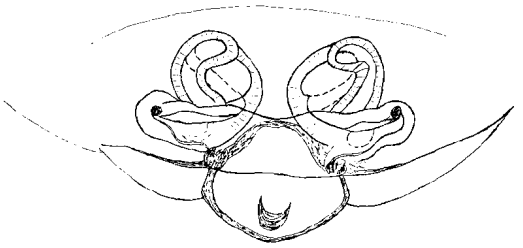

Fig. 2. *Porrhomma montanum* Jackson, ♀ vulva.

spots, as indicated in Fig. 1. The vulva (Fig. 2) should not give much doubt about the species, being very like the drawing made by Locket & Millidge (1953). The receptacula semini are somewhat more separated from the median line than is the case in the drawing made by Wiehle (1956, fig. 394). My specimen differs from the descriptions of the authors cited above, in having Tm = 0.32 instead of 0.40. Femora lack dorsal spines, but an abnormality seems to be that the *left* femur I has *two* distal, prolateral spines instead of one.

Distance between the eyes as described by Locket & Millidge (1953). Carapace light yellow-brown, and so are the legs. Abdomen unicolorous light grey. The distal part of the gnathocoxae remarkably white as mentioned by Wiehle (1956). Total length ca. 2.13 mm, carapace 0.92 mm long and 0.60 mm broad.

SILOMETOPUS URTUS (Sim.).

Locality: HOy: Herdla. Fourteen females and three males brought to the Zoological Museum, Bergen, in a sample taken from a sand/seaweed shore, 26 April 1970 (J.F.). The habitat corresponds very much with the type of habitat described for the species by Locket & Millidge (1953): 'On salt marshes, tidal estuaries, sandhills by the sea'. The species is, according to the distribution list given by Wiehle (1960), found as far north as Iceland, but not previously in the Scandinavian countries.

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PHAULOTHRIX HARDYI (Blw.).

Locality: HOi: Ljosmyr, Kvinnherad, Hardanger.

Seven adult males were collected 20 August 1971 by a student group on a bedrock surrounded by small boggy areas, scattered deciduous trees, some pines, and lots of junipers.

The species is known from Valdres (Thorell 1870–73), but the present record is the first from Western Norway.

DIPLOCEPHALUS PERMIXTUS (O.P.-Cambr.)

Locality: HOy: Herdla. One male collected 26 April 1970 in an old German bunker from World War II (J.F.)

The species has recently been reported from the eastern part of Norway as new to our country (Waaler 1971).

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The Effect of Physical and Chemical Stimuli on Oviposition in *Hylemya floralis* (Fallén) (Dipt., Anthomyiidae)

LAURITZ SÖMME & TRYGVE RYGG

Sömme, L. & Rygg, T. 1972. The Effect of Physical and Chemical Stimuli on Oviposition in *Hylemya floralis* (Fallén) (Dipt., Anthomyiidae). *Norsk ent. Tidsskr. 19*, 19–24.

Oviposition preference in the turnip root fly *(Hylemya floralis)* was studied in the laboratory by the use of artificial plants. Oviposition also took place in sand only, and the flies preferred sand of about 17 percent moisture content. Tests with crepe paper and glossy paper plants indicated that oviposition is influenced by colour and surface properties. Young swede plants were strongly preferred to the paper plants. More eggs were usually deposited on sponges dipped in extracts of leaves of turnips or swedes than on sponges dipped in water. Sponges treated with isothiocyanates were attractive or repellent to the flies, partly depending on concentration. Sinigrin was attractive in five concentrations tested. It is concluded that a number of factors influence oviposition, and that further studies may be of importance for the development of resistant varieties of cruciferous plants.

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The turnip root fly *(Hylemya floralis* (Fallén)) is an important pest on cruciferous plants in Norway (Rygg 1962, Taksdal 1963). In field trials turnips were less attacked than swedes (Rygg & Sömme 1972), and laboratory experiments with live plants suggested that the difference may partly be due to oviposition preference. It was also found that chemical stimulants affect the behaviour of newly hatched larvae, suggesting that chemical composition may influence larval penetration of the roots.

For the development of resistant varieties of cruciferous plants, several factors may be of importance. In the present investigation some factors that may influence oviposition in *H. floralis* were studied by the use of artificial plants. The effect of colours were investigated by the use of paper plants, and of chemical stimulants by the use of sponges impregnated with plant extracts, isothiocyanates, or sinigrin.

The complexity of oviposition behaviour has been more extensively studied in the closely related cabbage root fly *(Hylemya brassicae* (Bouché)). Various factors, like soil type, moisture, and content of animal dung, may affect oviposition (Schnitzler 1969). Zohren (1968) studied the ovipostion behaviour of this species on live and artificial plants, and found that olfactory and optical characteristics of the plants, as well as particle size and moisture content of the substratum may affect oviposition. Traynier (1967) showed that certain concentrations of sinigrin, allyl-isothiocyanate, B-phenylethylamin and carbon disulphide acted as oviposition stimulants for female *H. brassicae*. He also found that juices from natural host plants were more attractive than from non-host plants, and suggested that oviposition in *H. brassicae* is stimulated primarily by the interplay of many contact chemostimuli provided by host plant material.

Relatively little work has been done on factors affecting ovipositon in *H. floralis,* but Schnitzler & Müller (1968) showed that allyl-isothiocyanate attracted female flies, and that

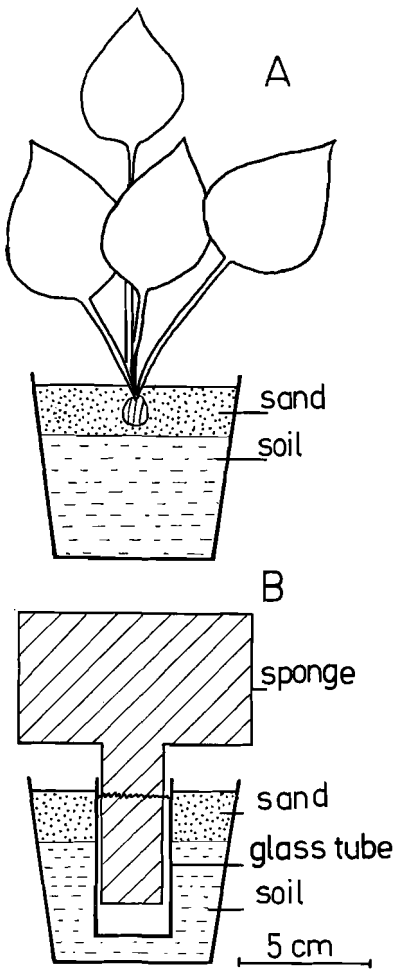

Fig. 1. Paper plant (A) and sponge in glass tube (B) placed in flower pots for studies of oviposition in *H. floralis*.

certain concentrations stimulated oviposition. The addition of allyl-isothiocyanate to juices of swedes made them more attractive to the flies.

METHODS

Rearing technique

A continuous culture of *H. floralis* was maintained in the laboratory by modifications of rearing techniques described for *H. brassicae* and *H. floralis* by Read (1965, 1969), Riedel (1967), Müller & Schnitzler (1969) and Zohren (1968). Adult flies were kept in cages (50 × 32 × 39 cm) at 20° ± 0.5 °C, 60–70 % RH and 16 hrs photoperiod. The flies were supplied with 5 cm Petri dishes containing cotton soaked in a 10 percent solution of honey in water, to which a small amount of dried yeast extract was added. In addition the flies had access to cotton soaked in water. Oviposition took place in moist sand surrounding 1.5 cm thick slices of swedes in 9 cm Petri dishes. The eggs were easily separated from the sand by flotation in water, and filtering through a black piece of cloth. Approximately 250 eggs, collected from the cloth with a brush, were transferred to each root of swedes, placed in moist soil in a large flower pot. The larval cultures were kept under similar conditions to the rearing cages, and development from egg to pupae lasted approximately four weeks. The pupae were transferred to Petri dishes for hatching, from which flies were collected daily.

Oviposition experiments

Oviposition preference was tested in cages (50 × 32 × 39 cm) containing 50 flies more than one week of age. The cages were kept at 22° ± 1 °C, 60–70 % RH and 16 hrs photoperiod.

Artificial plants for studies of the effect of colours on oviposition were made from thin wire, coloured crepe paper, or glossy paper (Fig. 1A). For studies on the effect of chemical composition on oviposition, plants were made from 0.5 cm sheets of green artificial sponge. Each sponge was cut to the shape of a 'T' (Fig. 1B), of which the lower end was placed in a tube containing water or extracts of plants.

Leaves and roots of swedes and turnips were extracted by grinding 100 g of plant tissue

Table I. The effect of different water contents in sand on oviposition in *H. floralis*

Percent water	n	Total No. of eggs
0	3	165
8.3	3	277
16.7	3	725
25.0	3	0

with 50 ml water in a homogenizer. The extract was filtered through a Büchner funnel, and used directly. For tests with isothiocyanates and sinigrin, 10 ml of a solution of homogenized suspension in water was applied with a pipette to the upper bar of the 'T' before the sponges were placed in water.

The artificial paper plants and tubes with sponges were placed in 8 cm flower pots. The upper 2 cm layer of the flower pot was covered with moist sand, separated from the lower layer of moist soil by a filter paper. This arrangement facilitated the collection of eggs, which were separated from the sand by flotation in water. Before use the sand was dried, and then mixed with water in a ratio of 20 ml pr. 100 g of sand. Eggs were collected daily. The total number varied, but usually between 50 and 150 eggs were deposited in each cage per day.

For tests of oviposition preference the flies were offered the choice between two artificial plants, or between one artificial plant and one flower pot with sand only. In tests where sponges were used, the flies were given the choice between one sponge in water, and one in plant extract, or treated with isothiocyanates as described above. A varying number of replicates were used, and the position of the plants in the cages were changed each day.

A separate experiment was run to test the flies' preference for moisture content in the sand. In this case four Petri dishes with sand of varying water content were placed in each cage.

RESULTS

Eggs were deposited in sand without the presence of plants, as shown in Table I. Oviposition took place in dry sand, but the flies preferred relatively wet sand. When the sand contained 25 percent water, in which case a thin water film was formed on the surface, no oviposition took place.

Flies given the choice between one young plant of swedes, about 16 cm high, and a flower pot with sand only, deposited an average of 87 percent of their eggs on the plants (Fig. 2).

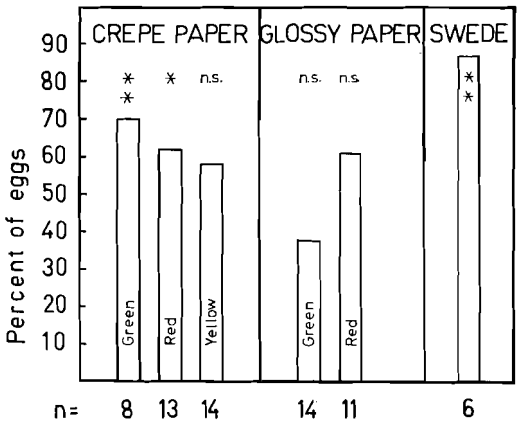

Fig. 2. Percent of eggs deposited on crepe paper, glossy paper, or young swede plants. The flies were given the choice between one plant in sand and sand only.
* : $P < 0.05$, ** : $P < 0.01$, n.s.: difference not significant. n = number of replicates.

The flies also showed a preference for green and red crepe paper plants, when these were te ted against sand only, bu not for yellow crepe paper plants. The number of eggs deposited on green and red glossy paper plants did not differ from the number laid in sand only.

Given the choice between one live swede plant and one crepe paper plant, the flies strongly preferred the live plant (Fig. 3). In tests with green against red crepe paper plants, no preference for colour was observed. When offered two glossy paper plants, however, most of the eggs were deposited on plants with

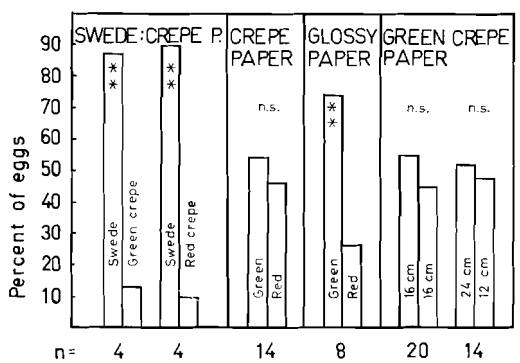

Fig. 3. Percent of eggs deposited in tests where the flies were given the choice between one swede plant and one paper plant, or between two paper plants. For further explanations see Fig. 2.

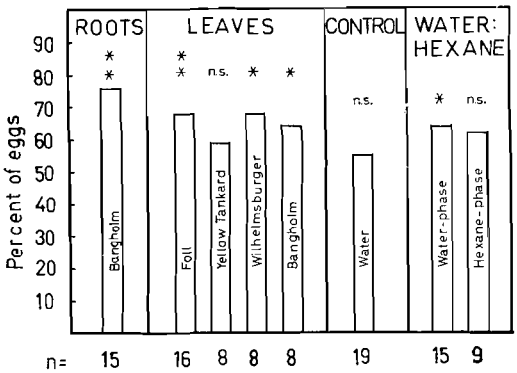

Fig. 4. Percent of eggs deposited on sponges dipped in extracts of roots or leaves of swedes and turnips. The flies were given the choice between one sponge in extract and one sponge in water. For further explanations see Fig. 2.

green colour. When the flies were offered the choice between two 16 cm high green crepe paper plants, no difference in number was found. Nor was there any difference between number of eggs laid on 12 cm or 24 cm high plants.

In tests where sponges were used, extracts of roots and leaves of host plants were attractive to the flies. About 75 % of the eggs were deposited in sand at the base of sponges soaked in root extract of swedes, when this was tested againgst sponges soaked in water only (Fig. 4). Leaf extracts of the Wilhelmsburger and Bangholm varieties of swedes were also preferred to water. With leaf extracts of turnips a significant difference was found for the Foll variety, but not for the Yellow Tankard variety.

When roots of the Bangholm variety were extracted with water : hexane (1 : 1), sponges soaked in the water phase were preferred by the flies to water only (Fig. 4). Other sponges were soaked in the hexane phase, and then in water after the hexane had evaporated. When these sponges were tested against sponges soaked in water only, no difference was found, indicating that most of the attractive substances were present in the water phase.

Sponges treated with isothiocyanates and tested against sponges in water only gave various responses in the flies. Phenylethyl-isothiocyanate was tested in four concentrations, of which the highest were highly repellent to the flies (Fig. 5). Two lower concentrations were less repellent, but for one of them the difference was significant.

An entirely different picture was obtained with allylisothiocyanate (Fig. 5). Sponges prepared with a suspension of 0.1 percent allylisothiocyanate in water were strongly repellent. Concentrations of 0.05 or 0.025 percent, however, were significantly attractive, while no differences were found with a concentration of 0.01 percent. No response was obtained with sponges treated with a solution of methyl-isothiocyanate.

Sinigrin was attractive to the flies in five concentrations, ranging from 0.4 to 0.005 percent in water (Fig. 6).

DISCUSSION

Under the conditions used in the present experiments the flies deposited their eggs in sand without the presence of natural or artificial plants (Table I). It has also been shown by Read (1965) and Zohren (1968) that female *H. brassicae* may deposit their eggs without chemical stimulants. Since oviposition also depended on the moisture content of sand used in the present study, it appears that physical factors of the substratum can act as oviposition stimulants. Approximately 17 percent water content

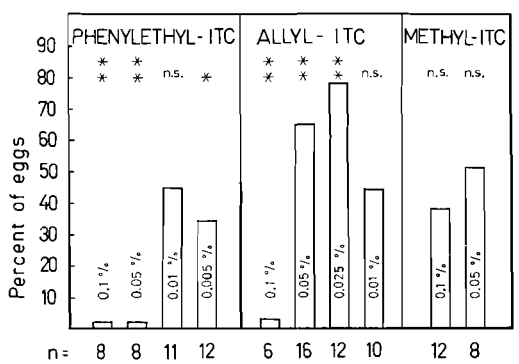

Fig. 5. Percent of eggs deposited on sponges treated with various concentrations of isothiocyanates (ITC). The flies were given the choice between one treated sponge in water and one sponge in water only. For further explanations see Fig 2.

was preferred, which is in fairly good agreement with the preference found for *H. brassicae* by Read (1965) and Schnitzler (1969).

While the number of eggs deposited on glossy paper plants did not differ from the number laid in sand, the flies preferred red and green crepe paper plants (Fig. 2). A possible explanation for this is that the rougher surface of the crepe paper offers a higher degree of stimulation. The perception of colours is suggested by the fact that green glossy paper plants were preferred to red glossy paper (Fig. 3). Green and red crepe paper plants, however, did not give different results. In this situation the rough surface of the paper may have been a more important factor.

Natural plants were strongly preferred when tested against green or red crepe paper plants (Fig. 3). This difference may partly be due to surface properties of the live plants, but it is reasonable to assume that chemical stimulants are of great importance. In accordance with this more eggs were deposited on sponges dipped in extracts of live plants (Fig. 4), than on sponges dipped in water. An exception was observed with leaves extract of Yellow Tankard, which is the variety subjected to least attack in the field (Rygg & Sömme 1972). The effects observed with pure chemicals show that the oviposition stimuli offered by a host plant may depend on its content of both attractive and repellent substances. The results with allylisothiocyanate are in agreement with those of Schnitzler & Müller (1969), who also found that most eggs were deposited at medium concentrations.

From the present study it may be concluded that several factors stimulate oviposition in *H. floralis,* as has been shown in more detail for *H. brassicae* by other authors (e.g. Traynier 1967, Zohren 1968, Schnitzler 1969). The relative importance of these factors is not known, but it seems likely that oviposition of *H. floralis* in the field will be influenced by the interaction of several physical and chemical stimuli. Similarly, the penetration of newly hatched larvae in the root may depend on various stimuli (Rygg & Sömme 1972). For the development of resistant varieties of cruciferous plants further studies of these factors may prove valuable. Such studies should include analysis of substances present in various varieties, and their relative importance as attractants or repellents. A higher degree of resistance could possibly be achieved if certain key stimuli were eliminated from natural host plants.

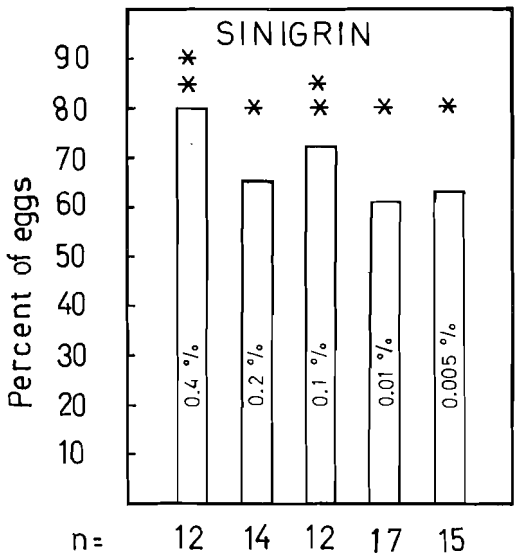

Fig. 6. Percent of eggs deposited on sponges treated with various concentrations of sinigrin. The flies were given the choice between one treated sponge in water and one sponge in water only. For further explanations see Fig. 2.

ACKNOWLEDGEMENTS

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Life History and Food-Spoiling Enzymes of *Dermestes lardarius* (L.)

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Hilali, M., Dahle, H. K. & Aurstad, K. 1972. Life History and Food-Spoiling Enzymes of *Dermestes lardarius* (L.). *Norsk ent. Tidsskr. 19*, 25–32.

The life history of *Dermestes lardarius* was investigated in the laboratory at 22 °C and 80% RH. The mean duration of the egg period was 4.4 days, while the larval period was 41.1 and 47.3 days in males and females respectively. Male insects moulted 8 times while females moulted 9 times, including the final moult which releases the pupa. The mean pupal period was 20.6 days. Large amounts of internal proteolytic and lipolytic enzymes could be demonstrated in extracts from the insects fed on different kinds of food. No external food-spoiling enzymes could be demonstrated in extracts from the immature and mature stages of the larder beetles. Three proteinase fractions were demonstrated in the zymograms of the enzyme extracts. The proteinases were completely inactivated by boiling for 2 minutes, and the activities were also inhibited by some naturally occurring proteinase inhibitors of vegetable and animal origin. Attempts to use *Dermestes lardarius* as a vector for *Salmonella* bacteria from infected meat to non-infected meat were unsuccessful.

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Improvements in food conservation methods and refrigeration techniques have, in many respects, changed the problems related to the preservation and storage of food products. Many products have not been affected by these improvements because they are suitable for storage under simpler conditions. Thus, dried meat and fish can be stored for long periods of time without being spoiled by putrifying processes. Such products may however be exposed to insect attacks which can cause great economic losses. Beetles are by far the most important and most numerous order of insects attacking food products. As far as beetles are concerned, *Dermestes lardarius* (L.) is of particular interest as it is a common domestic pest of stored meat and fish products. Stanek (1970) recorded that these beetles were responsible for severe damage to dried fish while Hinton (1945) believed that the total losses caused by the activities of *Dermestes* beetles on stored products throughout the world could be estimated to many millions of pounds every year. In addition to being responsible for meat spoilage by consuming and soiling it with their faeces, the insects may act as vectors of putrifying and disease-producing micro-organisms in certain types of food products.

In order to control these insects effectively it is necessary to know something of their life history. A survey of the available literature

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showed that the few records of Kreyenberg (1928), Canzanelli (1935) and Takio (1937) on the life history of *D. lardarius* were superficial, incomplete, and of conflicting nature, while references to the enzymes secreted by the larder beetles or their bacterial flora were completely lacking.

The aim of the present work was to carry out a systematic study of the life history of *Dermestes lardarius* and to investigate the enzymes secreted by the immature and adult stages. Furthermore, it was considered worthwhile to determine the normal bacterial flora, and the possible role of this insect as a vector of disease-producing micro-organisms.

MATERIALS AND METHODS

Breeding procedure

A laboratory colony was established from beetles *(D. lardarius)* which were collected alive during the last week of May and the first week of June from naturally infested cured meat in private households in Oslo, Norway.

Eggs were obtained by incubating equal numbers of males and females at 22 °C and 80 % RH in 150 ml glass beakers containing a moistened medium consisting of two parts beefburger bits, two parts ham bits and one part ground dog biscuits. After the females had oviposited on the adult food, the eggs were collected daily following the procedure used by Backs (1955) for handling insect eggs.

To determine the incubation period of the eggs, each one was placed in a small glass vial covered with a piece of gauze fixed with an elastic ribbon and incubated at 22 °C and 80 % RH. The eggs were examined daily for the appearance of newly hatched larvae.

The hatched larvae were collected daily. Each larva was placed in a 50 ml glass beaker, containing the same medium as used for the adult insect and covered with a piece of gauze fixed with an elastic ribbon and incubated under similar conditions. The larvae were examined daily to determine the number of moults which occurred during the larval period. The early stage larvae were easily recovered from the medium by following the method of Saunders & Krueger (1957) for separating insect larvae from the medium. The last larval stage was known to be reached when it appeared immobile and did not feed.

Pupae were obtained by putting small, 3 cm^3 pieces of cork into each beaker containing the mature larva. The larvae bored a tunnel in this cork, and the pupae formed were covered with the last larval skin. Each glass beaker containing the cork and the pupae was covered with a piece of gauze fixed with an elastic ribbon and incubated at 22 °C and 80 % RH. The pupae were observed daily by lifting a part of the cork around the tunnel to determine the exact time at which the pupae metamorphosed into adults.

The humidity was regulated according to O'Brien (1948) using a saturated solution of $(NH_4)_2SO_4$ for 80 % RH.

Enzymological examinations

The material to be examined (larvae, pupae, or imagos) was macerated in approximately one volume of water to one volume of the material and then stored overnight in a refrigerator at 4 °C. The mixture was centrifuged and the supernantant removed, and stored at –20 °C until use. The supernatants were examined for proteinases according to the Casein Precipitating method of Sandvik (1962) and for lipases according to the agar gel method incorporating tributyrin as substrate (Ellinghausen and Sandvik 1965).

Titrations of the proteinase activities were carried out by transferring aliquots of 25 μl from serial 2-fold dilutions of the solutions to wells of 7 mm diameter in sodium caseinate-containing agar, followed by incubation at 37 °C for 16 hours. The estimation of diffusion units was based on the diameter of the precipitation zones which occurred (Dahle 1969).

The effects of naturally occurring proteinase inhibitors of various origins (vegetables and blood sera) on the proteinases of the adult *D. lardarius* were tested by the crosswise Casein Precipitation Inhibition test (CPI-test) of Fossum (1970).

The thermoresistance of the proteinases of the adult beetles was examined according to the procedure given by Sandvik (1962). Aliquots of 0.1 ml of the enzyme solutions were transferred to 1 ml thin-walled glass ampoules. After sealing, the ampoules were stored in an ice bath at 0 °C until heating, which was carried out for 2 minutes in a Haake (Berlin, Germany) ultrathermostat. During heating, the ampoules were completely submerged in the water bath, after which they were rapidly cooled in an ice bath. The CP-activities were determined as above.

Zymograms of the proteinases of the larvae were prepared in agar gels by the electrophoretical procedure described by Dahle (1970 a).

Bacteriological examination

The external surface and internal organs of the larvae, pupae, and adult beetles were examined according to general bacteriological procedures. Incubations were performed aerobically, anaerobically, and in an atmosphere of 10 % CO_2 at 30 °C and 37 °C, and the organisms were identified on the basis of cultural and physiological properties (Breed et al. 1957).

The pupae and adults which had been reared through the larval stage on meat heavily infected with *Salmonella typhimurium* were examined according to the general bacteriological procedure for the detection of *Salmonella* organisms.

Newly emerged adult larder beetles were fed for 14 days on meat heavily infected with *Salmonella typhimurium*. The insects were then placed in sterile beakers with non-infected meat and both the beaker and meat changed daily. The possible role of these insects as vectors of *Salmonella* bacteria was investigated by daily bacteriological examinations.

RESULTS

Life history

From observations made during the collection of the adult larder beetles, it appeared that they started to occur in the various houses in Oslo from the middle of May to the middle of June.

Table I. Duration of the egg stage of *Dermestes lardarius* at 22 °C and 80% relative humidity

Date of oviposition	No. of eggs	Hatching eggs	
		No.	Egg period in days
4 June	7	4	4
		3	5
		4	4
6 June	9	4	5
		1	6
7 June	8	6	4
		2	5
		5	4
9 June	10	3	5
		2	6
11 June	7	5	4
		2	5
12 June	9*	6	4
		2	5

Number of hatching eggs: 49
Mean duration of the egg stage: 4.4 days
*One egg of this group did not produce a larva

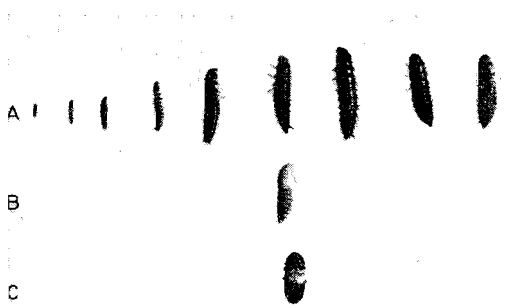

Fig. 1. Nine larval stages (A), pupa (B), and female *Dermestes lardarius* (C).

The normal oviposition period was from the middle of May to the end of July and the eggs were laid singly on the food during the day or night. Each egg was milky white in colour, elongated, cylindrical, rounded at both ends but with one end more pointed than the other. The eggs measured 2.4–2.5 × 0.6–0.7 mm.

The duration of the egg period of *D. lardarius* at 22 °C and 80 % RH was found to vary from 4–6 days, with a mean of 4.4 days (Table I).

Table II. Duration (in days) of the larval stages of *Dermestes lardarius* at 22 °C and 80% relative humidity

No.	Duration of the different larval stages									Total larval period	Adult sex
	1st	2nd	3rd	4th	5th	6th	7th	8th	9th		
1	2	4	3	5	5	6	6	6	9	46	♀
2	3	3	4	4	5	5	7	6	11	48	♀
3	3	5	3	4	4	5	6	11	–	41	♂
4	4	3	4	4	4	6	6	7	9	47	♀
5	3	3	4	7	4	5	6	12	–	44	♂
6	2	3	5	5	7	4	6	10	–	42	♂
7	4	3	3	4	4	6	7	9	–	40	♂
8	2	4	3	4	4	5	7	11	–	40	♂
9	2	3	6	4	4	6	6	7	10	48	♀
10	2	4	5	5	6	5	6	10	–	43	♂
11	3	3	3	4	5	6	6	10	–	40	♂
12	3	4	3	5	4	5	6	6	11	47	♀
13	2	3	4	5	5	7	7	6	9	48	♀
14	3	3	5	4	5	6	6	7	9	48	♀
15	3	4	4	4	4	6	6	10	–	41	♂
16	2	3	4	4	6	6	7	8	–	40	♂
17	2	3	3	5	6	5	7	7	10	48	♀
18	3	4	3	6	4	5	6	8	9	48	♀
19	2	3	3	5	6	5	6	6	10	46	♀
20	2	4	3	4	5	6	7	6	10	47	♀
Mean: ♂	2.6	3.5	3.7	4.5	4.7	5.3	6.3	10.1	–	41.1	
♀	2.5	3.3	3.7	4.6	4.8	5.6	6.3	6.5	9.7	47.3	

Under similar conditions of temperature and humidity (22 °C and 80 % RH), the number of larval moults was found to vary according to sex. Male insects moulted 8 times while females moulted 9 times. These numbers of moults include the final moult which releases the pupae.

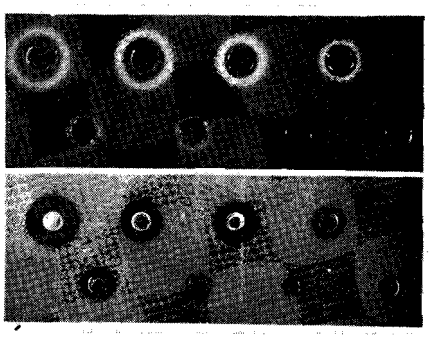

Fig. 2. Titration of casein precipitating enzymes in sodium caseinate-agar gel (a), and lipolytic enzymes in tributyrin-agar gel (b). The titre is determined using standard curves obtained when the diameters of the zones, caused by the enzymes in serial 2-fold dilutions, are plotted against the logarithm of the degree of dilution.

In males, the mean durations of the eight larval stages were 2.6, 3.5, 3.7, 4.5, 4.7, 5.3, 6.3 and 10.1 days (Table II). The mean durations of the nine larval stages in females were 2.5, 3.3, 3.7, 4.6, 4.8, 5.6, 6.3, 6.5 and 9.7 days (Table II and Fig 1).

Under these atmospheric conditions, the mean total duration of the larval stages was 41.1 days in males and 47.3 days in females.

The duration of the pupal period at 22 °C and 80 % RH was 20–22 days, the mean being 20.6 days (Table III).

Food spoiling enzymes

The extracts of the macerated insect materials (larvae, pupae and adults) were examined for proteinases and lipases by two separate agar diffusion methods. Fig. 2a shows precipitation zones of casein in agar gel caused by proteinases extracted from the imagos, while

Table III. Duration of the pupal period (in days) of *Dermestes lardarius* at 22 °C and 80% relative humidity

No. of pupae	Date of pupa formation	No. of emerging adults	Pupal period
		5	20
12	27 July	4	21
		3	22
8	28 July	5	20
		3	21

Mean duration of the pupal period: 20.6 days

Fig. 2b shows transparent zones of hydrolysed tributyrin caused by lipases from the same samples. The figure also shows the decreasing diameters of the zones throughout the dilution series, and this was used as the basis for the estimation of the amounts of diffusion units of enzymes in the various extracts.

As each volume of insect material was macerated in one volume of water, only approximate values of the enzyme activities could be obtained. Thus, the concentration of proteinases and lipases, in extracts originating from imagos fed on different kinds of food for 15 days, varied within the range of one thousand to twenty thousand diffusion units in 25 μl of the tested material (Table IV). Although proteolytic activity was observed during all the larval stages, lipolytic activity was found only in larvae older than 18 days. The pupae possessed smaller amounts of enzymes than the larvae and imagos.

In order to reveal whether more than one proteinase was present in the extracts, zymograms were prepared in agar gels. Fig. 3 shows that three distinct fractions could be demonstrated, two migrating rapidly in the cathodic direction, the third one migrating slowly in the anodic direction.

The temperature inactivation curve for the proteinases is shown in Fig. 4. The activity in the freshly prepared extracts was defined as being 100 %. It was shown that boiling for 2 minutes completely inactivates the enzymes.

To examine resistance against naturally occurring proteinase inhibitors, the crosswise CPI-test was carried out using inhibitors from various vegetables and animal blood sera. The effects of some of these inhibitors are shown in Fig. 5, were it can be seen that the proteinases are inhibited by all the inhibitors examined.

Bacteriological examinations

The external surface and internal organs of the larvae, pupae, newly emerged and six-week-old imagos were examined bacteriologically. No micro-organisms could be isolated

Table IV. Food spoiling enzymes in macerated material of *Dermestes lardarius* fed on various food stuffs

Material	Diet	Proteolytic enzymes	Lipolytic enzymes
Larvae (1 day)	fatty meat	++*	—
Larvae (18 days)	fatty meat	+++	(+)
Larvae (34 days)	fatty meat	++++	+
Larvae (46 days)	fatty meat	+	+++
Pupae	none	+	++
Imagos (1 day)	none	+	++
Imagos (30 days)	fatty meat	++	++
Imagos (15 days)	pure meat	++++	++
Imagos (4 days)	pure fat**	++++	++
Imagos (15 days)	wheat meal	+++	++
Imagos (15 days)	potato starch	++	+
Faeces from imagos	fatty meat	+	—
Faeces from larvae	fatty meat	++	—

*+, ++, +++ and ++++ designate increasing amounts of enzymes. ++++ corresponds to approximately 20,000 diffusion units.
**The beetles fed on pure fat died after 4 days.

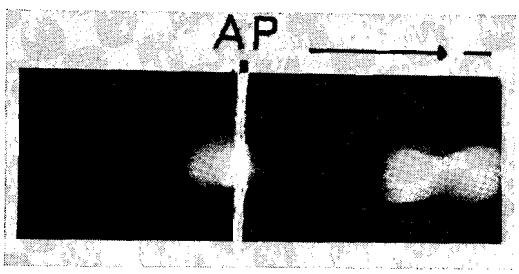

Fig. 3. Zymograms, in agar gel, of the proteinases of *Dermestes lardarius*. The points of application are on the line AP, and the cathodic direction is marked with an arrow. Two fast-moving fractions can be seen to the right, and one slow-moving fraction near the line of application.

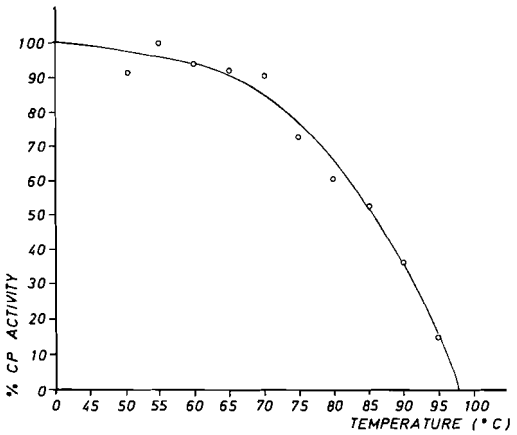

Fig. 4. The influence of heat on the casein precipitating activity of the enzyme solutions from *Dermestes lardarius* as a function of temperature. The heating period was 2 minutes.

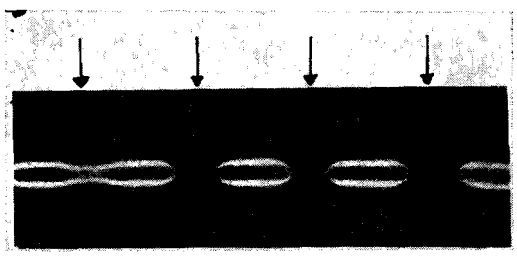

Fig. 5. Demonstration of proteinase inhibitors by the crosswise CPI-test. Narrow filter paper strips moistened with solutions of inhibitors were placed on sodium caseinate-agar plates, which were incubated for 3 hours at 37 °C. After removal of these strips, a similar strip, moistened with the proteinase solution, was applied to the surface on the agar gel at right angles to the direction of application of the inhibitors, and the plate incubated for a further 16 hours at 37 °C. Proteolytic activity is indicated by the greyish-white zones in the transparent agar, while inhibition is indicated by interruptions in the precipitation zones. The inhibitors are, from left to right as marked with arrows: Wheat-meal, sheep-serum, pig-serum and cow-serum.

by the methods used from the former categories, while the six-week-old adult larder beetles had a very sparse flora consisting of micrococci and enterobacteria.

Salmonella typhimurium was not isolated from the pupae and adults which were previously reared as larvae on *Salmonella* infected meat. Newly emerged adults which were reared on *Salmonella* infected meat for 14 days failed to transmit the organisms to non-infected dried meat.

DISCUSSION

The present observations on the life history of *D. lardarius* in Norway showed the normal oviposition period to be exactly similar to that found by Takio (1937) in Japan, in contrast to Zacher (1924) in Germany, who recorded that this period was from June to early August — somewhat later than our results.

Hinton (1945) claimed that the eggs of the larder beetles were laid in batches of 6–8 with extremes of 4–12. In the present study, the eggs were always observed to be laid singly on the adult food. The incubation period of the eggs at 22 °C and 80 % RH in this work conforms well with the data of Zacher (1924) during August but not with his observations for June. Kreyenberg (1928), found that the egg period varied from 7–9 days at 17–20 °C. However, Canzanelli (1935) recorded that this period varied according the the environmental temperature (2.5 days at 25–28 °C, 3.5 days at 24 °C and 7 days at 18 °C).

There is a great deal of confusion in the literature concerning the number of moults which occurs during the larval stage (Sacharow 1921 (10 times), Canzanelli 1935 (7 times) and Hinton 1945 (5–6 times)). These conflicting results may be due to the variations in the conditions under which these larvae were incubated. In this investigation, the number of moults observed at 22 °C and 80 % RH was not similar to any of these previous records. Our results, however, confirm the general belief of Kreyenberg (1928) that the female larvae have one more moult than the males.

The total duration of the larval period was recorded by Takio (1937) in Japan to be from 43–80 days, while Theobald (1904) in Britain found that this period was only 35 days. The data presented here fall within the wide range given by Takio (1937).

Concerning the pupal period, the present results were in contrast to the previous obser-

vations of both Zacher (1924) and Hinton (1945).

Among the food spoiling enzymes, proteinases and lipases are of particular interest (Dahle 1971a); they can be conveniently demonstrated by the agar diffusion methods used in the present study. Although the determinations of the enzymes were semiquantitative, and do not represent the exact amounts of enzymes present in the materials, the casein precipitating activity and the lipolytic activity of the solutions indicated that the insects possessed very high biocatalythic activities (Table IV). This is also in accordance with the findings of Dahle et al. (1971) for the larvae of *Calliphora erythrocephala*. In contrast to the larvae of the blue bottles, no external digestive enzymes could be demonstrated in any stage of the life of *D. lardarius*.

The problem of induced enzymes in animals and insects has not been so thoroughly analysed as in certain types of yeasts and bacteria (Rose 1968, Dahle 1971b). Some reports from entomologists, however, indicate that the problem is of importance for insects. Thus Thomsen & Møller (1963) found that the proteinase activity of the adult female *Calliphora erythrocephala* is highly influenced by the diet in the first 5 days after emergence. The enzyme activity in females fed on sugar, water and meat was much higher than that in females fed on sugar and water only. Corresponding observations have been made in this laboratory. The amounts of proteolytic and lipolytic enzymes produced by *D. lardarius* when fed on various diets shown in Table IV, may indicate induction of the enzymes, if the amounts produced by the imagos fed on potato starch and pure meat are compared. On the other hand, as the enzymes were never totally absent, an explanation of the different amounts of enzymes, based on a common response of the beetles to the various food stuffs, cannot be excluded. The death of the adult beetles after 4 days of feeding on pure fat may be due to the fact that the fat clogs their mouth parts, as suggested by Kreyenberg (1928).

The existence of more than one proteinase fraction in proteinase-producing organisms is a basic problem in nature which has been discussed for some bacterial proteinase systems (Dahle 1971a). It is, therefore, interesting that the zymograms (Fig. 3) show three fractions for extracts from this beetle, although the serological relationships between them have not yet been analysed. At present the zymogram technique for lipases has not been finally standardized, but the number of lipase fractions and their mutual relationships are also of interest, together with the proteinases, for possible application in toxonomical and phylogenetic studies (Dahle et al. 1971).

The temperature inactivation curve in Fig. 4 is important for the treatment of food products previously attacked by larder beetles. The fact that the temperature needs to reach nearly 100 °C before the enzymes are completely inactivated emphasizes the general thermoresistance of such food-spoiling enzymes (Sandvik 1962, Dahle 1971a, Dahle et al. 1971).

In connection with food-spoiling processes, the functions of the naturally occurring proteinase inhibitors in certain foods (Fossum 1971) are also of interest. The present results (Fig. 5) indicate that all the inhibitors examined were active against the proteolytic enzymes of *D. lardarius*. The consequence of this may be that when the insect feeds on food stuffs containing inhibitors, the equilibrium between the proteinase and the inhibitor shifts in favor of the enzymes, because of the very high biocatalytic activity of the digestive secretion of *D. lardarius*.

Bacteriological examinations indicate that neither the adult larder beetle nor its larval stages seem to play any role as vector of *Salmonella* organisms. Hinton (1945) claimed that unsuccessful attempts have been made to infect *D. lardarius* with bubonic plague by feeding it on infected guinea-pig liver. The very sparing flora of this insect may indicate the presence of bacterial inhibitors which need further investigation.

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Effect of Temperature on Development of *Thomasiniana theobaldi* Barnes (Dipt., Cecidomyidae)

CHR. STENSETH

Stenseth, C. 1972. Effect of Temperature on Development of *Thomasiniana theobaldi* Barnes (Dipt., Cecidomyidae). *Norsk ent. Tidsskr. 19*, 33–37.

The development of *Thomasiniana theobaldi* Barnes was studied at temperatures ranging from 12 ° to 30 °C. The eggs had incubation periods ranging from 10 days at 12 °C to 2 days at 30 °C. The durations of the larval periods were from 40 days at 12 °C to 8 days at 24 °C. Prepupal and pupal periods ranged from 22 days at 15 °C to 10 days at 27 °C. An arrest in development or diapause in the prepupae was demonstrated. The percentage of diapausing larvae was negatively correlated with the soil temperaure to which the full-grown larvae had been exposed. Temperatures favourable to morphogenesis were also favourable to the diapause development. Only part of the population proved to have a diapause factor.

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Pitcher (1952) and Nijveldt (1963) have given descriptions of the biology of *Thomasiniana theobaldi*. The life cycle is shown in Fig. 1.

The females oviposit in freshly wounded skin on first-year raspberry canes. The larvae live under the skin of the canes. Having ended their feeding period, the larvae fall to the ground. In the soil they enclose themselves in cocoons and go through a pre-pupa period before pupation.

The tissue damaged by the feeding larvae is often invaded by fungal pathogenes which may cause the death of the canes in the following season (Labruyere & Engels 1963; Pitcher & Webb 1952).

The first record of *T. theobaldi* in Norway was made at Asker in Akershus county in 1959 (Valset 1960). Since then, the midge has been recorded in different places in southern parts of Norway. In recent years the attacks have been more severe in some raspberry plantations. This provided an opportunity of studying work on the phenology of this pest and its consequences under Norwegian conditions. The present paper, which forms a part of these investigations, presents data on the temperature as a factor in the ecology of this species.

MATERIAL AND METHODS

Raspberry canes infested with larvae of *T. theobaldi* were collected in a plantation at Tjöme, Vestfold county, at the end of August. Full-grown larvae were transferred to soil in flower pots. One half of this material was used for investigations of development from oviposition to full-grown larvae. The other half of the larval material was used for investigation of development of pre-pupae and pupae. The term full-grown larvae is here used to describe the stage or time when the larvae end their feeding period and fall to the ground.

Development from oviposition to full-grown larvae. The larval material mentioned above was stored at 1 °C for about 140 days and then transferred to 20 °C for the emerging of the midges. The midges were trapped and used for egg-laying. Slits were made in the outer skin of raspberry canes which were exposed for oviposition for one day at 20 °C. The plants were then transferred to constant temperatures of 12°, 15°, 18°, 21°, 24°, and 30 °C, six plants at each temperature. Three plants were harvested for registration of the hatching of the eggs. The rest of the plants were used

Egg	Larvae			Pupa	Imagines
	I	II	III		
	Feeding period		Prepupa		
On raspberry cane			In soil		

Fig. 1. Life cycle of *Thomasiniana theobaldi*.

for registration of the larval development. The time of development was calculated from the time the experimental plants were exposed to the different temperatures. Sticky plates around the basis of the canes collected the full-grown larvae.

Development of pre-pupae and pupae. Full-grown larvae, taken outdoors at Tjöme, were placed at constant temperatures of 12°, 15°, 18°, 21°, 24°, 27°, and 30 °C. The time required for the development of pre-pupae and pupae was calculated from the time the flower pots were placed at the constant temperatures. The emerging period was considered as completed after three successive days had passed without midges emerging. The flower pots were then exposed to 1 °C for 120 days, and then to 21 °C. When a second emerging period was registered, any material left over was exposed to a new chilling period of 1 °C, and then to 21 °C.

A second batch of full-grown larvae was kept outdoors for 130 days before exposure to 21 °C.

RESULTS

Development from oviposition to full-grown larvae. Fig. 2 presents the time of development from oviposition to full-grown larvae. Development was completed at all temperatures between 12° and 30 °C. On the basis of the mean hatching of the eggs, the incubation period ranged from 10 days at 12 °C to 2 days at 30 °C, and the time of the larval development from 40 days at 12° to 8 days at 24 °C. There was a considerable variation or spread between the minimum and the maximum time required to complete the larval development, especially at the lower temperatures.

On average, the time required for the development from oviposition to full-grown larvae varied from 50 days at 12 °C to 11 days at 24 °C. As will be seen from Fig. 2, the larval development had its optimum temperature at 24 °C.

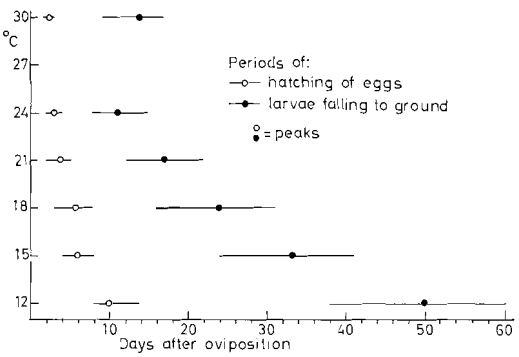

Fig. 2. Relationship between temperature (°C) and time required for the development of *Thomasiniana theobaldi* from oviposition to the hatching of the eggs, and from oviposition to full-grown larvae falling to the ground.

Development of pre-pupae and pupae. The experiments gave data on the time required for development as well as the ability to complete development at different temperatures. At 12 °C, the development of pre-pupae and pupae was not completed in 130 days. The time of development at temperatures ranging from 15° to 30 °C is shown in Fig. 3. On the basis of the emerging peak, 27°C was the optimum temperature for the time of development. The times of pre-pupal and pupal development were varied from 22 days at 15 °C to 10 days at 27 °C. It appears from Fig. 3 that the midges at 27° and 30 °C had skew and prolonged emerging periods of 43 and 23 days respectively. The emerging periods for the lower temperatures were 6 to 10 days.

Table I shows the degree to which the larvae completed their development at the differ-

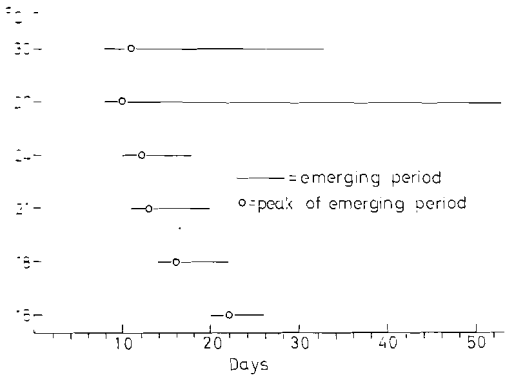

Fig. 3. Relationship between temperature (°C) and time required for development of *Thomasiniana theobaldi* from full-grown larvae to the emerging of the adult midge.

ent temperatures. The percentage of emerged midges in the first period had a positive correlation to the temperature. Most of the midges with arrested growth in the first emerging period emerged at 21 °C after having been chilled for 120 days at 1 °C. As will be seen from Table I, there was also a low percentage of emerging midges in the third emerging period.

Fig 4 shows the time of development and the emerging intensity in the second emerging period (Fig. 4 B) compared with those at 21 °C in the first emerging period (Fig. 4 A). It will be seen that material with arrested growth in the first emerging period (Fig. 4 B) required the same time of development as material without arrested growth.

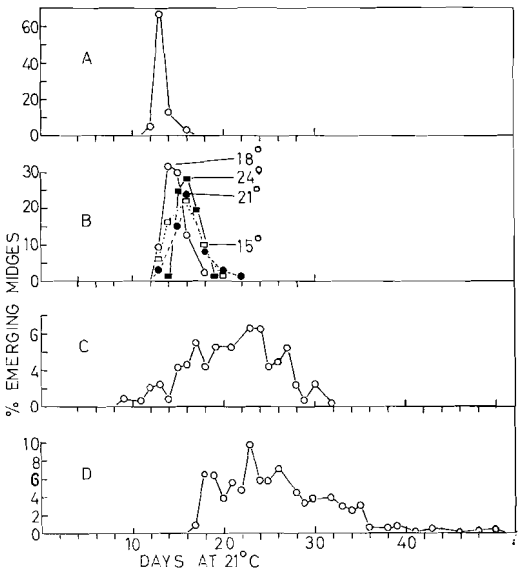

Fig. 4. Time of development of pre-pupae and pupae of *Thomasiniana theobaldi* without and with arrested growth. Treatments before being exposed to 21 °C: A. Without arrested growth, no special treatment. B. Arrested growth during exposure to 15 °, 18 °, 21 ° and 24 °C. (Fig. 3), then stored for 120 days at 1 °C. C. Stored 130 days at 120 °C. D. Stored outdoors for 130 days.

Fig. 4 also shows the emerging of midges in material stored at 12 °C (Fig. 4 C) and material stored outdoors (Fig. 4 D) for 130 days prior to exposure to 21 °C. The emerging period shows here a considerable variation between the minimum and the maximum time

Table I. Developmental response to temperature in *Thomasiniana theobaldi*. Full-grown larvae transferred to temperatures ranging from 12° to 30°C. After the 1st and the 2nd emerging periods the material was stored at 1°C for 120 days and then transferred to 21°C for further morphogenesis

Initial temp. °C	% of emerging midges 1st emerging period	2nd emerging period 21°C	3rd emerging period 21°C	Total No. of midges emerging
30	100[1]	0	–	88
27	99.2[1]	0.8	0	421
24	51.7[2]	47.4	0.9	556
21	37.0[2]	61.0	2.0	370
18	21.7[2]	77.7	0.6	387
15	2.5[2]	96.5	1.0	735
12	0	100	–	224

[1] Skew and prolonged distributions of emerging period
[2] Normal distribution of emerging midges.

required to complete the pre-pupal and the pupal development, especially in material stored outdoors.

DISCUSSION

The time of development of *T. theobaldi* has been described previously by Pitcher (1952) and Nijveldt (1963). Pitcher reported that the eggs had a development period of from 2 to 7 days and that the larvae lived on the cane for 9 to 49 days. These results, however, are not directly comparable with the data in the present work, as no temperatures were given by Pitcher (1952). In the paper of Nijveldt (1963) larval periods of 4–10 days at 30 °C and 18 days at 13.5 °C were mentioned, indicating a faster rate of development than found in the present study.

A summary of the data on all stages of development shows that the time required to complete the life cycle was 16–28 days at 30 °C, 18–32 days at 24 °C, 23–46 days at 21 °C, 32–55 days at 18 °C, and 44–67 days at 15 °C. From this it will be seen that several generations may occur during one growth season, but the variations between the minimum and the maximum time required for the completion of the life cycle will cause an overlapping of the generations, a fact which has also been demonstrated in the field (Pitcher 1952 and unpublished data of the author). Nijveldt (1963) supposes separated flight periods for *T. theobaldi*. This may indicate that the material used in the present study is more heterogeneous in its response to temperature than the material used by Nijveldt.

An arrested development of *T. theobaldi* as demonstrated in the present paper shows the same characteristics as diapause. The results (Table I) indicate that temperature plays a role in the induction of the diapause. The temperature is often a modifying factor when diapause is induced by photoperiod (Lees 1955). In the present study, the temperature acted on the insect material in the soil. Thus, if the photoperiod was to have a function in the induction of the diapause, it would have to operate prior to the temperature treatment in the experiment.

The fact that the emergence of midges at 21 °C occurred at the same time for non-diapausing and diapausing midges (Figs. 4 A and B) is an indication that the diapause is induced in the prepupae just after the larvae become full-grown.

At 27° and 30 °C, the first days of the emerging periods showed a normal distribution pattern. It was followed by a prolonged period with scattered emerging of the midges (Fig. 3). This indicates that the population was composed of larvae with and without the diapause factor and that the diapausing part of the populations causes the prolonged emerging period. This shows that temperatures of 27° and 30 °C make a faster diapause development than lower temperatures. The same is illustrated in Fig. 4, where material from natural winter conditions had a longer time of development than material which had been subjected to higher temperatures prior to the emerging temperatures. The fact that diapause development and morphogenesis take place concurrently has also been established for other insects (Bakke 1970).

The diapause in *T. theobaldi* seems to be an important factor in the adaptation of the species to the regions where the experimental material was collected, but this aspect will be discussed in a later paper.

ACKNOWLEDGEMENTS

This work has been supported by the Agricultural Research Council of Norway. The author wishes to express his thanks for the financial aid.

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Changes in the Coleopterous Fauna Associated with the Maturational Stages of the Fungus *Leccinum testaceo-scabrum* (Secr.) Sing. (Boletaceae)

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Hågvar, E. B. & Hågvar, S. 1972. Changes in the Coleopterous Fauna Associated with the Maturational Stages of the Fungus *Leccinum testaceo-scabrum* (Secr.) Sing. (Boletaceae). *Norsk ent. Tidsskr. 19*, 39–42.

The beetle fauna in three different maturational stages of the fungus *Leccinum testaceo-scabrum* (Secr.) Sing. was examined. One species of Carabidae and 14 species of Staphylinidae were found. *Aleochara moerens* Gyll. accounted for 70% of the sample. Eight species belonged to the genus *Atheta* Thoms. The density and the number of beetle species increased from stage 1 (youngest mushrooms) to stage 3 (old mushrooms). Most species occurred in one maturational stage only. All beetles found in the young mushrooms (stages 1 and 2) belong to species that prefer fungus as habitat. The old mushrooms contained a beetle fauna that is less specific as to fungus, including scavengers, which are attracted to the rotten mushrooms. The results illustrate how a rapidly changing habitat may contain a corresponding rapidly changing fauna. The changes in fauna are caused by emigration and immigration of species that have particular preferences for the various maturational stages of the mushroom.

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The topic of beetles in fungi has previously been thoroughly investigated by Scheerpeltz & Höfler (1948), Benick (1952), and Rehfous (1955). However, information concerning qualitative and quantitative changes of the beetle fauna associated with the maturation of a certain fungus species is rather incomplete. The present investigation deals with three maturational stages of the common mushroom *Leccinum testaceo-scabrum* (Secr.) Sing. (*Boletus rufescens* Secr.) and the associated changes in the beetle fauna.

MATERIAL AND METHODS

The samples were taken between 16 and 30 August 1970 at Trandum, 40 km north-east of Oslo, Norway. The habitat consisted of spruce mixed forest, with aspen and birch being the predominant deciduous components. The mushrooms were assigned to one of the three maturational stages:

Stage 1. The tubes are narrow, spores are not yet produced, and the entire mushroom has a solid consistency. Most frequently the mushrooms are not yet attacked by larvae of Nematocera, and the diameter of the cap is less than 10 cm.

Stage 2. The spores are produced. No decay of the mushroom is visible. Larvae of Nematocera and slugs are the major consumers. The diameter of the cap is, in most cases, 10–15 cm.

Stage 3. The mushroom is rotten, emitting a strong odor. The hymenophor (if any at all) and the edge of the cap are black and sticky, often dripping. The entire mushroom has a soft consistency and is usually perforated by larvae of Nematocera. The diameter of the cap is in most cases 15–20 cm.

Table I. Total number examined and number of Coleoptera-infested *Leccinum testaceo-scabrum* in the three maturational stages

Stage	Number examined	Number infested	Per cent infested
1	9	1	11
2	13	7	54
3	9	9	100
Total	31	17	55

The mushrooms were collected by tilting them over into a plastic bag. The beetles were picked up from the bag after all the mushroom had been fragmented and examined. Only one coleopterous larva (fam. Carabidae) was found. Some of the mushrooms contained many Collembola. Parasitic Hymenoptera could be found in the inner channels of the cap, probably parasiting the larvae of Nematocera. A total of 31 mushrooms was examined, providing 141 beetles.

RESULTS

55 % of the mushrooms were infested with beetles. The infestation was, however, different in the three maturational stages (Table I). Whereas all the oldest mushrooms (stage 3) contained beetles and 54 % of those in stage 2, only 11 % of the youngest mushrooms were infested. Thus the oldest mushrooms are those most frequently invaded by beetles.

In Table II the coleopterous fauna of *L. testaceo-scabrum* is listed. The relationship between fungus and beetle species is indicated according to Hansen (1952, 1954) and Palm (1948). Staphylinidae, with the exception of one specimen of Carabidae, was the only coleopteran family represented. The number of beetles per mushroom increased with the maturation of the mushroom. The density per infested mushroom increased from 3.0 individuals in stage 1 to an average of 10.9 beetles in stage 3 (Fig. 1). This tendency also holds for the dominant species, *Aleochara moerens*

Table II. Number of Coleoptera found in the three maturational stages of *Leccinum testaceo-scabrum*. The dependence on fungus (Hansen 1952, 1954; Palm, 1948) is roughly indicated for each species, using the following symbols:

÷ : Fungus not mentioned as habitat
\+ : Occasionally found in fungi
++ : Found in fungi, debris, dung, carcass etc.
+++ : Primarily found in fungi

Maturational stage	1	2							3									
Mushroom No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Total
Staphylinidae																		
+++ *Aleochara moerens* Gyll.	3	1	11	5	7	1	6		10	16	5	10	6	6	6	2	4	99
+++ *Oxypoda alternans* Grav.				1	3													4
+++ *Bolitobius thoracicus* Fabr.					1													1
+++ *Atheta gagatina* Baudi								1										1
+++ *Atheta pilicornis* Thoms.							1											1
+++ *Atheta paracrassicornis* Brundin			1		1				1	1						1	3	8
+++ *Atheta picipennis* Mann.									1	2							5	8
++ *Atheta fungi* Grav.												2			1			3
++ *Atheta subtilis* Scriba.															1			1
+ *Atheta picipes* Thoms.															1	1		2
÷ *Atheta microptera* Thoms.																1		1
+++ *Proteinus brachypterus* Fabr.																1	2	3
++ *Tachinus laticollis* Grav.									1		1		2		1		2	7
++ *Tachinus pallipes* Grav.																	1	1
Carabidae																		
÷ *Calathus micropterus* Dft.												1						1
Total number	3	1	12	6	12	1	7	1	13	19	6	13	8	6	10	6	17	141

Gyll., which reached an average density of 7.2 individuals per infested mushroom in stage 3. This species made up 70 % of the total material.

Changes in the beetle fauna associated with the maturation of *L. testaceo-scabrum* are obvious from Table II. In the youngest mushrooms only one species was found, in stage 2 six species, and in stage 3 eleven species. Only two of the species from stage 2 were also present in stage 3, and all beetles found in stage 2 are species primarily found in fungi (+++). Seven of the nine new species in stage 3 are as often as not found in other habitats (++, +,-). Thus the change in species composition from stage 2 to stage 3 results from both emigration and immigration of species.

Apparent causes for the increase in density of coleopterous fauna associated with aging of the mushroom are that *Aleochara moerens* increases in number and that many species that are scavengers are attracted to the oldest mushrooms.

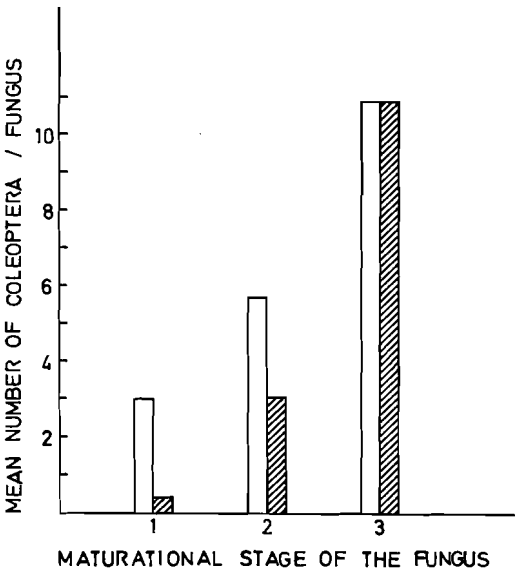

Fig. 1. Average number of Coleoptera per examined (hatched blocks) and per infested (light blocks) *Leccinum testaceo-scabrum* in the three maturational stages.

DISCUSSION

Benick (1952) lists the biocoenotic complexes in 5 different fungi species. The beetles dominate, exceeding Diptera larvae (especially Mycetophilidae), Collembola, and other insects in number. 57 beetle families were represented in fungi, Staphylinidae being by far the dominant one. Thus, in his study, 41 % of the beetle species and 81 % of the beetle specimens belonged to this family. The genus *Gyrophaena* Mann. is the most numerous, followed by *Atheta* Thoms.

Neither Scheerpelz & Höfler (1948) nor Rehfous (1955) give information about beetles in *L. testaceo-scabrum.* Benick (1952) found 10 species of Staphylinidae in this mushroom, seven of these belonging to the genus *Atheta.* However, *Atheta gagatina* Baudi was the only beetle species in *L. testaceo-scabrum* that was found both in Benick's and the present investigation. Brundin (1934) examined the beetle fauna in *Leccinum scabrum* (Bull. ex Fr.) S.F. Gray from Swedish Lapland. *Aleochara moerens* was the dominant species (77.2 % of the total beetle individuals), and 4 of the 15 species found were in common with those in Table II. The genus *Gyrophaena,* which is dominant in many species of fungi (Benick 1952), was absent in *L. scabrum* as in *L. testaceo-scabrum* in the present investigation. Because of the dominance of *Aleochara moerens,* Brundin (1934) designed the fauna in *L. scabrum* as '*Aleochara moerens*-Gesellschaft'. From the present results, it seems that this term is also valid for the beetle fauna in *L. testaceo-scabrum.* However, the fauna in *L. scabrum* found by Rehfous (1955) only had *Atheta gagatina* in common with the species in Table II. Both Scheerpeltz & Höfler (1948) and Benick (1952) try to group the beetles according to their dependence on fungi. None of the species listed in Table II belong to those that are fully dependent on fungi for their ontogeny, with the possible exception of *Oxypoda alternans* Grav.

No information concerning changes in beetle fauna associated with maturation of *L. testaceo-scabrum* is available from the literature. Scheerpeltz & Höfler (1948) compared the

beetle fauna in *Phallus impudicus* (L.) Pers. of different ages, and Benick (1952) examined four different age groups of *Polyporus squamosus* Huds. ex Fr. Both authors, however, used fungi from different times of the year. This complicates the study of the response of the beetles to the aging of the fungus, because the development cycle of the beetle has to be considered in addition to the age of the fungus. However, both authors, as well as Rehfous (1955), found a change in the beetle fauna associated with the maturation of the fungus. It seemed to be a general trend that the youngest fungi, if infested at all, are often inhabited by the genus *Gyrophaena,* which is fully dependent of fungi. The two genera *Atheta* and *Proteinus* Latr. became numerous as the fungi grew older. The most decayed specimens contained a fauna which still included species primarily found in fungi, but in addition a less specific fauna, including necrophagous, coprophagous, and saprophagous beetles.

The general trend outlined above conforms very well with the present results. In maturational stage 2, only species preferring fungi as habitat were found, whereas 7 of the 11 species found in stage 3 are apparently only slightly specific for fungi.

All mushrooms containing beetles in the present investigation were already attacked by larvae of Nematocera. The hymenophor was partly eaten by the larvae and by slugs, and many holes led to the inner part of the mushroom. It was typical that the beetles were found in the crevices on the underside of the cap, or in the inner channels of the mushroom. The reason why stage 1 of *L. testaceo-scabrum* so rarely contains beetles may partly be that the species in question need access to crevices and holes and a suitable microenvironment. Perhaps some of the species eat larvae of Nematocera, or some of their predators, and have to wait until the fungus is infested by them.

The change in the beetle fauna associated with the maturation of the mushroom is not part of a typical succession, because the aging process of the mushroom is only partly regulated by the present fauna. However, it is an example of how a rapidly changing habitat may contain a corresponding rapidly changing fauna. This change in fauna is caused by an emigration and immigration of species that have different affinities for the maturational stages of the mushroom.

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Contribution from the Norwegian IBP/PT-UM Sections

Tipula excisa Schum. (Diptera, Tipulidae), Life Cycle and Population Dynamics

TROND HOFSVANG

Hofsvang, T. 1972. *Tipula excisa* Schum. (Diptera, Tipulidae), Life Cycle and Population Dynamics. *Norsk ent. Tidsskr. 19*, 43–48.

The weights of larvae, pupae, and adults of *Tipula excisa* Schum. collected in a high mountain habitat, Finse, South Norway, are given. The life cycle of this crane-fly takes two years to complete in this area. The duration of the different stages of *T. excisa* are shown. The larval stages are separated by measuring the diameter of the spiracular discs. Some biomass data from one generation of larvae are given.

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Crane-flies are an important group of insects in the relatively simple ecosystems of alpine and arctic areas. The adults and the larvae seem to be heavily preyed upon by birds in these areas. Several species have larvae living in soil and acting as saprovores; they play an important part in creating the soil in the habitat. Twelve species of Tipulidae were registered in the Finse area during the two years of investigation. Three species appeared to be dominating: *Tipula excisa* Schum., *Tipula subnodicornis* Zett. and *Tipula invenusta* Ried.

The present paper describes the life cycle and population dynamics of *Tipula excisa*. The larvae of *T. excisa* were found in damp soil; the larvae of the two other species lived in aquatic moss.

Besides *Tipula montana* Curtis, *T. excisa* is the most common crane-fly in the boreal and alpine areas in the western part of the Palearctic (Theowald & Mannheims 1962). *T. excisa* is distributed in Fennoscandia, in Great Britain, and in the South- and Middle-European alpine areas (Theowald & Mannheims 1962). In Norway, *T. excisa* is common in the northern part of the country. In the south of Norway it is distributed in the great mountain areas (Lackschewitz 1935, 1936, Tjeder 1965).

DESCRIPTION OF THE AREA

The work was carried out at Finse, situated in the north-western part of the mountain plateau Hardangervidda (60°36′ N–7°30′ E), 1200 m a.s.l., in the mid-alpine region. The two habitats investigated were: 1) a field with well developed tussocks and moist soil, which probably represents the climax plant community of the area, 2) an oligotrophic dry heath community. The localities are situated a few hundred metres south of the south-eastern end of lake Finsevatn.

MATERIAL AND METHODS

The adults and larvae of *T. excisa* were collected in the Finse area during the period June 1969 to June 1971.

Extraction of the larvae

The larvae of *T. excisa* were extracted from soil by use of a modified hot water process described by Milne et al. (1958). Four turfs of the size 30 × 30 × 8 cm were extracted at the same time, instead of only one as described in the original paper. This modification of the apparatus made the outer box so large, 60 × 60

cm, that the temperature in the water-jacket had to be lowered to 60 °C for practical reasons. But even at this temperature, the critical temperature for the larvae in the soil was obtained by lowering the boxes with the turfs 2 cm every half hour during the extraction.

When using the hot water process, one has to observe the surface of the turf all the time and remove the larvae as soon as they appear. If the larvae are to be extracted from four turfs at the same time, 2–3 minutes must pass between each time the same turf is controlled. The larvae of *T. excisa* are large, 4th instar about 3 cm long, and they move slowly. Thus it is believed that this modification has little or no influence on the results. And as more samples can be examined within a few days, the biological changes will be less, and the density estimates of the larvae will be more reliable.

Determination of the larval instars

Tipulidae has four instars (Alexander 1920, Brindle 1960). Hemmingsen (1965) and Hadley (1971) have separated the different instars by measuring the diameter of the spiracular discs of the larvae of Tipulidae. This method also appeared to be suitable for the larvae of *T. excisa.*

Adult crane-flies

The adults were collected with a sweeping-net in the two habitats at intervals of 1–2 weeks during the summer the two years of investigation. A special route was followed through the habitat at each sweeping.

RESULTS

Tussock field

In Fig. 1 the relationships between the weights of larvae, pupae, and adults of *T. excisa* during the whole life cycle are shown. The figure shows that the life cycle of this crane-fly takes two years to complete. I have come to this conclusion from the following observations:

During the greater part of the year two distinct weight classes of larvae were found. The smaller larvae weighed only about 10 per cent

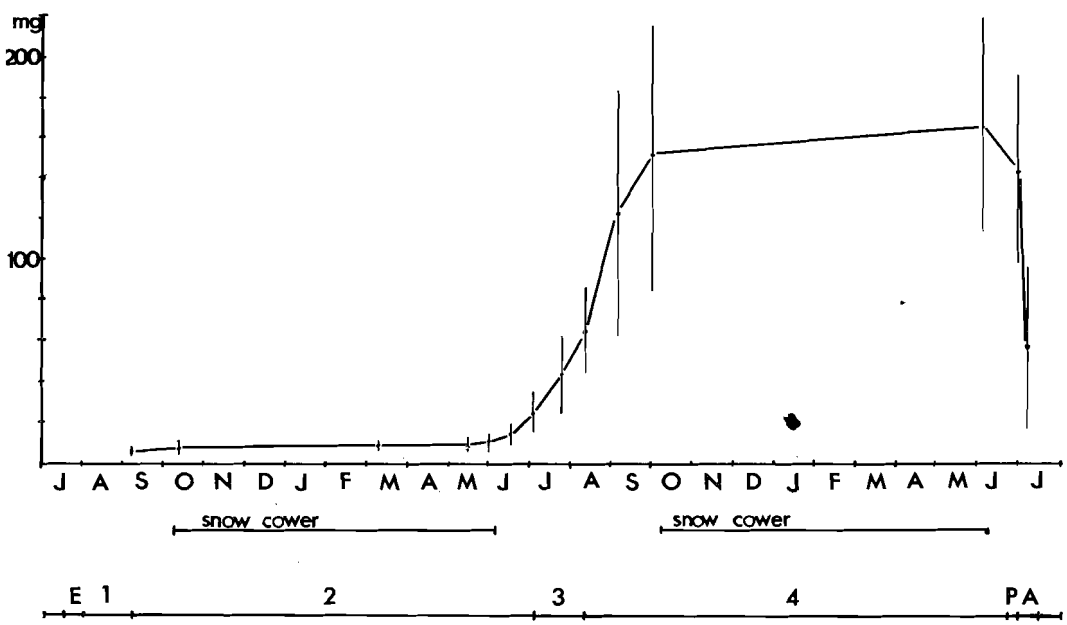

Fig. 1. The weights of larvae, pupae, and adults of *Tipula excisa.* The standard deviations are shown (vertical lines). The lower part of the figure shows the duration of the different stages.

Table I. The diameter of the spiracular discs of 301 larvae of *Tipula excisa*. The lower part of the table shows the separation of the different instars

The diameter of the spiracular discs in mm.	0.14	0.16	0.19	0.21	0.23	0.26	0.28	0.30
Number of larvae	26	25	5	2	4	2	6	27
The diameter of the spiracular discs in mm.	0.33	0.35	0.37	0.40	0.47	0.54	0.56	0.58
Number of larvae	123	19	1	1	1	1	10	28
The diameter of the spiracular discs in mm.	0.61	0.63	0.65	0.67	0.70	0.72		
Number of larvae	8	3	5	2	1	1		

Instar No.	Diameter of the spiracular discs in mm.
2	0.14–0.19
3	0.28–0.40
4	0.54–0.72

of the weight of the larger ones. During a short period in the summer there were only small larvae in the samples, at the same time as *T. excisa* had its pupal stage, its imago stage, and the development of the new eggs. In Fig. 1, one special generation of larvae is shown, during the period 2 September 1969 to 8 June 1971. The weights of the pupae and adults are from the generation the year before, collected in June and July 1970. After 14 May 1970 the larvae were collected by the hot water process. Because of the differences in the methods of collections the weights and standard deviation cannot be correlated for the whole life cycle.

301 larvae from this material were used to measure the diameter of the spiracular discs; the results are shown in Table I.

Between two different instars, 3–4 weeks could pass before all the larvae had shed their old cuticle. The date when more than 50 per cent of the larvae collected in one period of about four days had entered the next instar is used in Fig. 1 to mark the beginning of a new instar.

The development of the eggs in *T. excisa* takes about two weeks (Hemmingsen 1956). The duration of instars 2, 3, and 4 was determined as mentioned above. The duration of the pupal stage was determined in the laboratory; the pupae were held at room temperature. The duration of the imago stage is estimated to take two weeks; half of the time *T. excisa* was observed swarming in the Finse area, but exact information is missing. Larvae of instar No. 1 have not been examined in this work.

The lower part of Fig. 1 shows the duration of the various stages of *T. excisa*.

Table II shows the density estimates for the larvae in the tussock field extracted by the hot water process during eight different periods.

Oligotrophic dry heath community

Sixteen turfs were extracted by the use of the hot water process from the oligotrophic dry heath community during the period 6 August to 7 August 1970. No larvae of *T. excisa* were found.

Collections of adults

Collections of adults with a sweeping-net on both habitats during the summer 1969 and 1970 showed that *T. excisa* only had one gen-

Table II. Estimated density of larvae of *Tipula excisa* from tussock field, June 1970 to June 1971

Date	No. of samples	No. of larvae	Density/m² ± S. D.
2–6 June	40	169	47 ± 7
18–22 June	16	72	47 ± 11
30 June – 4 July	32	141	49 ± 8
19–23 July	32	142	49 ± 8
8–12 Aug.	32	82	28 ± 6
31 Aug. – 3 Sept.	32	100	35 ± 7
25–28 Sept.	32	92	32 ± 6
5–8 June	32	63	22 ± 4

eration a year. Adults were found during the following periods on the tussock field: 26 June to 3 August 1969, 18 June to 24 July 1970. On the oligotrophic dry heat community only three adults of *T. excisa* were found in 1969, on 16 July; in 1970, only two adults were collected, on 8 July. These individuals must be considered as swarming adults which have lived their larval stages in other nearby habitats with moist soil.

Biomass

Table III shows the biomass/m² for the larvae of *T. excisa* from the tussock field. The biomass for the young larvae previous to the first winter is calculated on the assumption that the mortality during the first winter was as large as the mortality during the following winter. This assumption gives a minimum density estimate of the young larvae. The length of the winter and the winter temperatures in the tussock field soil for these two years were much the same.

DISCUSSION

The present investigations show that *T. excisa* in the Finse area has a life cycle that takes two years to complete. This conclusion was reached from work in the laboratory. Two weight classes of larvae were collected at Finse in May 1970, when the snow cover was still nearly one meter high. When exposed to room temperature, after 7–8 days the large larvae entered the pupal stage. They emerged from the pupae 6–7 days later. The smaller larvae continued to grow during the summer with no sign of the pupal stage.

Table III. The biomass (g/m²) of larvae of *Tipula excisa*, October 1969 to June 1971

Date	Biomass (g/m²)
9 Oct.	0.552
2–6 June	0.528
18–22 June	0.768
30 June – 4 July	1.344
19–23 July	2.352
8–12 Aug.	2.176
31 Aug. – 3 Sept.	3.968
25–28 Sept.	5.024
5–8 June	3.718

Some other species of Tipulidae also appear to have a life cycle that takes more than one year to complete. Brindle (1960) reports that *Tipula flavolineata* Mg. takes at least two years to become adult in Great Britain. Chernov & Savchenko (1965) say that the life cycle of *Tipula carinifrons* Alex. seems to take two years on the arctic plateau in the U.S.S.R. Maclean & Pitelka (1971) found that the complete life cycle probably takes three years in *T. carinifrons* and in *Prinocera gracilistyla* Holmgr. on the tundra near Barrow, Alaska.

The life cycle of *T. excisa* takes two years in the Finse area. The area has an arctic character; the summer is short with low temperatures, and there are few days with optimal conditions for the insects. Insects commonly adapt themselves to low temperature areas by extending their life cycle over several years (Downes 1962, Mani 1968).

T. excisa is well known in mountain areas in Great Britain. It is possible that the life cycle in these areas only takes one year to complete, since the area is very different from Finse with its arctic temperatures.

The hot water process has a 100 per cent efficiency, but the efficiency drops 5–10 per cent after prepupation starts and until emergence is complete (Milne et al. 1958). The hot water process cannot be used from the time the larvae emerge from the eggs until the first winter, because the larvae must be of a certain size if the method is to be as efficient as described.

In the calculations of the biomass of the larvae in Table III, the efficiency of the method is 100 per cent. Average values are used for the density estimates before and after the sudden reduction of the density of the larvae in the summer of 1970, 23 July to 8 August. The first density estimates for the larvae in the summer of 1970 may be a little too low. This may be due to the fact that the larvae were as yet too small, and it was therefore easier to miss them during the hot water process. A disadvantage of the method is in fact the de-

pendence on the concentration of the observer.

The sudden and drastic lowering in the density of the larvae in the tussock field during the summer of 1970 is difficult to explain. The decrease may be caused by several factors, but the most likely explanation is a greater predation of the larvae by birds. When the larvae are growing during the summer, they have a tendency to come to the surface of the soil, where they seem to live in the great amount of litter in this rich vegetation.

In the samples examined 2 June to 23 July, no larvae were found in the litter; in the samples examined 8 August to 12 August, 15 per cent of the larvae were found in the litter by hand-sorting before the hot water extraction started; in the samples examined 31 August to 3 September and 25 September to 28 September the values were 33 and 31 per cent.

The estimate from the period 8 August to 12 August seems to be somewhat low compared with the two following estimates. It has not been examined whether this difference is statistically significant or not. In this period, however, the larvae are going from instar 3 to instar 4. The larvae are then less able to move, and they may more easily be killed by high temperature before they manage to reach the surface of the turf.

An investigation of an animal population should be carried out during a period of several generations of the animal. When considering the larvae of Tipulidae living in soil, drought seems to be an important limiting factor of a population. Coulson (1962) registered a large population drop in larvae of *T. subnodicornis* due to very little rain. Milne et al. (1965) made the same observation on larvae of *Tipula paludosa Mg.* Collections of larvae and adults of *T. excisa* in the two habitats in the Finse area show that this species lives in moist soil. There is reason to believe that drought is a limiting factor to populations of *T. excisa* as indicated by the investigations mentioned above and the selection of the habitat.

In the Finse area there were severe droughts in August 1968 and in August 1969. There is reason to believe that the density estimates of the generation of larvae investigated are somewhat low compared with estimates during normal conditions.

It is difficult to say whether the drought kills the eggs or the larvae of *T. excisa. T. excisa* have eggs that are better protected than eggs of *T. paludosa* or *T. subnodicornis.* These two species lay their eggs in the top layer of the soil (Hemmingsen 1956, Coulson 1962, Milne et al. 1965). *T. excisa* and the rest of the subgenus *Vestiplex* have eggs that seem to be better protected against drought; they are laid in clumps well buried in the soil. According to Hemmingsen (1956), this is an adaptation to the generally drier habitats in northern areas. A population decrease in *T. excisa* due to drought will probably give a greater mortality in an early larval stage than in the egg stage.

The fact that this paper only deals with one generation of *T. excisa,* and the probability of a limiting effect of drought in the Finse area in 1968 and 1969, make the biomass data only preliminary, until further investigations are presented.

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Spiders (Araneae) from Ringsaker, Norway

PER F. WAALER

Waaler, P. F. 1972. Spiders (Araneae) from Ringsaker, Norway. *Norsk ent. Tidsskr. 19,* 49–57.

This paper describes a collection of spiders made at Ringsaker, Norway. A total of 1402 spiders were collected, 976 spiders from moss, 196 from spruce twigs, and 230 from straw. The collection was concentrated on the Linyphiidae s.lat., a little known family in Norway. *Gongylidiellum murcidum* Simon is reported for the first time from Norway.

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The main purpose of this paper is to make a further contribution to our knowledge of the spider fauna of Norway, knowledge of which is still scanty. The collection of spiders was made at Ringsaker, Hedmark County, Norway. Ringsaker is situated about 150 km north of Oslo on the east side of Lake Mjösa. The collection period was from 22 June to 20 October 1968, although a few collected on 16 May and 25 July 1967 are included.

Spider records from the County of Hedmark are very scanty. Previous literature, including that of Collett (1876, 1877), Strand (1901, 1903, 1904), Tambs-Lyche (1940) and Waaler (1966), describes a total of 46 species divided into 12 families, thus:

	No. of Species
Gnaphosidae:	2
Clubionidae:	3
Sparasidae:	1
Thomisidae:	6
Salticidae:	3
Lycosidae:	9
Pisauridae:	1
Agelenidae:	1
Theridiidae:	3
Tetragnathidae:	1
Araneidae:	11
Linyphiidae:	5

A striking feature about this list is the low number of Linyphiidae s.lat. Locket & Millidge (1951, 1953) describe 24 British families consisting of about 575 species, two-thirds of which belong to the Linyphiidae. The Linyphiidae are known to increase in the number of species north from the equator. Inferentially therefore the number of Linyphiidae should be larger in Norway than in Great Britain on account of its more northern latitude.

The five species of Linyphiidae, all recorded by Strand (1903) are: *Bathyphantes dorsalis* (Wider), *Lepthyphantes expunctus* (O. P.-Cambridge) (= *L. lepidus* (O. P.-Cambridge)). *Linyphia marginata* (C. L. Koch), *Linyphia triangularis* (Clerck) and *Pityohyphantes phrygianus* (C. L. Koch) (= *Linyphia phrygiana* (C. L. Koch)). No species of Erigonidae is recorded.

In making this collection, particular emphasis has been placed on those habitats where linyphiids are known to constitute the major part of the spider fauna – notably mosses.

MATERIAL AND METHODS

976 spiders were collected in mosses, 884 by sieving and 92 in pitfall traps. An additional 426 spiders were collected, 230 from straw and 196 from spruce twigs.

A map of the Ringsaker area, with the two localities chosen for the investigation of the spider fauna in mosses, is shown in Fig. 1.

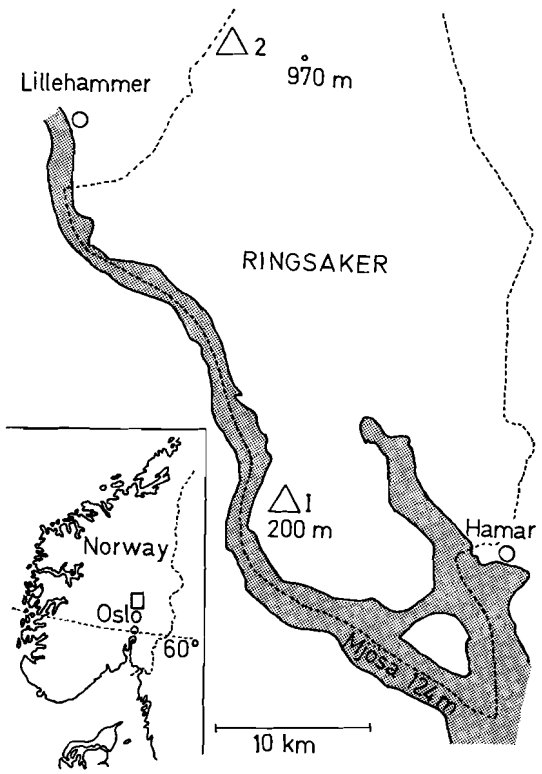

Fig. 1. Map of Ringsaker, with the two localities △ 1 and △ 2.

Locality 1: Mosses in an old cultivated forest at Dalby farm, 1 km from Lake Mjösa and 200 m a.s.l. The ground level vegetation is of the *Oxalis – Myrtillus* type. Locality 2: Mosses in spruce forest in the sub-alpine region between regio coniferina and regio alpina in the Sjusjö district, north-east of Lillehammer, 800 –950 m a.s.l. (Fig. 2). The forest is of the *Empetrum-Myrtillus* type, probably including *Chamaemorus* type in stretches of boggy land. The *Calluna-Cladina* type is present in the more highly situated areas where small spruces make their last stand against wind and cold. The birch zone, which in Norway often forms the characteristic transition zone from the lowlands to the highlands, is lacking in this district.

The collection method, similar to that used in 1971 (Waaler 1971) contains the same element of error when applied to estimating the population density.

Nine samples were taken from Locality 1, eight from Locality 2. The seventeen study plots are described in Table I.

In addition four pitfall traps (D = 8 cm) containing 4 % formaline solution were used in mosses. The traps were modified Barber-traps as described by Näsmark (1964). The samples from the pitfall traps are numbered 18 to 21. Description of the samples is given in Table II.

Spiders were also sieved from an old heap of straw after harvest at Dalby Farm. The reap, part of which had been lying there from the previous year, was situated on the upper edge of a south-sloping field. Collecting was carried out on 16 May 1967 and 23 September and 28 October 1968. The samples are numbered 22 to 24.

The spiders from spruce twigs, collected (1–3 August) by beating the twigs over a sweepnet (D = 26 cm), were from three different forest habitats as follows: Sample 25: Forest at the treeline, altitude 850–900 m. Spiders were taken from twigs up to 1 m above the ground. Low branches of these trees are often found creeping along the soil and mingling with

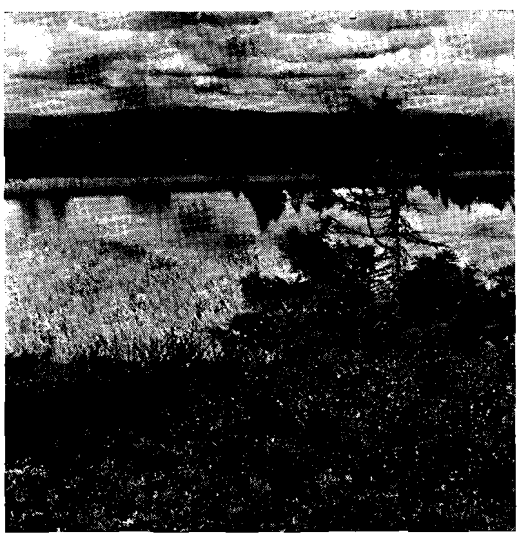

Fig. 2. From locality 2, above the timber line. *Robertus lyrifer* Holm was found here.

Table I. Locations of the 17 samples in mosses

Sample No.	Date	Altitude m	Area m^2	Habitat
Locality 1				
1	16 May	200	0.4	Mixed, non-productive dense grove of *Picea*, *Alnus*, *Sorbus* and *Betula*. *Climacium dendroides* and *Mnium* sp.
2	28/30 June	200	0.8	Mixed, non-productive dense grove of *Picea*, *Alnus*, *Sorbus* and *Betula*. *Climacium dendroides* and *Mnium* sp.
3	21 Sept.	200	0.5	Mixed, non-productive dense grove of *Picea*, *Alnus*, *Sorbus* and *Betula*. *Climacium dendroides* and *Mnium* sp.
4	29 June	200	0.25	Old cultivated spruce forest. *Pleurozium schreberi* on an old spruce stump.
5	22 Sept.	200	0.25	Old cultivated spruce forest. *Pleurozium schreberi* on an old spruce stump.
6	29 June	200	0.5	Cleared area in the same forest. Open space dominated by *Rubus idaeus* and *Equisetum silvaticum*. *Polytrichum commune*.
7	29 June	200	0.25	Shady habitat. Lower vegetation scarce. *Sphagnum girgensohnii* on the margin of a drainage ditch.
8	22 Sept.	200	0.25	Woodland road. Rich carpet of *Hylocomium splendens* and *Rhytidiadelphus squarrosus*.
9	20 Oct.	200	0.5	Woodland road. Rich carpet of *Hylocomium splendens* and *Rhytidiadelphus squarrosus*.
Locality 2				
10	25 July	850–900	0.5	Spruce forest at treeline. Boggy landscape. *Sphagnum* sp.
11	29 July	850–900	0.6	Spruce forest at treeline. Boggy landscape. *Sphagnum* sp.
12	26/27 July	850	1.5	On the edge of the continuous woodland. South-west facing slope, marshy. *Sphagnum girgensohnii* together with a few patches of *Polytrichum commune* and *Dicranum majus*.
13	26 July	850	0.25	A few m from sample 12. *Pleurozium schreberi*.
14	28 July	900	0.4	A few spruces. *Sphagnum* sp.
15	28/29 July	900	1.0	A few m from sample 14. *Pleurozium schreberi* and *Polytrichum commune*.
16	31 July	900	1.0	Main character of habitat as Nos. 14 and 15. *Sphagnum girgensohnii*.
17	13 Aug.	950	0.5	A few small spruces. *Sphagnum riparium*. (Fig. 2)

heather and mosses. Sample 26: Plantation of spruces; height of stand up to 3 m, 200 m a.s.l.; plantation thinned out and trees exposed to sun and light. Sample 27: North-facing steep slope; old, very dark and shady spruce grove; mostly naked twigs.

RESULTS AND DISCUSSION

Sieving in mosses

Results from the seventeen samples are shown in Table III. The population density has been determined by the same method as

Table II. Locations of the pitfall traps in mosses

Sample No.	Date	Altitude m	
18	28 June–31 July	200	Adjacent to samples Nos. 1–3.
19	28 June–31 July	200	Near sample No. 4. Dry place at the top of a small hill.
20	1 Aug.–14. Aug.	200	In connection with samples Nos. 4–6. Dry place.
21	1 Aug.–14 Aug.	200	In connection with samples Nos. 4–6. Boggy place.

Table III. Number of spiders found in samples from mosses

	Total			Sample No.															
	♂	♀	juv.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Drassodes sp.			3					2			1									
Gnaphosidae indet.			15		1			6			1	2				2	2	1		
Clubiona subsultans (Thor.)	1											1								
Clubionidae indet.			1				1													
Zora sp. juv.			1								1									
Xysticus sp. juv.			4									2						2		
Lycosidae indet.			25					2	2			1		4			3	9	2	2
Cryphoeca silvicola (C.L. Koch)	3	5	3	5				3			2							1		
Hahnia pusilla (C.L. Koch)		2		2																
Araneus sp.			2		1		1													
Robertus lividus (Blackwall)	2	1	1						2											2
R. scoticus Jackson	4	9	7	1	1					3				12				3		
R. lyrifer Holm		1																		1
Ceratinella brevipes (Westr.)		1	1															2		
Wideria antica (Wider)		1											1							
W. nodosa (O.P.-Cambr.)		1							1											
W. fugax (O.P.-Cambr.)	1	2			2				1											
Trachynella nudipalpis (Westr.)		3											1				1		1	
Cornicularia cuspidata (Blackw.)		4											2	1					1	
Dicymbium tibiale (Blackwall)	2	4		2	2										2					
Dicymbium sp.		3				2					1									
Entelecara erythropus (Westr.)		3		3																
Gonatium rubens (Blackwall)		1											1							
G. rubellum (Blackwall)		1		1																
Maso sundevalli (Westr.)		3									1					1		1		
Pocadicnemis pumila (Blackwall)	1	5							6											
Cnepalocotes obscurus (Blackw.)		2											2							
Tiso vagans (Blackwall)		1		1																
Minyriolus pusillus (Wider)	8	4		5				5			1	1								
Tapinocyba pallens (O.P.-Cambr.)	1	7		1					4				2			1				
Lophomma punctatum(Blackwall		2				2														
Micrargus herbigradus (Blackwall)	4	7			6	5														
Erigonella hiemalis (Blackwall)	9	12		19	1							1								
Savignia frontata (Blackwall)	3	2		2		3														
Diplocephalus latifrons (O.P.-Cambr.	1	4		2	1					1		1								
Asthenargus paganus (Simon)	2	12	1	7		1			2	1		4								
Diplocentria bidentata (Emerton)	1	44		2	1	3		2			3	10	10	3	5		1	4	1	
Rhaebothorax sp.	2												1		1					
Eboria sp.		3										3								
Latithorax sp.	7	2										9								
Drepanotylus uncatus (O.P.-Cambr.)		2			1								1							
Hilaira pervicax Hull	3	21	1										4	4	8		1	1	3	4
H. herniosa Thorell		3	3												6					
Porrhomma pygmaeum Blackwall		1				1														
P. convexum (Westr.)		4			4															
P. pallidum Jackson	1	9		2				1			1		2		4					
Porrhomma sp.		1									1									
Agyneta sp.		2													1				1	
Centromerus arcanus (P.O.-Cambr.)	7	41	11	13	5	3			7	4		1	11				2	13		
Oreonetides vaginatus (Thorell)	1	2											1		2					
Macrargus rufus (Wider)	1	3					1	2			1									
Stylophora concolor (Wider)	1								1											
Bathyphantes nigrinus (Westr.)		5		5																

Cntd

Cntd

	Total			Sample No.															
	♂	♀	juv.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Bolyphantes alticeps (Sundev.)	1																	1		
Lepthyphantes alacris (Blackw.)		1		1																
L. cristatus (Menge)		2							1		1									
L. angulatus (O.P.-Cambr.)	5	5				9								1						
Helophora insignis (Blackw.)	1					1														
Mengea scopigera (Grube)	1					1														
Linyphiidae indet.			477		95	10	12	4	47	35	21	14		30	117	13	16	27	15	21
Total	74	254	556	74	121	41	15	27	74	45	35	50	43	51	146	17	26	65	24	30

described by Waaler (1971). The figures for the nine samples from Locality 1 are as follows: 74, 121, 41, 15, 27, 74, 45, 35 and 50. When converted to individuals per m^2 the figures read respectively 123, 151, 123, 60, 108, 148, 180, 140 and 100, averaging 121. For Locality 2 the population density was, as expected, lower. The figures for the eight samples (10–17) were as follows 43, 51, 146, 17, 26, 65, 24 and 30. When converted to individuals per m^2 the figures read respectively 86, 170, 97, 34, 65, 65, 24 and 60, averaging 75.

As proved the case at Son (Waaler 1971), this collection was also dominated by the Linyphiidae s.lat. Of the 328 adult spiders collected, Erigoninae and Linyphiinae constituted 176 and 124 specimens, respectively forming 53.7 % and 37.8 % of the adult collection. In addition to being the most dominant group, the linyphiids also show the greatest diversity in number of species, forming 40 out of 46 species collected (Erigoninae 23 species (51.1 %), Linyphiinae 17 species (37.7 %)). The five species dominating the picture are shown in Table IV. The 152 specimens from this table constitute 46.2 % of the adult collection.

Table IV. Dominating species in mosses

	No. of adults	% of all adults
Centrometrus arcanus	48	14.6
Diplocentria bidentata	45	13.7
Hilaira pervicax	24	7.3
Erigonella hiemalis	21	6.3
Asthenargus paganus	14	4.3

There are 13 specimens of *Robertus scoticus*, 12 of *Minyriolus pusillus*, 11 of *Micrargus herbigradus*, and 10 of *Porrhomma pallidum* and *Lepthyphantes angulatus*.

Another distinctive feature of the dominating species is their preponderance in the various samples: e.g. *Diplocentria bidentata* in 12, *Centromerus arcanus* in 9, and *Hilaira pervicax* in 7 of 17 samples.

Females were, as expected, more frequent than males. Of the 328 adults, 74 were males (22.6 %) and 254 females (77.4 %), the sex ratio being 1 : 3.4, a figure in agreement with the author's investigation in Son (Waaler 1971).

The majority of the juvenile specimens, 494 out of 556, belonged to the Linyphiidae.

Pitfall traps in mosses

The results are shown in Table V. The traps contained 92 spiders, of which 18 were adults; an additional 8 species were present in addition to those mentioned in Table III.

Spiders in straw

The results are shown in Table VI. The find contained 230 spiders, of which 119 were adults. The average sex ratio was 1 : 1.7. The heap of straw seemed to constitute a hibernation place for *Stylophora concolor*. The 82 specimens of *S. concolor* constituted 35.7 % of the finds. The majority of them (74) were found in September and October.

Spiders from spruce twigs

The results are shown in Table VII. Number of spiders: sample No. 25, 115; sample No. 26, 63 and sample No. 27, 18. The figures give no

Table V. Number of spiders found in pitfall traps in mosses

	Total			Sample No.			
	♂	♀	juv.	18	19	20	21
Zelotes sp.	1		1		2		
Oxyptila sp.			1	1			
Pardosa amentata (Clerck)		1					1
P. lugubris (Walck.)		2			2		
P. prativaga fulvipes Collett		1					1
Tarentula aculeata (Clerck)	1			1			
Lycosidae indet.			14		9		5
Thyrosthenius biovatus (O.P.-Cambr.)		1			1		
Micrargus herbigradus (Blackw.)	1			1			
Leptorhoptrum robustum (Westr.)	1						1
Hilaira excisa O.P.-Cambr.)	2			2			
Porrhomma pallidum Jackson		1			1		
Centromerus arcanus (O.P.-Cambr.)		1		1			
Macrargus rufus (Wider)		1			1		
Bolyphantes crucifer (Menge)	1					1	
Lepthyphantes alacris (Blackw.)		1		1			
L. tenebricola (Wider)	2			1		1	
L. sp.			1				1
Linyphiidae indet.			57	10	1	1	45
Total	9	9	74	18	17	3	54

Table VI. Number of spiders found in samples from straw

	Total			Sample No.		
	♂	♀	juv.	22	23	24
Drassodes pubescens (Thorell)		1	1	2		
Gnaphosidae indet.			6	6		
Agroeca brunnea (Blackwall)	1				1	
Clubionidae indet.			15		15	
Phrurolithus festivus (C.L. Koch)			4	4		
Zora sp.			1	1		
Thanatus sp.			1	1		
Xysticus sp.			2		2	
Evarcha falcata (Clerck)			2			2
Neon sp.			1	1		
Lycosidae indet.			36	33	3	
Hahnia pusilla (C.L. Kocl)		4		4		
Theridion sp.			1		1	
Robertus lividus (Blackwall)		1			1	
Widerla antica (Wider)	1				1	
Dicymbium tibiale (Blackwall)	1	1			2	
Pocadicnemis pumila (Blackwall)	1					1
Gongylidiellum murcidum Simon	3	1		1	3	
Savignia frontata Blackwall	1					1
Diplocephalus latifrons (O.P.-Cmbr.)		1		1		
Meioneta sp.		2		1	1	
Micronela viaria (Blackwall)	4	10		9	5	
Centromerus arcanus (O.P.-Cmbr.)		1		1		
C. silvaticus (Blackwall)	1	7		1	7	
Stylophora concolor (Wider)	32	45	5	53	21	8
Linyphiidae indet.			36	29	7	
Total	45	74	111	148	70	12

Table VII. Number of spiders from spruce twigs

	Total			Sample No.		
	♂	♀	juv.	25	26	27
Dictyna arundinacea (L)		3		3		
Dictyna sp.			11	11		
Clubiona subsultans (Thorell)	1					1
Xysticus sp.			2		2	
Dipoena sp.			1		1	
Tetragnatha sp.			2		2	
Cyclosa conica (Pall.)			5			5
Araneus sp.			3		2	1
Dicymbium sp.		1		1		
Trichopterna mengei (Simon)	1	1		2		
Bolyphantes index Thorell	5	26	15	44	1	1
Lepthyphantes alacris (Blackw.)	1	1		2		
L. obscurus (Blackw.)	1	1		1		1
L. expunctus (O.P.-Cmbr.)	3	36	1	36		4
L. kochiellus (Strand)		1				1
L. suffusus Strand	7	8		15		
Linyphia triangularis (Clerck)	3	6	6		15	
Pityohyphantes phrygianus (C.L.K.)		2	22		20	4
Linyphiidae indet.			20		20	
Total	22	86	88	115	63	18

indication of the population density in the habitats, since more strokes were given on the branches in sample No. 25 than in the other two. The twigs in the sub-alpine zone were dominated by *Bolyphantes index* (44), *Lepthyphantes expunctus* (36), and *L. suffusus* (15). The 95 specimens of these three species constituted 82.6 % of the sum of 115 spiders in the habitat. The planted area, sample 26, was dominated by *Linyphia triangularis* and *Pityohyphantes phrygianus,* and the dark forest, sample 27, by *Cyclosa conica* and *Lepthyphantes expunctus.*

REMARKS ON SOME OF THE SPECIES

Clubiona subsultans (Thorell). Found both in mosses and on spruce twigs (samples Nos. 9 and 27). Several authors have described this species as occurring on trees, in mosses, and among spruce- and pine-needles. Locket & Millidge (1951) write: 'It should be looked for on and under bark of conifers and among pine needles.' Reimoser (1937) emphasizes bark, and Brændegård (1966) says it is beaten down from twigs, but is also met with in pine needles, in wet forest ground and under loose bark. Järvi (1916) has found it under stones. The author has found adult females in silk cells under stones as late as 23 October, which could imply that they hibernate there as well as in mosses (Palmgren 1943).

Cornicularia cuspidata (Blackwall). Four females, all found in the highlands (850–900 m); may also occur in lowlands (Locket & Millidge 1953; Whiele 1960).

Trichopterna mengei (Simon). Found on spruce twigs (sample No. 25). Occurs frequently in mosses, but the twigs on which the spiders were caught were low and entwined with mosses and heather.

Thyreostenius biovatus (O. P.-Cambridge). In pitfall trap, sample No. 19, typically occurs in ant hills. About 150 ants *(Formica rufa)* were found in the same pitfall trap.

Diplocentria bidentata (Emerton). Found in samples Nos. 1, 2, 3, 5, 8–12, 14–16 in all mosses mentioned, and in habitats both at 200 m and 850–900 m. Wiehle (1960) characterizes

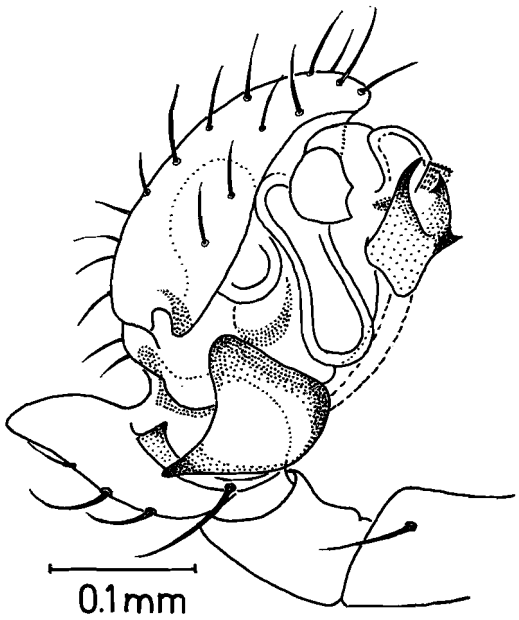

Fig. 3. *Gongylidiellum murcidum* Simon, male palp.

the species as Nordic (p. 432). Several authors (Holm 1950, Palmgren 1965), mention its eurytope character, which is also indicated by the author's finds in different kinds of mosses both in lowland and highland habitats.

Oreonetides vaginatus (Thorell). In mosses, samples Nos. 10 and 12. Locket & Millidge (1953) only mention finds from under stones. Holm (1950) reports sublapidicole finds as well as finds in mosses.

Bolyphantes index (Thorell). Frequent on spruce twigs, sample No. 25 (44 out of 46 specimens). While Palmgren (1965) reports numerous finds from birch twigs, Holm (1950) emphasizes its frequent occurrence on spruce twigs.

Leptyphantes expunctus (O. P.-Cambridge). 36 of 40 spiders on spruce twigs, sample No. 25, 900 m. Here again, Palmgren has found the species on birches, while Holm (1950) and Hackman (1954) mention finds on spruce twigs. Together with *Bolyphantes index,* it constituted the most frequent species on spruce twigs.

L. kochiellus (Strand). Previously only reported once from Hatfjelldalen; three females (Strand 1901).

L. suffusus (Strand). Also only one previous find reported (Strand 1901).

Gongylidiellum murcidum Simon is here reported for the first time in Norway. Male palp shown in Fig. 3, the female epigyn in Fig. 4.

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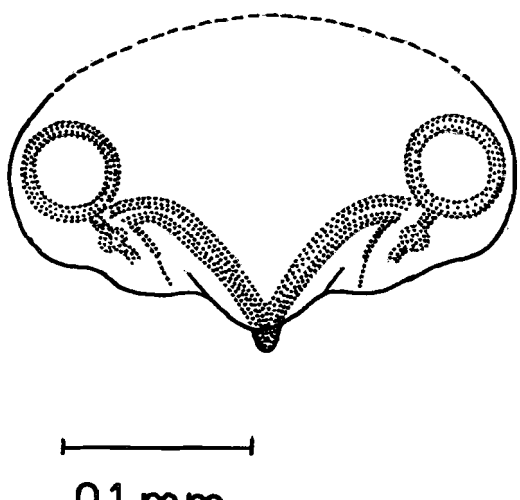

Fig. 4. *Gongylidiellum murcidum* Simon, female, epigyn.

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Present and Late Weichselian Occurrence of *Corynocera ambigua* Zett. (Dipt., Chironomidae) in Norway

ARNE FJELLBERG

Fjellberg, A. 1972. Present and Late Weichselian Occurrence of *Corynocera ambigua* Zett. (Dipt., Chironomidae) in Norway. *Norsk ent. Tidsskr. 19*, 59–61.

This species was recorded at Hardangervidda, South Norway, in 1968 (1200 m a.s.l., middle alpine zone). Larval head capsules, sometimes with body skin attached, were found in Late Weichselian sediments at Jæren, Southwest Norway. A map of the species' present and Late Weichselian occurrence in Fennoscandia and Denmark is given. Swarming was observed at Hardangervidda in the period July – September. The species is supposed to have a two-year cycle at this locality.

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DISTRIBUTION

The peculiar chironomid *Corynocera ambigua* Zett. was found in great masses on the surface of a pond near Lake Omkjelvann (1200 m a.s.l.) at Hardangervidda in southwestern Norway Hordaland: Ullensvang) 19 July 1968 by A. Fjellberg. Several specimens were taken in copula. The species has lost its capacity to fly, but with its reduced wings makes rapid, whirling movements on the surface of the lakes where it hatches and mates.

C. ambigua was discovered by Zetterstedt at Torneträsk in northern Sweden. This species was later found in Småland in southern Sweden (Brundin 1949), and at several places in northern Finland (Hirvenoja 1960, Lindberg 1970) (Fig. 1). Outside Fennoscandia, it is reported from Holstein and Böhmen eastwards through Poland and USSR to the Urals (Mothes 1968).

Larvae were unknown until 1960, when Hirvenoja found some in Lake Sompiojärvi in Finnish Lapland, guided by mass occurrence of imagines the previous year (Hirvenoja 1960, 1961). The larvae of *C. ambigua* proved to be identical with *Dryadotanytarsus edentulus* described by Sögaard-Andersen (1943) from

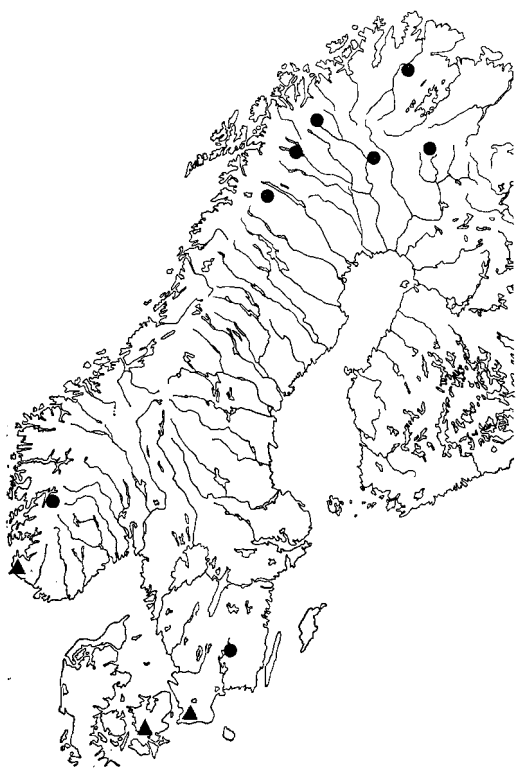

Fig. 1. Present (dots) and Late Weichselian (triangles) occurrence of *C. ambigua* in Fennoscandia and Denmark.

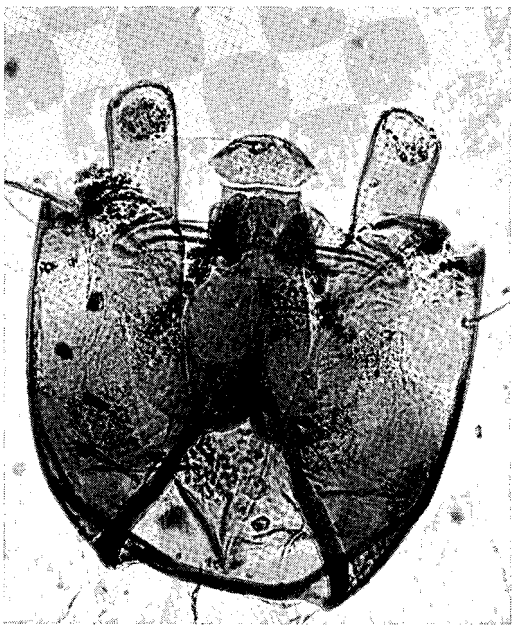

Fig. 2. Head capsule (ventral) of *C. ambigua*-larva from Late Weichselian sediments from Jæren.

subfossil specimens in a late Weichselian depoposit in Denmark. Berglund & Digerfeldt (1970) discovered head capsules of *C. amgigua*-larvae in a Late Weichselian deposit at Torreberga in Southern Sweden. In 1970, I started an investigation of the fauna in a Late Weichselian deposit at Bröndmyra, Jæren, southwestern Norway (for pollen-analytical investigation of the site, see Chanda 1965). Larvae of *C. ambigua* were found in layers dating from Older Dryas, Alleröd and Younger Dryas (13,000–10,000 years B.P.) (Fig. 2). An intact male hypopygium verified the determination. The species is thus an early immigrant in Norway, possibly arriving from the south across the North Sea Continent.

ECOLOGY

C. ambigua has a preference for oligotrophic clear-water lakes and is often found associated with Characeae (Mothes 1968). A similar situation was found to exist in the Late Weichselian localities in Denmark, Sweden, and Norway where oospores of Characeae *(Nitella, Chara)* were found together with the larvae (Sögaard-Andersen 1943, Berglund & Digerfeldt 1970).

Brundin (1949) supposed that the pupa is cold-stenothermous, hatching just after breakup of the ice. In Northern Germany, the imagines are observed in April and May (Thienemann 1954, Mothes 1968). Hirvenoja (1960) noted the imagines in Sompiojärvi in late May-early June, with maximum hatching when the water was about 8° C. Other observations in Finnish and Swedish Lapland date from late June–early July.

In the summer of 1971 I made further observations of the species at Lake Omkjelvann. Swarming was noted 25 July on a pond (about 25 × 15 m, depth ca. 1 m) near the norhern end of Lake Omkjelvann. Two similar ponds, lying at successively lower levels, are connected with the first by a little brook (Fig. 3). All three ponds have mud bottoms with dense vegetation of *Nitella opaca* Agardh. The swarming, which I observed in the upper pond only, may be explained by the water temperature, which was 8.5° C in the upper and 10.5–11.0 °C in the two lower ponds. Thus the swarming may have occurred earlier in the two lower ponds. After a brief examination of the bottom mud, larvae were found in the upper two ponds. A full grown larva (prepupa, 6.8 mm), extracted from a mud tube, was taken together with two small larvae only 2.5 mm long (outstretched). The gut content of the larvae consisted of detritus (inter alia diatomes and other algae) and mineral grains.

Fig. 3. The three *Nitella*-pools at the outlet of Lake Omkjelvann. *C. ambigua* was swarming in the nearest on 25 July 1971.

The locality was visited again 8 Sept. Two larvae were collected, one of which measured 5.8 mm, while the other was a 6.5 mm prepupa situated in a mud tube. At the same time swarming was observed on a small lake (about 100 × 50 m) near the western shore of Lake Omkjelvann. This lake also contained *Nitella opaca*. Unfortunately I han no thermometer available at that moment, but the lake is situated in a position so that long ice cover and seeping from surrounding snow fields can be predicted. In spite of the late date, the temperature may not have been more than 8 °C. The midges were swarming in the middle of the lake, behaviour also observed by Hirvenoja (1960). The weather conditions were ideal for swarming, two warm days with bright sunshine following a cold and rainy period. But September must be considered a very late swarming time for this species. If the unfavourable weather conditions had continued, the species might not have hatched from that lake that year. Some larvae, measuring from 4.7 to 6.4 mm, were found in the bottom sediments.

Mothes (1968) found that *C. ambigua* had a one-year cycle in Nehmitzee in Northern Germany. The eggs were laid in April. In September the larvae hatched and were fully grown the following spring. The observations from Lake Omkjelvann indicate that the larvae need at least two years to complete their development. The final hibernation may occur in the prepupa stage. A similar situation was found on Ellesmere Island in Arctic Canada by Oliver (1968). He found a species of *Procladius* that had at least three years larval time and could hibernate as prepupa. Therefore a two-year life cycle for *C. ambigua* at Lake Omkjelvann is not unreasonable. This also prevents the species being excluded from a lake when hatching fails one year.

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I would like to express my thanks to Richard Wiger, M. Sc., for improving the English, and to Cand. mag. Anders Langangen for determination of *Nitella opaca*.

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Syrphidae (Dipt.) from Jæren, Norway, II.

TORE RANDULFF NIELSEN

Nielsen, T. R. 1972. Syrphidae (Dipt.) from Jæren, Norway, II. *Norsk ent. Tidsskr. 19,* 63–71.

The Syrphidae fauna of Jæren in SW Norway was investigated mainly during the period 1963–66. This second article gives information on distribution, flight period, and flowers visited by 60 species of the subfamilies Cheilosinae, Volucellinae, Sericomyinae, Eristalinae, Xylotinae, and Eumerinae. Ten species are reported as new to the Norwegian fauna. The two papers present a total list of 128 Syrphid species from the area; two new species have been described and 25 species are reported as new to Norway.

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This paper reports on a further 60 Syrphid species from Jæren, and completes the list of 128 species found in the area. The following 10 are new to the Norwegian fauna:
Chrysogaster macquarti Loew 1843
Sphegina sibirica Stackb. 1953.
Pipizella varipes (Meig.) 1822
Cheilosia albipila (Meig.) 1822
Cheilosia bergenstammi Beck. 1894
Eristalis abusivus Coll. 1931
Eristalis vitripennis Strobl 1893
Xylofa coeruleiventris Zett. 1838
Tropidia scita (Harr.) 1776
Eumerus tuberculatus Rond. 1857

Concerning situation of the localities, abbreviations and terms used, see article I (Nielsen 1971).

SUBFAMILY CHEILOSINAE

Genus *RHINGIA* Scopoli
R. campestris Meig. 1822

68 specimens from 9 localities. Frequent in May-June, rare in late summer: May (21 ex.), June (41 ex.), July (3 ex.), Aug. (1 ex.), Flight period: 28 May–17 Aug.

NF: *Cardamine pratensis* L., *Malus silvestris* (L.) Mill., *Vaccinium myrtillus* L., *Taraxacum* sp.

Norway: SE (Ö, AK, VE, Os, On, STy, STi); N (TRy, TRi).

Genus *FERDINANDEA* Rondani
F. cupera (Scop.) 1763

A female specimen at Dale 25 July 1964, indoors.

Norway: According to Forsslund (1951) found at Nyseter, Herjehogna (HEn).

Genus *CHRYSOGASTER* Meigen
Subgenus *LIOGASTER* Rondani
L. metallina (Fabr.) 1777

663 specimens from 15 localities. Frequent in humid biotopes (locally abundant on humid *Ranunculus acris* meadows: Reke and Stokka 14 June 1963, 129 ex. and 147 ex. respectively). Flight period: 28 May–31 Aug., with peak in early summer (June). Taken in copula (8 pairs) 14 June 1963.

NF: *Caltha palustris* L., *Ranunculus acris* L., *Taraxacum* sp.

Norway: SE (AK, HEn, STy); W (HOy) and N (Nnö).

Subgenus *ORTHONEURA* Macquart
O. geniculata Meig. 1830

18 specimens from 4 localities; on bogs and meadows in early summer. Flight period: 29 May–20 June.

NF: *Salix repens* L., *S. caprea* L., *Caltha palustris.*

Norway: According to Siebke (1877) at Evenes, Ofoten (Nnö). 'Rare'.

O. nobilis (Fall.) 1817

36 specimens from 7 localities; in forests as well as on meadows in cultivated land. Flight period: 18 June–20 Aug.

NF: *Ranunculus acris, Potentilla fruticosa* L., *P. erecta* (L.) Räusch.

Norway: SE (AK, Os, On) and W (SFi).

Subgenus *CHRYSOGASTER* Meigen, s. str.

C. macquarti Loew 1843

New to Norway. 74 specimens from 12 localities; frequent on humid *Comarum* bogs, otherwise more rarely on meadows and riverbanks. Flight period: 4 June–2 Sept.

NF: *Ranunculus acris, Comarum palustre* L., *Sanguisorba officinalis* L., *Valeriana officinalis* L., *Taraxacum* sp.

Genus *NEOASCIA* Williston

N. aenea (Meig.) 1822

35 specimens from 5 localities; on bogs, meadows and in forests. An early summer species, on Jæren found during the period: 28 May–5 June.

NF: *Salix caprea, Caltha palustris, Taraxacum* sp.

Norway: SE (Os, On).

N. dispar (Meig.) 1822

255 specimens from 10 localities. Obviously a hygrophile species; almost exclusively found on humid bogs and meadows, where it may be a rather dominating Syrphid species. Flight period: 28 May–27 Aug., however most abundant in June–July.

NF: *Caltha palustris, Comarum palustre, Potentilla erecta, Taraxacum* sp.

Norway: SE (AK, On, STi, NTi) and N (Nnv, TRi, Fi).

N. geniculata (Meig.) 1822

4 specimens from 4 localities: Kleppe 15 Aug. 1965 (1♀); Sele 12 July 1965 (1♀); Brattebö 8 July 1965 (1♀); Gimra 17 July 1964 (1♀). Flight period 8 July–15 Aug.

NF: *Ranunculus acris.*

Norway: SE (Os, NTi).

N. podagrica (Fabr.) 1775

134 specimens from 15 localities; common and met with in most of the biotopes investigated. Flight period: 21 April–5 Sept. The earliest ones found have quite certainly been hibernating specimens (all specimens were well sclerotinized and pigmented, and cold weather before these dates would make hatching less probable).

NF: *Ranunculus acris, Potentilla erecta, Sanguisorba officinalis, Valeriana officinalis, Taraxacum* sp.

Norway: SE (AK, HEs, STy, STi, NTi) and W (MRy, MRi).

Genus *SPHEGINA* Meigen

S. clunipes (Fall.) 1816

32 specimens from 2 localities (Myrland, Dale); in glades and at the edges of forests. The *Sphegina* species usually fly in the low vegetation, not too high above the ground. Their slender shape, long abdomen and 'dancing' flight make them often resemble very much *Ichneumonidae.* Flight period: 22 June –5 July.

NF: *Rubus idaeus* L.

Norway: SE (Ö, AK, Os, Bö, STi, NTi) and N (Fi).

S. sibirica Stackb. 1953

New to Norway. A female specimen on *Potentilla fruticosa* flowers, Dale 24 July 1970.

Genus *PARAPENIUM* Collin

P. flavitarsis (Meig.) 1822

4 specimens from 2 localities: Stokka 14 June 1963 (3♂♂) and Austrått 18 June 1963 (1♂), on humid *Ranunculus* meadows.

Norway: SE (Ö, AK, HEs, HEn, Bö, Bv, NTi).

Genus *PIPIZA* Fallén

P. bimaculata Meig. 1822

1 male specimen on dry meadows, Ogna 27 June 1962.

Norway: One find near Oslo, Lysaker 28 June 1873.

P. quadrimaculata (Panz.) 1804

6 specimens from 4 localities: Öksnevad 21 June 1964 (1♀); Myrland 26 June 1964 (1♀), 1 July 1964 (1♀), 17 July 1964 (1♀); Brattebö 8 July 1965 (1♀); Skogsbakken, Sandnes 28 June 1963 (1♀), in glades and at the edges of forests. Flight period: 21 June–17 July.

NF: *Ranunculus acris.*

Norway: SE (Ö, AK, HEn, Os, NTi).

P. noctiluca (L.) 1758

1 female specimen on *Ranunculus acris,* in forests glade at Dale 24 June 1967.

Norway: SE (AK, HEs, HEn, On, STi, NTi); W (HOy) and N (Nnö, TRy).

Genus *PIPIZELLA* Rondani

P. varipes (Meig.) 1822

New to Norway. 24 specimens from 5 localities; (Ogna, Öksnevad, Brattebö, Dale, Gimra) mostly in dry biotopes (meadows, heaths), occasionally in humid areas. Flight period: 21 June–15 Aug.

NF: *Comarum palustre.*

Genus *NEOCNEMODON* Goffe

Neocnemodon sp.

5 specimens from 2 localities: Skogsbakken, Sandnes 28 June 1963 (1♀); Brattebö 4 June 1965 (1♀), 5 June 1965 (1♀), 1 June 1967 (2♀♀), in spruce forests. As the females of this genus cannot yet be determined with certainty, it is impossible to state the species of this sample.

Genus *CHEILOSIA* Meigen

C. albipila Meig. 1838

New to Norway. A male specimen on flowering *Salix caprea,* Dale 25 April 1968.

C. albitarsis (Meig.) 1822, Fig. 1

19 specimens from 7 localities; mainly in open, cultivated fields, occasionally on forest meadows and along riverbanks. Flight period: 30 May–29 June. Both the dates from Jæren and the finds from other parts of Norway indicate that *C. albitarsis* is a distinct early summer species.

NF: *Ranunculus acris.*

Norway: SE (AK, VE, TEy, HEn, STy, STi) and N (Nsi, Nsy, TRy, TRi). Bidenkap (1900) reports it as extremely abundant on *Ranunculus* and *Taraxacum* at Maukstad, Troms.

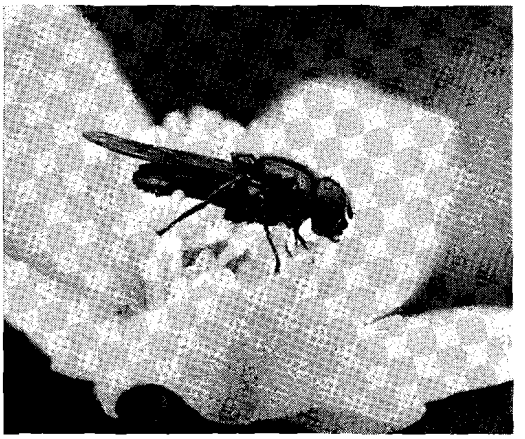

Fig. 1. *Cheilosia albitarsis* (Meig.), an early summer species, has its flight maximum in second half of May – medio June.

C. bergenstammi Beck 1894

New to Norway. 35 specimens from 6 localities (Ogna, Vik, Öksnevad, Skjæveland, Gimra, Stokka); on cultivated fields and in gardens, in the western, open part of the landscape. Flight period: 28 May–31 Aug.; most numerous in late summer.

NF: *Taraxacum* sp.

C. fraterna (Meig.) 1830

3 specimens from 1 locality: Figgjo 11 July 1965 (1♂, 2♀♀); on riverbank.

Norway: SE (AK).

C. gigantea (Zett.) 1838

42 specimens from 7 localities. An early summer species with peak in the numbers from late May till second half of June. Flight period: 29 May–3 July.

NF: *Ranunculus acris, Anthriscus silvestris* L. (Hoffm.), *Taraxacum* sp.

Norway: SE (AK, VE, HEs, Os, Bv, STy, NTi) and N (Nnv, TRi).

C. intonsa Loew 1857

15 specimens from 5 localities: Vik 27 July 1960 (1♂), 2 Aug. 1963 (3♂♂,2♀♀), 11 Aug 1963 (2♂♂), 25 Aug. 1966 (1♀); Orre 31 Aug. 1962 (1♀), 25 Aug. (1♀); Brattebö 1 June 1967 (1♀); Gimra 29 Aug. 1962 (1♀), 16 Aug 1963 (1♂); Kverneviken 30 July 1963 (1♂); in most occasions on cultivated fields, but also in sand-dunes (Orre). The species was most frequently met with in the open, coastal areas. Flight period: 1 June–31 Aug.

NF: *Senecio jacobaea* L., *Taraxacum* sp.

Norway: SE (AK) and N (TRy).

C. longula (Zett.) 1838

21 specimens from 5 localities; in most cases in forest areas, but also along riverbanks. Flight period: 6 July–21 Sept.

NF: *Potentilla fruticosa, P. erecta.*

Norway: SE (HEs, AAi, STi) and N (Nsi).

Note: The material contains a diverging female, with strongly swollen hind metatarsi, as mentioned by Lundbeck (1916).

C. mutabilis (Fall.) 1817

72 specimens from 3 coast localities: Ogna, Brusand, Orre. Locally abundant on barren shore meadows. Flight period: 29 June–7 Aug.

Norway: According to Siebke (1877) all over southern and central parts of Norway (except Dovre), in the north to Verdal, Nord-Trøndelag. Bidenkap (1900) reports it from Alta in Finnmark.

C. pagana (Meig.) 1822

59 specimens from 9 localities; widespread and frequent (locally abundant). Flight period: 15 May–24 Aug.

NF: *Sanguisorba officinalis, Anthriscus silvestris, Senecio jacobaea, Taraxacum* sp.

Norway: SE (Ö, AK, VE, On, STi, NTi) and N (TRy).

C. praecox (Zett.) 1843

2 female specimens on sand-dune meadows; Orre 1 June 1963 (Arne Nielsen leg.).

Norway: SE (VE).

C. scutellata (Fall.) 1817

34 specimens from 4 localities; mainly in forest areas. Flight period: 5 June–16 Aug.

NF: *Comarum palustre, Potentilla fruticosa, P. erecta, Angelica silvestris* L.

Norway: SE (Ö, AK, HEs, HEn, Os).

C. variabilis (Panz.) 1798

2 specimens from 2 localities: Ogna 21 July 1963 (1♂); Skogsbakken, Sandnes 28 June 1963 (1♂); on forest meadows.

Norway: SE (VE, Bö, STy, STi, NTi).

C. vernalis (Fall.) 1817

200 specimens from 18 localities. The commonest *Cheilosia* species in the area, and especially abundant in the western, greatly cultivated part of Jæren. Apart from in sand-dunes, found in all biotopes investigated. Flight period: 28 May–31 Aug.

NF: *Valeriana officinalis, Senecio jacobaea, Taraxacum* sp., *Hieracium* sp.

Norway: SE (AK, VE, HEs, Os, On, STy, NTi); W (SFi) and N (TRy, TRi). Bidenkap (1892) reports it as very common in county Vestfold (VE).

SUBFAMILY VOLUCELLINAE

Genus *Volucella* Müller

V. bombylans (L.) 1758, Fig. 2

43 specimens from 10 localities; not rare and found in most of the biotopes investigated, but in greatest numbers in wooded areas. Flight period: 26 June–16 Aug.

NF: *Cakile maritima* Scop., *Comarum palustre.*

Norway: SE (Ö, AK, VE, HEs, Os, Bö, Bv, AAi, VAi, STy, STi); W (HOy, MR) and N (Nnö, Fi, Fö).

V. pellucens (L.) 1758

15 specimens from 6 localities; Ogna 29 July (1♂,1♀), 21 July 1963 (1♀); Öksnevad 14 July 1964 (5♀♀); Myrland 23 June 1965 (1♂), 4 July 1965 (1♂); Gravaren, Sandnes 25 July 1964 (1♂); Dale 7 July 1960 (1♂, Arne Nielsen leg.), 3 July 1969 (1♀); Viste 29 June 1969 (1♀); most frequently met with in forests and on meadows

Fig. 2. Female *Volucella bombylans* (L.).

neighbouring forests. Flight period: 23 June –9 Aug.

NF: *Rubus idaeus, Potentilla fruticosa, Valeriana officinalis.*

Norway: SE (Ö, AK, VE, HEs, Os, AAi, STy, STi) and W (Ri, HOy). Bidenkap (1892) found it in numbers in Vestfold (VE), especially on Compositae.

SUBFAMILY SERICOMYIINAE

Genus *SERICOMYIA* Meigen

S. lappona (L.) 1758

19 specimens from 6 localities; mainly in wooded areas. It is most numerous in early summer (June), very scarse later on. Flight period: 30 May–10 Aug.

NF: *Rubus idaeus, Potentilla erecta, Vaccinium myrtillus.*

Norway: SE (Ö, AK, VE, HEn, On, Os, Bö, STi) and N (Nnv, TRy)

S. silentis (Harr.) 1776. Fig. 3

103 specimens from 16 localities; frequent and found in most biotopes investigated: in forests, on meadows in cultivated land, on bogs and riverbanks and on one occasion in sand-dunes by the sea. Flight period: 4 June–12 Sept.

NF: *Rubus idaeus, R. nessensis* W. Hall., *Comarum palustre, Potentilla erecta, Calluna vulgaris* (L.) Hull, *Valeriana officinalis, Taraxacum* sp., *Hieracium* sp.

Norway: SE (Ö, AK, HEs, HEn, AAy, STy, STi, NTi); W (MRy) and N (Nnv).

SUBFAMILY ERISTALINAE

Genus *ERISTALIS* Latreille

E. abusivus Coll. 1931

New to Norway. 849 specimens from 30 localities; common and widespread, but not found in forest biotopes. It has been observed most frequently in the western, coastal areas, where it dominates over the otherwise abundant *E. arbustorum* (L.). Quantitative catches at Vik (loc. no. 5) in July and August on shorstet meadows proportion the ratio *E. abusivus*/*E. arbustorum* as 81 %/19 %; at Orre (3 kms north of Vik) in the same period as 78 %/22 %. Flight period: 15 May–12 Sept.

NF: *Salix repens, Ranunculus acris, Cakile maritima, Sedum acre* L., *Parnassia palustris* L.,

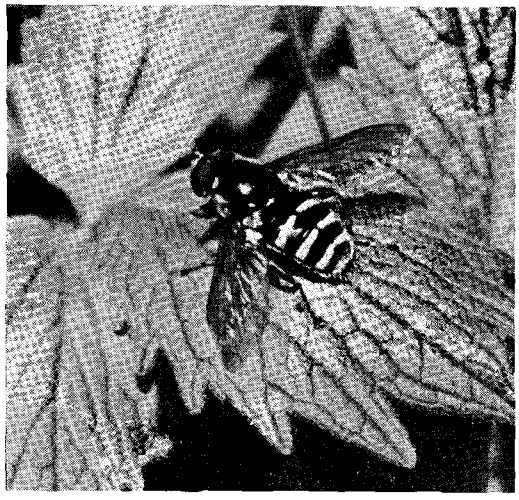

Fig. 3. Male *Sericomyia silentis* (Harr.) sunning itself on *Valeriana* leaf. It is easily recognised from other Norwegian species of the genus by the yellow abdominal tip and its broad, yellow bands on the tergites.

Fig. 4. *Eristalis cryptarum* (Fabr.) were most frequently observed in humid bogs, feeding on flowering *Comarum palustre*.

Comarum palustre, Sanguisorba officinalis, Angelica silvestris, Valeriana officinalis, Achillea millefolium L., *Matricaria indora* L., *Arnica montana* L., *Senecio jacobaea, Sonchus arvensis* L., *Taraxacum sp., Hieracium* sp.

E. arbustorum (L.) 1758

478 specimens from 27 localities. Common and widespread, but scarce in forests. See otherwise under *E. abusivus*. Flight period: 15 May –3 Oct.

NF: *Salix repens, Cakile maritima, Potentilla fruticosa, P. erecta, Calluna vulgaris, Myosotis* sp., *Valeriana officinalis, Matricaria indora, Arnica montana, Senecio jacobaea, Sonchus arvensis, Taraxacum* sp., *Hieracium* sp.

Norway: SE (Ö, AK, VE, HEs, Os, Bv, STy, STi); W (Klepp, Ry (Ardö 1957)) and N (Nnö TRi).

E. cryptarum (Fabr.) 1794, Fig. 4

19 specimens from 6 localities. Almost exclusively met with on bogs, occasionally along riverbanks and on humid meadows. Flight period: 24 June–9 Aug.; most abundant in early summer (June–medio July).

NF: *Comarum palustre.*

Norway: SE (AK, HEs, HEn, On, Bö, NTi) and N (TRi).

E. horticola (De Geer) 1776

294 specimens from 24 localities; common and eurytope. Flight period: 28 May–31 Aug.

NF: *Sedum acre, Rubus idaeus, Comarum palustre, Malus silvestris, Potentilla fruticosa, Angelica silvestris, Calluna vulgaris, Myosotis sp., Valeriana officinalis, Matricaria indora, Senecio jacobaea, Cirsium arvense* L. (Scop.), *Taraxacum* sp., *Hieracium* sp.

Norway: SE (Ö, AK, VE, AAy, HEn, STi, STy); W (MRy, MRi) and N (Nsy, Nnö).

E. intricarius (L.) 1758

188 specimens from 18 localities. Common in most biotopes, e.g. abundant in the coastal sand-dunes in July–Aug. Flight period: 26 April –4 Sept.

NF: *Cakile maritima, Sedum acre, Malus silvestris, Comarum palustre, Potentilla fruticosa, Sanguisorba officinalis, Angelica silvestris, Galium verum* L., *Valeriana officinalis, Matricaria indora, Sonchus arvensis, Taraxacum* sp., *Hieracium* sp.

Norway: SE (Ö, AK, VE, HEs, On, Bv, STy, STi); W (HOy, MRy) and N (Nnö, Nnv. TRy, TRi).

E. nemorum (L) 1758

60 specimens from 11 localities. Frequent, but usually in smaller numbers. Flight period: 15 May–22 Aug.

NF: *Malus silvestris, Comarum palustre, Valeriana officinalis, Senecio jacobaea, Taraxacum* sp.

Norway: SE (Ö, AK, VE, AAy, Bv, Bö, HEs, STi, STy, NTi) and N (TRi).

E. pertinax (Scop.) 1763

166 specimens from 21 localities. Common (most abundant in late summer) and eurytope. It is the *Eristalis* species most often met with in forests. Flight period: 9 May–3 Oct.

NF: *Cakile maritima, Malus silvestris, Poten-*

tilla fruticosa, Anthriscus silvestris, Angelica silvestris, Calluna vulgaris, Valeriana officinalis, Senecio jacobaea, Sonchus arvensis, Taraxacum sp., *Hieracium* sp.

Norway: SE (VE, AAy, HEs, STi, STy); W (MRy).

E. rupium Fabr. 1805

120 specimens from 16 localities. Rather common. Most frequently met with in the inner, wooded parts of Jæren, but it seems scarce on the outer coast localities. Flight period: 3 June–30 Aug.

NF: *Rubus idaeus, Comarum palustre, Angelica silvestris, Valeriana officinalis, Matricaria indora, Arnica montana, Taraxacum* sp.

Norway: SE (Ö, AK, VE, HEs, HEn, Os, Bv, STi, NTi); N (Nsi, TRy).

E. sepulchralis (L.) 1758

18 specimens from 8 localities; on meadows, bogs and riverbanks in the western areas. Flight period: 5 June–25 Aug.

NF: *Ranunculus acris, Comarum palustre, Angelica silvestris, Vateriana officinalis, Matricaria indora, Senecio jacobaea.*

Norway: According to Siebke (1877) observed at Oslo, otherwise taken in Vestfold (VE) by Bidenkap (1892).

E. tenax (L.) 1758

90 specimens from 12 localities. Rare in early summer, abundant in late summer and autumn. The material proportions as follows: April (3 ex.), May and June (0 ex.), July (23 ex), Aug. (29 ex.), Sept. (33 ex.), Oct. (2 ex.). The specimens taken in early April, all females, were well pigmented and fully sclerotinized, and most probably specimens on first flight after hibernation. Flight period: 7 April–19 Oct. It is an eurytope species, but, like most *Eristalis* species (see *E. pertinax*), occurring in smaller numbers in the forests.

NF: *Crokus vernus* All., *Cakile maritima, Sedum acre, Rubus idaeus, Potentilla fruticosa, Valeriana officinalis, Senecio jacobaea, Sonchus arvensis, Hieracium* sp.

Norway: SE (Ö, AK, VE, AAy, HEs, On, Bv, STi); W (HOy, SFi, MRy) and N (Nsi).

E. vitripennis Strobl 1893

New to Norway. 4 specimens from 4 localities: Kleppe 16 July 1965 (1♀); Skjæveland 17 July 1965 (1♀); Gimra 17 July 1964 (1♂); Hogstad 14 June 1963 (1♂); on meadows, bogs and riverbanks. Flight period: 14 June–17 July.

NF: *Ranunculus acris, Valeriana officinalis.*

Genus *MYIATROPA* Rondani

M. florea (L.) 1758

48 specimens from 9 localities. Frequent, on meadows, pastures, in gardens and at borders of forests; most frequently met with in inner part of Jæren. Flight period: 5 June–22 Aug.

NF: *Angelica silvestris.*

Norway: According to Siebke (1877) in all of the country, in the north to Alta, Finmark. Bidenkap (1892) found it very abundant on meadows in Vestfold (VE).

Genus *HELOPHILUS* Meigen

Species of this genus have been published in a separate paper (Nielsen 1966). The following seven species were reported: *H. affinis* Wahlb., *H. consimilis* Malm, *H. hybridus* Loew, *H. lineatus* (Fabr.), *H. lunulatus* Meig., *H. pendulus* (L.) and *H. trivittatus* (Fabr.). Additional material of the less common species may be mentioned:

H. consimilis Malm 1860

Gimra 3 July 1967 (4♀♀), 19 June 1968 (16♂♂, 23♀♀), 5 June 1971 (1♂); on humid *Comarum-Sphagnum* bog.

H. lunulatus Meig. 1822

Gimra 19 June 1968 (♂), on humid *Sphagnum-Comarum* bog.

SUBFAMILY XYLOTINAE

Genus *XYLOTA* Meigen

X. coeruleiventris Zett. 1838

New to Norway. 51 specimens from 5 localities; in wooded areas. Flight period: 22 June–17 Aug.

NF: *Ranunculus acris, Rubus idaeus, Potentilla erecta.*

X. segnis (L.) 1758

97 specimens from 15 localities. Common, and seems to be less tied to wooded areas than other *Xylota* species on Jæren. It also has a rather wide flight period: 30 May–16 Aug. (23 Sept., Bergen).

NF: *Ranunculus acris, Potentilla fruticosa.*

Norway: According to Siebke (1877) observed almost everywhere in the southern and central parts of Norway (except the mountain areas of Dovre). Otherwise reported from SE (AAy, STi, STy) and N (Nnö).

X. tarda Meig. 1822

6 specimens from 2 localities : Myrland 23 June 1965 (1♀); Dale 29 July 1969 (1♀), 27 July 1970 (1♂,3♀♀), in wooded areas.

NF: *Potentilla fruticosa.*

Norway: Found at Trondheim (STi) by Storm (1895).

Genus *SYRITTA* St. Farg. et Serv.

S. pipiens (L.) 1758

229 specimens from 22 localities. Common and eurytope. Flight period: 7 April–3 Oct.

NF: *Anemone nemorosa* L., *Brassica campestris* L., *Sedum acre, Potentilla erecta, Sanguisorba officinalis, Calluna vulgaris, Valeriana officinalis.*

Norway: SE (Ö, AK, VE, AAy, AAi, Bv, Bö, On-Os, HEn, NTi) and N (Nsi, Nnv).

Genus *TROPIDIA* Meigen

T. scita (Harr.) 1776

New to Norway. 8 specimens from 3 localities: Myrland 1 July 1964 (1♂), 5 July 1964 (1♂, 1♀), 6 July 1964 (1♂, 1♀), 22 June 1965 (1♂); Gimra 19 June 1968 (1♀); Sande 29 July 1963 (1♂); in forests on flowering *Rubus idaeus* (6 ex), on pasture (1 ex.) and on bog (1 ex.).

SUBFAMILY EUMERINAE

Genus *EUMERUS* Meigen

E. strigatus (Fall.) 1817

2 specimens from 1 locality: Gimra 16 Aug. 1963 (1♂), 12 June 1964 (1♂); on meadows and bog.

NF: *Comarun palustre.*

Norway: SE (Ö, AK).

E. tuberculatus Rond. 1857

New to Norway. 3 specimens from 2 localities: Skogsbakken, Sandnes 28 June 1963 (1♂, 1♀), on forest meadow; Trones, Sandnes 20 Aug. 1971 (1♂), in garden.

ADDENDA

The former article (Nielsen 1971, p. 56) reports *Paragus tibialis* Fall. from Jæren. Dr. P. Goeldlin, Lausanne, Switzerland has shown by studying the types, and Mr. E. Torp Pedersen, Jelling, Denmark by studying Danish and southern European material, that Sack (1932) in his keys leads two different species towards the name *P. tibialis*. Mr. Torp Pedersen has now most kindly examined my material and found that they all belong to the other species, *Paragus haemorrhous* Meig. 1822. The name *P. tibialis* Fall. should thus be deleted from the reported material.

Dasysyrphus friuliensis Goot is a new name of *D. postclaviger* (Stys & Moucha)(p. 55, 64), and *D. venustus* has (in 1971) replaced the synonym *D. arcuatus* (Fall.) (p. 65).

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I am indebted to Professor H. Kauri and Curator A. Löken, Zoological Museum, Bergen for giving me advice of a practical and theoretical nature. Mr. R. L. Coe, British Museum (Nat. Hist.), London, Professor A. A. Stackelberg, Zoological Institute, Leningrad and Lecturer E. Torp Pedersen, Jelling, Denmark verified and determined some species, Curator H. Andersson, Lund, Sweden lent me material from the collections of Zoological Institute, and Dr. P. Goeldlin, Lausanne, Switzerland gave me useful information about *Paragus*. For their generous and most valuable help I express my sincerest thanks.

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Notes on Norwegian Limoniinae (Diptera, Tipulidae)

HANS MENDL & JOHN O. SOLEM

Mendl, H. & Solem, J. O. Notes on Norwegian Limoniinae (Diptera, Tipulidae). *Norsk ent. Tidsskr. 19*, 73–76.

Light trap and net collections of Limoniinae are presented. Four species, *Antocha vitripennis* Meigen, *Cryptiria limnophiloides* Bergroth, *Monophilus medius* de Meijere, and *Limonia (Dicranomyia) handlirschi* Lackschewitz are reported new to Norway. Another species, *Limonia (Dicranomyia) stigmatica* Meigen, is possibly found for the second time. Flight periods are given for 22 species in Sör-Tröndelag.

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The Limoniinae fauna of Norway is, in comparison with that of other European countries, only coincidentally recorded. While these insects are well known from studies in Sweden, Great Britain, Holland, Belgium, Switzerland, Czechoslovakia, and Western USSR, regretfully few investigations have been carried out on this subject in Norway.

Publications on the Norwegian Limoniinae fauna for the last forty years are mainly limited to the works of Lackschewitz (1933, 1935) and Tjeder (1955, 1965); the former author almost exclusively gives a revision of earlier references and collections.

We captured the present collection of Limoniinae at Målsjöen, Klæbu, Sör-Tröndelag, and operated two light traps from ultimo May to primo November 1971. The conservation liquid was ethylenglycol and the traps were emptied on the dates given in Fig. 1. Air temperature was recorded continuously on an automatic recorder, and Fig. 2A shows the maximum and minimum air temperature in the periods of capturing.

RESULTS

Altogether 164 specimens of Limoniinae belonging to 22 species were collected from the light traps. The species are classified by tribe as follows:

Limoniini 13 species
Pediciini 3 species
Hexatomini 2 species
Eriopterini 4 species

Fig. 1 gives data on the species collected and their flight period indicated by the first and last capture in the light traps. The collection is small, considering that it represents a complete summer capture of two light traps. Nevertheless, it contains some noteworthy species, previously not recorded in Norway. The species new to the Norwegian fauna are: *Antocha vitripennis* Meigen, 1 ♀ captured 21–24 August, distribution Europe and Afghanistan; *Crypteria limnophiloides* Bergroth, 1 ♀ captured in each of the periods 24–27 August, 5–9 and 21–24 September, distribution central and northern Europe; *Molophilus medius* de Meijere, 1 ♂ captured 21–24 August, distribution central and northern Europe.

Another species which is of interest is *Limonia (Dicranomyia) stigmatica* Meigen. 1 ♂ and 3 ♀♀ were captured in the period 27 September–1 October, and 1 ♀ 8–13 October. The distribution is Europe. This is most probably the first record of *L. stigmatica* in Norway for 123 years. In the year 1848, Francis Walker in 'List of the specimens of Dipterous Insects in the collection of the British Museum London' described 6 nov. spec. from northern Norway. Among the species described was

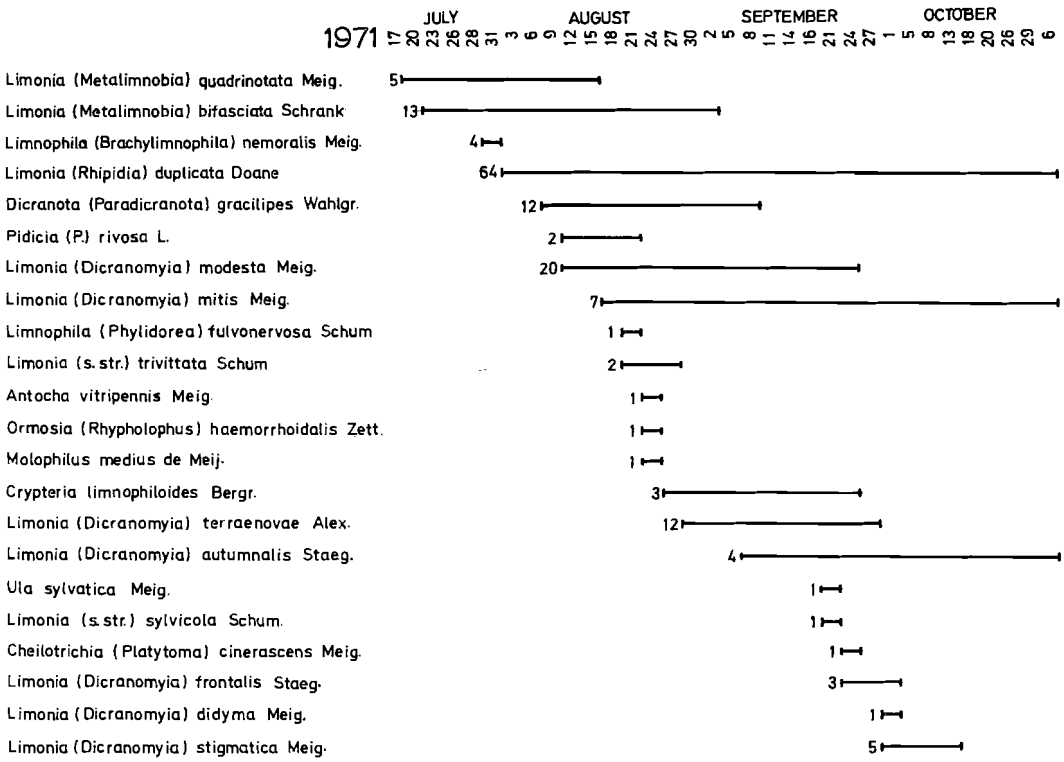

Fig. 1. Flight periods of Limoniinae species according to captures in two light traps, which were operating at Målsjöen, Klæbu, Sör-Tröndelag, Norway. The traps were emptied at the dates given. The figures give the total number of trapped specimens.

Limnobia reperta n. sp., which Lachschewitz (1935) identified as *Limonia (Dicranomyia) stigmatica* Meigen. As far as we know, there has been no record, until the present captures, of this species in Norway since 1848.

DISCUSSION

Concerning the flight periods presented in Fig. 1, the present collection is too small for definite conclusions, but some reflections may be made.

Tjeder (1958, 1959) deals with the Swedish Limoniinae and gives data about the flight period of nearly all specimens mentioned. In general, the flight periods found in the present study are somewhat delayed compared with the data given by Tjeder (1958, 1959), which is to be expected, since Tjeder also refers to southern Sweden. As for *Limonia (D.) mitis*, Tjeder (1958) states the flight period to be May, June, and July, while our captures in the area of the lake Målsjöen were from medio August to primo November.

Considering this is a complete summer capture and that a fairly small number of specimens were captured, Fig. 2 may perhaps give some explanation of the difference. The temperature curve shows fairly low temperatures in the summer, and especially in the autumn, and during the period as a whole there was a great deal of rain and wind. Comparing the temperature curve and that of the number of species and specimens each time the traps were emptied, we see that there is a fairly good correlation between the number of species and

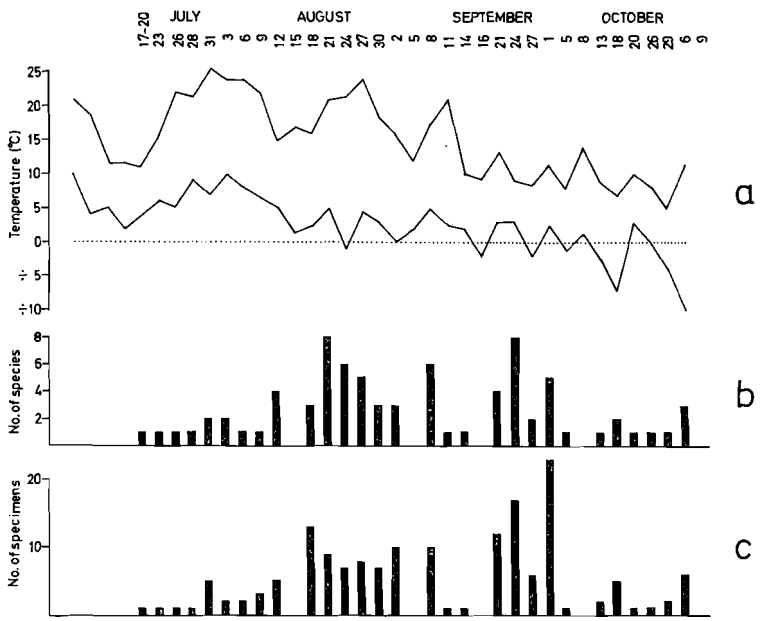

Fig. 2. A. Maximum and minimum air temperature at the trapping site in the collecting period. B. Number of species every time the traps were emptied. C. Number of specimens every time the traps were emptied.

specimens captured and sudden decreases in the air temperature in August and early September. Great drops in air temperature were due to bad weather and often resulted in no captures of Limoniinae.

The greatest number of species and specimens occurred in August and September (Fig. 3). In these two months, 14 species were captured, while only 3 species were taken in July and 4 in October. This indicated that most of the Limoniinae species occur in August and September, but we must remember that light trap material cannot give a complete picture of the flying insects at the trap location, since some species of the Limoniinae, for example, are not attracted by the light. An additional collection by nets in the trap area would give a more complete survey of the abundance.

APPENDIX

One of us (H. Mendl) made some collections of Limoniinae in Norway in 1970, and as a contribution to the knowledge of the Limoniinae fauna, the following records are mentioned. District abbreviations are according to Strand (1943).

Limoniini

Limonia (Dicranomyia) handlirschi Lackschewitz, Ö. Moss 2 June 1970 1 ♂, new to Norway. The distribution elsewhere is central Europe and Sweden.

Pediciini

Dicranota (s.str.) guerini Zetterstedt. Fn. Vadsö 21 August 1970 1 ♂. Distribution: central and northern Europe.

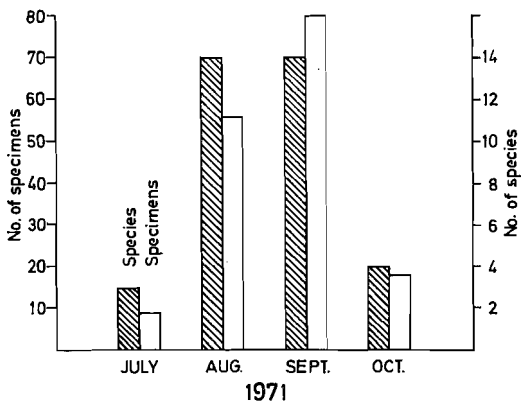

Fig. 3. The total number of species and specimens captured every month.

Dicranota (Paradicranota) gracilipes Wahlgren. Fn. Vadsö 21 August 1970 5 ♂♂ 6 ♀♀.

Dicranota (Paradicranota) subtilis Loew. STi. Soknedal 2 September 1970 1 ♂. Distribution: central and northern Europe.

Eriopterini

Cheilotrichia (Platyoma) cinerascens Meigen. STi. Soknedal 2 September 1970 6 ♂♂ 2 ♀♀; Ö. Moss 2 September 1970 8 ♂♂ 6 ♀♀.

Erioptera (s. str.) diuturna Walker. Fn. Vadsö 21 August 16 ♂♂ 17 ♀♀. Distribution: Central Italy (1971 leg. Mendl), Spain, Great Britain and North Europe.

Ormosia (Rhypholophus) haemorrhoidalis Zetterstedt. STi. Soknedal 2 September 1970 2 ♂♂.

After Lackschewitz (1933, 1935), Tjeder (1955, 1965), and the present paper, a total of 113 species of Limoniinae are now recorded in Norway. Since 1955, 65 species have been confirmed or published new to the fauna. When we know that 209 species are recorded in Sweden, we must expect more species to be found in Norway, when more intensive collecting has been carried out.

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The Larva of *Agraylea cognatella* McLachlan (Trichoptera, Hydroptilidae)

JOHN O. SOLEM

Solem, J. O. 1972. The Larva of *Agraylea cognatella* McLachlan (Trichoptera. Hydroptilidae). *Norsk ent. Tidsskr. 19*, 77–79.

The larva of *Agraylea cognatella* McLachlan is described, and a key to the larvae of the gen. *Agraylea* is provided. *Agraylea sexmaculata* Curtis is reported new to Norway.

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Three species of the gen. *Agraylea*, *A. multipunctata* Curtis, *A. sexmaculata* Curtis, and *A. cognatella* McLachlan, are known to belong to the European fauna. The larvae of *A. multipunctata* and *A. sexmaculata* are described in detail in several papers (Nielsen 1948, Lepneva 1964, Hickin 1967, and Barnard 1971), while the larva of *A. cognatella*, as far as I know, is not described earlier.

In collections of Trichoptera from mountain areas of Tröndelag, larvae of *A. cognatella* were found and are described below. As the larva of *A. cognatella* very much resembles *A. multipunctata* and *A. sexmaculata*, the present description will mainly deal with the differences between the larvae.

The material from which the following description is made consists of one larva collected in Röyrvik, Nord-Tröndelag; 3 larvae and 2 pupal cases in which the ecdysed cuticle of the 5th instar larva was left, collected in Oppdal, Sör-Tröndelag; and one prepupa collected in Sör-Varanger, Finnmark.

In an attempt to study all known *Agraylea* material from Norway, I examined the collection of the Entomological Department, Zoological Museum, Oslo, consisting of seven pupae and one prepupa, taken from lake Borrevann, Borre, Vestfold by Jan Ökland. I found that these specimens belonged to *A. sexmaculata*. *A. sexmaculata* is not earlier reported from Norway. The determination was made on the ecdysed cuticle of the 5th instar larva left in the pupal cases. On these fragments, the characteristic larval features described by Lepneva (1964) and Barnhard (1971) were clearly seen.

DESCRIPTION OF THE LARVA OF *AGRAYLEA COGNATELLA*

The larvae described are about 5 mm in length. Head oblong (Fig. 1a) and the dorsal surface brown at the anterior part, pale yellow at the posterior. As in *A. multipunctata* and *A. sexmaculata*, the frontal sutures are not visible anteriorly and the gular sclerite cannot be distinguished. The ventral surface has a brown area at the posterior margin (Fig. 1b) and is elsewhere pale yellow. Antennae are situated near the base of the mandibles. The assymetrical mandibles are drawn in Fig. 1 c, d, and no brush of chetoids is situated on the left mandible as in *A. multipunctata* and *A. sexmaculata*. Labrum (Fig. 1e) is short and broad and almost resembles that of *A. multipunctata* and *A. sexmaculata*.

Prothorax is about equally as broad as the head. Pronotum is brown with a light area on the anterior part (Fig. 1f). The posterior and lateral margins are dark brown to black, which *A. cognatella* has in common with *A. sexmaculata*, but they are lacking in *A. multipunctata*. The anterior margin is brown. In *A.*

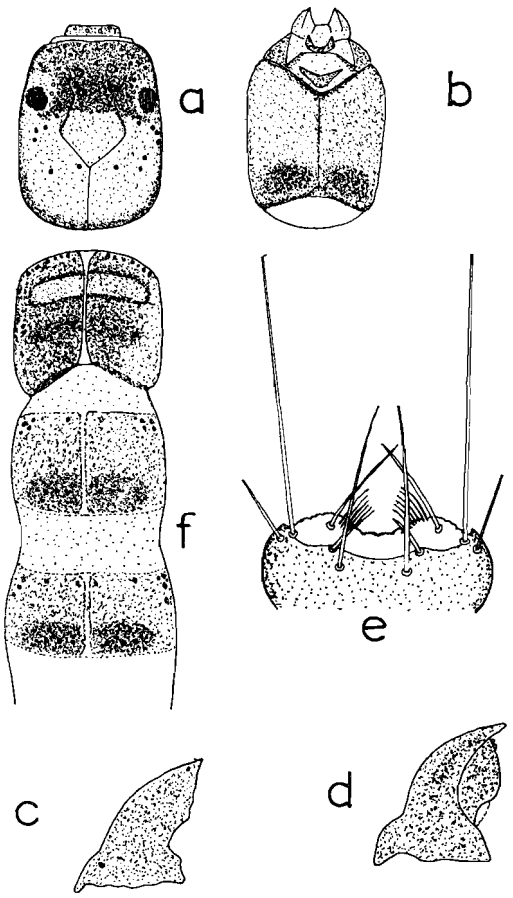

Fig. 1. *Agraylea cognatella* McLachlan. a. Dorsal surface of head. b. Ventral surface of head. c. Right mandible. d. Left mandible. e. Labrum. f. Pro-, meso-, and meta-thorax. The position of the setae on head and thorax is indicated by black dots.

multipunctata, pronotum is pale yellow, and so also is that of *A. sexmaculata,* but *A. sexmaculata* has characteristic dark brown spots (Figs. 4 and 5). Meso- and metathorax are a little broader than head and prothorax. Although only a small number of larvae have been examined, the colour of meso- and metanotum has been found to vary greatly, from pale yellow with brown patches on the posterior region (Fig. 1f) to more or less the same as pronotum.

The legs resemble that of *A. multipunctata* and *A. sexmaculata,* and so does the dorsal sclerite of segment 9 (Fig. 2). There are no gills on the abdominal segments. No lateral line is present, but as in *A. sexmaculata,* each abdominal segment bears four setae on each side.

The case of the full-grown larva is drawn in Fig. 3. It is about 6–7 mm long and 1.5 mm broad. The case is constructed of filamentous algae and very much resembles that of *A. multipunctata* and *A. sexmaculata,* but slight differences seem to occur. The case of *A. cognatella* is rounded at the ends but the ends are more elongated than that of *A. multipunctata.*

NOTES ON HABITAT

In lake Dalsvann, Oppdal, Sör-Tröndelag, larvae of *A. cognatella* were found to the depth of 7–8 m. Pupal cases were found to the depth

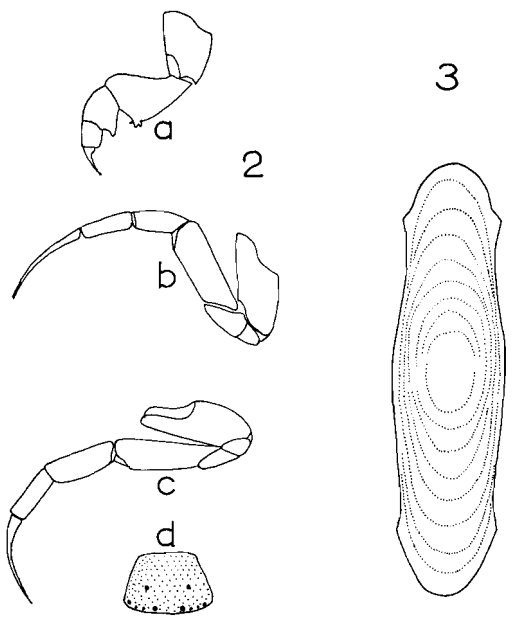

Fig. 2. Legs (a, b, c) and dorsal sclerite of segment 9 (d) of *Agraylea cognatella* McLachlan. a. Pro-, b. Meso-, and c. Meta-thoracic leg.

Fig. 3. The larval case of *Agraylea cognatella* McLachlan.

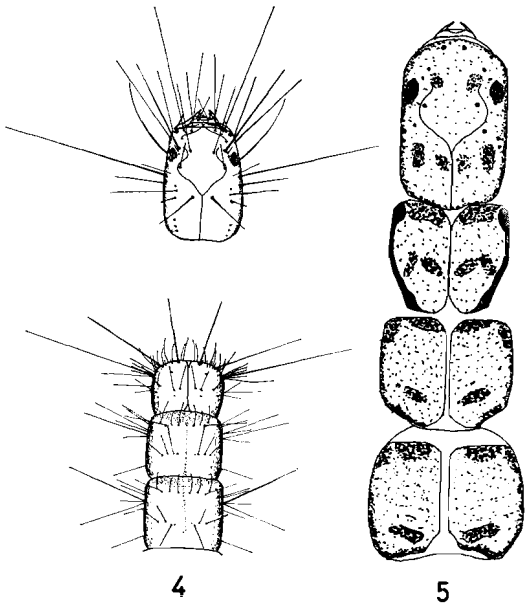

Fig. 4. Dorsal side of head and thorax of *Agraylea multipunctata* Curtis (after Nielsen 1948).

Fig. 5. Dorsal side of head and thorax of *Agraylea sexmaculata* Curtis (after Barnard 1971).

of 6 m. The lake is oligotrophic and has a rich submersed vegetation of *Isoetes* sp. and *Sphagnum* spp. *Sphagnum* spp. penetrates down to the depth of about 7 m.

A KEY TO THE FULL-GROWN LARVAE OF *AGRAYLEA*

The following key is partly quoted from Lepneva (1964):

1 (2) Head yellow; two small dark spots, which are sometimes absent, between the eyes in the curvature of the frontal sutures (Fig. 4). Light spots in posterior part of head indistinct. Ventral surface of head pale yellow. Dorsal sclerites of thorax without dark spots; mesonotum darker posteriorly than anteriorly; metanotum sometimes almost completely dark, except at the anterior margin. Left mandible with a brush of setoids... ..... *Agraylea multipunctata* Curtis

2 (3) Posterior part of dorsal surface of head (sometimes the whole frontoclypeus) greyish brown; a dark, small, spot in the curvature of the frontal sutures; a row of four dark spots near the bifurcation of the epicranial suture (Fig. 5); ventral surface of head pale yellow; pronotum with three dark spots; mesonotum and meta-notum with one dark spot. Left mandible with a brush of setoids... *Agraylea sexmaculata* Curtis

3 (2) Posterior part of the dorsal surface of head, yellow, anterior part brown (Fig. 1a). Ventral surface brown on the posterior part (Fig. 1b). Pronotum brown with a lighter area on the anterior region. Meso- and metanotum, each with one brown patch on the posterior region, or more or less like pronotum. Left mandible without a brush of setoids... *Agraylea sexmaculata* Curtis

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Oviposition and Larval Development of *Hylemya floralis* (Fallén) (Dipt., Anthomyiidae) on Varieties of Swedes and Turnips

TRYGVE RYGG & LAURITZ SÖMME

Rygg, T. & Sömme, L. 1972. Oviposition and Larval Development of *Hylemya floralis* (Fallén) (Dipt., Anthomyiidae). *Norsk ent. Tidsskr. 19*, 81–90.

In order to find possible sources of plant resistance, oviposition and larval development of *H. floralis* on different varieties of swedes and turnips were studied in the field and laboratory. In the field, a clear oviposition preference for swede varieties compared to turnip varieties was observed. Within swedes and turnips there were significant differences between varieties, and even between selections of varieties. Significant differences also occurred in the number of larvae developed in the roots compared to the number of eggs laid near the base of the same plants. In the laboratory, oviposition preference for swedes in *H. floralis* was influenced by plant age. The development of larvae was equally successful in slices of turnip and swede roots. Larval perception of the roots was influenced by chemical stimuli, and the peel contained more attractive substances than the inner tissue. Allyl-isothiocyanate acted as an attractant, while phenylethyl-isothiocyanate had a repellent effect.

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The cabbage root flies *Hylemya brassicae* (Bouché) and *H. floralis* (Fallén) are serious pests on cruciferous plants. Both species occur throughout the country, but *H. floralis* is normally the more abundant species and responsible for most of the damage done to swedes and turnips (Rygg 1962, Sundby & Taksdal 1969). In spite of the numerous experiments carried out during the last two decades on chemical control of the cabbage root flies in these crops (Lein 1955, Jörgensen 1957, Rygg 1962, Taksdal 1963), complete control has never been achieved. Field experiments have also demonstrated that the efficiency of chemical treatment is lower when infestation is high (Nordby & Rygg 1968). Other methods of lowering infestation could be of importance in combination with chemical control. One possibility is the selection of resistant varieties, and a search for sources of resistance may provide a background for further work in this direction. It therefore seemed valuable to investigate possible differences in susceptibility between varieties of swedes and turnips. For this purpose field investigations were carried out during the years 1967–71.

The difference in attack on turnips and swedes demonstrated in the present field study may depend on differences in oviposition stimuli offered by the plants. Oviposition preference in *H. floralis* offered artificial plants has been reported in a separate paper (Sömme & Rygg 1972), while the present study included laboratory experiments with turnips and swedes. Some factors regarding larval ability of penetration and development in the roots were also studied in the laboratory.

FIELD INVESTIGATIONS

Material and Methods

Field investigations were carried out during the years 1967–70 at two locations. At Jelöy, 60 km south of Oslo on the east side of the

Table I. Number of eggs per plant at different sampling dates. Jelöy 1967–1968

Variety	19 July $\bar{x} \pm$ SE	2 Aug. $\bar{x} \pm$ SE	3 Sept. $\bar{x} \pm$ SE
Wilh.burg.	22.6 ± 3.4	46.1 ± 4.3	12.0 ± 2.9
Bangh. V.Ö.	33.5 ± 3.6	55.7 ± 5.5	19.3 ± 3.0
Bangh. Gok.	33.2 ± 4.1	52.4 ± 4.6	16.3 ± 2.8
Gry	29.8 ± 3.7	37.4 ± 3.9	23.3 ± 3.5
Göta	23.3 ± 2.9	24.5 ± 2.7	21.0 ± 2.9
Kvit Mai	5.4 ± 1.8	17.4 ± 2.2	1.6 ± 0.9
Foll	4.6 ± 1.4	9.0 ± 1.9	2.5 ± 1.1
Yellow T.	1.5 ± 1.1	3.5 ± 1.3	0.8 ± 0.4

fjord, and at Hvam, 50 km north of Oslo. The soil at Jelöy was a moreen sand, at Hvam of a silty type, approaching fine sand. At both localities the organic matter content was about 2.5 per cent. In the first two years observations were carried out at both sites, in the last two years at Jelöy only. The following varieties were included in the studies.

Swede varieties: Wilhelmsburger Trifolium Elite No. 4, Bangholm Vilby Ötofte S 62, Bangholm Gokstad, Gry, Göta Ledaal.

Turnip varieties: Kvit Mai (Root shape: Flat-oval), Foll (Root shape: Round), Yellow Tankard Roskilde (Root shape: Long, cylindrical).

Additionally, a number of selections of the varieties Bangholm Gokstad, Gry, and Foll were compared.

Seeds for the experiments were obtained from the Farm Crops Institue, The Agricultural College of Norway, and seeds from the same units were used throughout the investigation period. Details about the varieties are given by Svads (1969, 1970).

The experiments were laid out in a randomized block design, replicated two times. The plot size was 2 rows of 12 m. Dates of drilling varied between 5 and 15 May. In June the plants were thinned out to approximately 23 cm, leaving a total of 100 plants per plot. No insecticides were used in the fields.

Egg sampling was done by 'scimming' the soil around the roots with a glass tube 20 × 100 mm. This procedure was carried out carefully to avoid eggs escaping the samples. From each plot, eggs were sampled from five randomly chosen plants in each of the two rows. Plants used for egg samples were individually marked, and at harvest the number of larvae in the roots and pupae in the surrounding soil were counted. In 1967 and 1968 egg samples were collected three times – at the peak, at the end of the oviposition period, and at harvest. The last two years eggs were sampled only once at the end of the oviposition period.

Beside *H. floralis* other species occurred, but as *H. floralis* was numerically very dominant, the investigations should be considered as a study on this species.

Results

Eggs were collected at the same dates in 1967 and 1968, and the average numbers per plant are shown in Table I. Most eggs were found on the second sampling date. The increase in egg numbers from 18 July until 2 August makes it reasonable to consider egg losses before the second sampling to be negligible. The comparatively smaller standard deviations at the second sampling date support this consideration. Obviously, however, by the beginning of September, many eggs were lost or washed away, so they escaped sampling.

Concerning egg hatching, there were no further increases in the percentage from 2 August to 3 September (Table II), which means that nearly all the eggs that were going to hatch had done so before the second sampling date. Egg sampling at the beginning of August

Table II. Percentage of eggs hatched at different sampling dates. Jelöy 1967

Variety	18 July	2 Aug.	3 Sept.
Wilh.burg.	47	83	76
Bangh. V.Ö.	39	76	72
Bangh. Gok.	26	72	77
Gry	33	66	79
Göta	45	81	67
Kvit Mai	24	63	68
Foll	37	59	71
Yellow T	29	67	61
Mean	35.0	70.9	71.4

Table III. Species composition of pupae in samples from Jelöy 1967 and 1968. Figures as percentages

Species	1967		1968	
	Bangh. V.Ö.	Wilh.burg.	Bangh. V.Ö.	Wilh.burg.
H. floralis	83.5	90.5	93.5	97.5
H.brassicae	9.5	3.5	2.0	11.5
Others	7.0	6.0	4.5	9.0

should therefore not influence the larval infestation, and the number of larvae developed in the root can be related to the number of eggs collected at the beginning of August. The ratio larvae/eggs (× 100) thus expresses the percentage of survival.

From samples of pupae collected at Jelöy 1967 and 1968 200 specimens were chosen at random, and identified to species. As shown in Table III, *H. floralis* was numerically very dominant.

Table IV shows the number of eggs collected at Jelöy at the beginning of August on the different swede and turnip varieties. In 1968 infestation was about twice as high as in the other years. Comparing the five swede varieties as one group against the three turnip varieties as another group, the difference is significant at the $P < 0.01$ level. Significant differences also occurred between varieties within swedes and turnips. Yellow Tankard constantly had fewest eggs, followed by Foll and Kvit Mai. Among the swede varieties, less eggs were found on Göta than on any of the others, whereas most eggs were found on the two Bangholm varieties.

The resulting larval infestation of the roots exhibits the same pattern as that of the eggs (Table V). Again there is a highly significant difference ($P < 0.01$) between swede and turnip varieties, with Yellow Tankard and Göta being the least attacked varieties within the respective

Table IV. Average number of eggs per plant collected on swede and turnip varieties. Jelöy 1967–70

Variety	2 Aug. 1967	2 Aug. 1968	6 Aug. 1970	6 Aug. 1970	Mean
Wilh.burg.	34.6	57.5	21.4	29.2	35.7
Bangh. V.Ö.	23.2	88.3	48.5	27.2	44.3
Bangh. Gok.	26.6	77.9	37.5	28.3	42.5
Gry	32.8	42.0	24.2	25.1	31.0
Göta	17.2	31.7	20.8	11.3	20.2
Kvit Mai	14.9	19.9	17.3	5.9	14.5
Foll	13.2	4.8	7.2	9.4	8.7
Yellow T.	4.7	2.3	10.1	5.2	5.6
Mean	20.9	40.5	23.4	17.7	25.4

Source of variation	DF	MS	Significance
Years	3		
Varieties	7	504.8	$P < 0.01$
Between plant groups[1]	1	2091.0	$P < 0.01$
Within plant groups	6	105.5	$P < 0.01$
Residual	21	56.1	

1 The variance for varieties split in variance between swede and turnip varieties (plant groups) and residual, e.g. varieties within the groups.

Table V. Average number of larvae and pupae collected per root of swede and turnip varieties. Jelöy 1967–70

Variety	1967	1968	1969	1970	Mean
Wilh.burg.	17.8	40.8	14.1	20.3	23.2
Bangh. V.Ö.	21.6	77.9	29.1	18.0	36.6
Bangh. Gok.	15.7	57.3	7.2	18.5	23.2
Gry	17.3	36.2	13.2	15.5	20.5
Göta	13.9	23.7	7.2	9.4	13.3
Kvit Mai	3.4	8.6	1.2	4.8	4.5
Foll	2.4	3.9	1.4	9.0	4.2
Yellow T.	1.1	0.4	0.5	2.8	1.2
Mean	11.6	30.4	9.2	12.2	15.9

Source of variation	DF	MS	Significance
Years	3		
Varieties	7	611.7	$P < 0.01$
Between plant groups[1]	1	3524.2	$P < 0.01$
Within plant groups	6	126.0	$P < 0.01$
Residual	21	139.9	

[1]See Table IV.

groups. The ratio larvae/eggs, which expresses the survival rate (Table VI), was poorest for Yellow Tankard and highest for Bangholm Vilby Ötofte.

Results from Hvam are shown in Table VII. Also at this location the same highly significant difference between swede and turnip varieties occurred. Again Yellow Tankard had less eggs and larvae than Foll and Kvit Mai. The variety Göta was not included here, and among the other swede varieties there were only insignificant differences. The ratio larvae/eggs was lower at Hvam than at Jelöy, and poorest for Yellow Tankard.

Table VIII gives the numbers of eggs and larvae from selections of the swede varieties Bangholm Gokstad and Gry. Selections 733/68 and 736/68 of Bangholm Gokstad both years contained less larvae than the others, although they were just as heavily infested with eggs. With the Gry selections no significant differences occurred.

Among the selections of Foll (Table IX), numbers one and two were significantly more

Table VI. Ratio larvae/eggs on swede and turnip varieties. Jelöy 1967–71

	Ratio larvae eggs (× 100)				
Variety	1967	1968	1969	1970	Mean
Wilh.burg.	51.4	71.1	65.8	69.5	64.4
Bangh. V.Ö.	92.3	87.5	60.0	66.2	76.5
Bangh. Gok.	59.0	73.5	19.2	65.3	53.7
Gry	52.7	86.1	54.5	61.7	63.7
Göta	80.8	74.7	34.7	74.3	44.1
Kvit Mai	22.8	43.2	6.9	81.3	38.5
Foll	18.1	81.2	19.4	95.7	53.6
Yellow T.	23.4	17.3	5.0	50.0	23.9
LSD 5%					7.5

Table VII. Average numbers of eggs and larvae per plant on swede and turnip varieties at Hvam 1967–1968

Variety	Numbers of eggs	Numbers of larvae[1]	Ratio larvae/eggs (× 100)
Wilh.burg.	25.5	10.7	55.3
Bangh. V.Ö.	28.0	11.6	42.8
Bangh. Gok.	24.6	7.1	37.0
Gry	35.4	9.5	29.7
Kvit Mai	11.2	2.0	28.8
Foll	13.2	0.7	13.2
Yellow T.	4.3	0.1	1.3
LSD 5%	6.4	4.5	11.7

[1] Counted as larvae and pupae.

infested with eggs and larvae than the other selections.

Outdoor cage experiment

An outdoor cage experiment was carried out to test the survival rate (larva egg ratio) on three varieties of swedes and three varieties of turnips.

Plants were raised in pots in a greenhouse and transplanted into field cages on 5 July when the plants were about 20 cm high and with root diameters of approximately 15 mm. The plants were set in rows 30 cm apart and with 25 cm between the plants in the rows. The experiment had three replicates (cages), each replicate consisting of 12 plants from each of the six varieties. Within the cages four plants of each variety were randomly distributed in each of the three rows. The cages consisted of a wooden frame at the ground with iron rods attached to the frame making a skeleton for a terylene sheet cover. During the days of 20–25 July, 50 eggs of *H. floralis* obtained from a laboratory culture were placed in the soil around each plant. The plants were then left undisturbed until harvest on 15 September, when the number of larvae in the roots and pupae in the soil were counted (Table X). Percent survival was very low in this experiment. Poor hatching or predation may have caused much of the loss, but these factors should be expected to be of the same magnitude in all varieties. However, the severity of larval attack of the varieties follows the same pattern as that observed in the field trials, indicating a variety-dependent factor counting for the differences in attack.

Table VIII. Average numbers of eggs and larvae per plant on selections of the swede varieties Bangholm Gokstad and Gry

Selection No.	1969 Egg	1969 Larvae	1970 Egg	1970 Larvae[1]	Mean Egg	Mean Larvae[1]
Bangh. Gok.						
731/68	29.4	13.5	49.3	22.9	34.4	18.2
732/68	27.2	20.7	22.6	10.4	24.9	15.6
733/68	37.1	8.6	24.0	5.2	30.2	6.9
734/68	41.4	14.9	30.1	13.1	35.8	14.9
735/68	33.4	10.9	38.1	9.3	35.8	10.1
736/68	53.3	5.1	24.3	8.5	38.8	6.8
LSD 5%					8.7	3.3
Gry						
737/68	39.5	8.4	32.7	8.6	36.1	8.5
738/68	39.5	12.4	22.0	8.3	30.8	10.4
739/68	32.4	14.7	16.2	13.3	24.3	18.5
740/68	27.6	13.5	32.8	12.7	30.2	13.1
LSD 5%					7.8	5.8

[1] Counted as larvae and pupae

Table IX. Average number of eggs and larvae per plant from selections of the turnip variety Foll

Selection No.	1969		1970		Average	
	Egg	Larvae[1]	Egg	Larvae[1]	Egg	Larvae[1]
1/68	21.5	7.4	13.8	2.4	17.7	4.9
2/68	21.2	6.7	16.3	1.2	18.8	4.0
3/68	15.4	4.6	6.1	0.3	10.8	2.5
4/68	16.1	2.3	7.4	2.9	11.8	2.6
5/68	15.3	1.3	4.6	1.3	10.0	1.3
6/68	15.0	1.3	2.5	0.8	8.8	1.1
7/68	13.1	2.4	4.3	0.5	8.7	1.5
LSD 5%					4.1	1.2

[1] Counted as larvae and pupae

LABORATORY EXPERIMENTS

Methods

Rearing of flies is described by Sömme & Rygg (1972). Oviposition preference was tested in cages (50 × 32 × 39 cm) containing 50 or 100 flies. The cages were kept at 22° ± 1 °C, 70 % RH, and 16 hrs photoperiod. Since they showed greatest differences in the field, the Bangholm Vilby Ötofte variety of swedes and the Yellow Tankard variety of turnip were chosen for the laboratory experiments.

In two series of experiments, the flies were supplied with 1.5 cm thick slices of roots placed in moist sand in 9 cm Petri dishes. Two slices of Bangholm and two slices of Yellow Tankard were placed in each cage, containing 50 flies in one series, and 100 flies in a second series.

Oviposition on plants of different age were studied in three different series with 50 flies in each cage. In the first series, plants, approximately one month old, were grown in 10 cm flower pots. The second series had plants of two months, and the third series plants of three months, grown in 13 cm flower pots. A layer of moist sand was placed on top of the soil in all pots. The eggs could easily be extracted from the sand by flotation in water. Each series consisted of 10 to 20 replicates. Number of eggs deposited on slices of roots or on plants were counted each day.

Table X. Number of larvae developed on plants artificially infested with 50 eggs per plant

Variety	Mean No. of larvae per replicate	Ratio larvae/eggs (× 100)
Wilh.burg.	29.0	4.8
Bangh. V.Ö.	37.3	6.2
Gry	19.3	3.2
Kvit Mai	8.0	1.3
Foll	6.0	1.0
Yellow T.	1.7	0.3
LSD 5%	10.6	1.1

Slices of roots from five varieties were used for studies of larval development. In one series of experiments 10–12 eggs one day old were placed on each slice, while in another series 20–25 newly hatched larvae were used. The slices were kept in moist sand at 20° ± 1°. The number of larvae present in each slice was counted about three weeks later, at a time when the larvae were ready to pupate.

Preference of newly hatched larvae for swedes or turnips were studied in experiments where the larvae were given the choise between one small cylinder of each variety. The cylinders were 3 cm high and 1 cm in diameter, and consisted of inner root tissue without peel. The cylinders were placed 2 cm apart in moist sand, and 6 larvae were placed in the sand in equal distance from each. Number of larvae found in each cylinder was counted after one week.

Extracts of peels from Bangholm and Yellow Tankard roots were made by grinding 100 g of tissues with 50 ml of water in a homogen-

izer. The extracts were filtered through a Böchner funnel. Root cylinders for larval preference tests were soaked in the extracts for 30 min before use. Treated cylinders were tested against cylinders soaked for the same time in water. The effects of phenylethyl- and allyl-isothuocyanates on larval behaviour were studied with cylinders treated with a 0.02 percent suspension of one of these substances in water.

Finally, an experiment was carried out to see how far newly hatched larvae could travel. One slice of Bangholm root was placed in a tray with moist sand, and 20 eggs buried in the sand from 0 to 18 cm from the slice. Number of larvae in the slices were counted after three weeks.

Results

The total number of eggs deposited in each cage varied from ten to several hundreds each day, and the results are expressed as percentages. The average percentage of eggs deposited on slices of roots, when the flies were given the choice between Bangholm and Yellow Tankard, is shown in Fig. 1. A significant preference for slices of Bangholm was found both with 50 and 100 flies in the cage. The

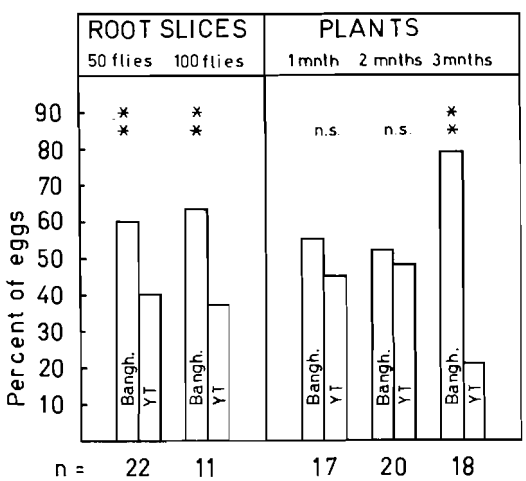

Fig. 1. Percentage of eggs deposited in preference tests with root slices of Bangholm and Yellow Tankard, or with plants of different age of the same varieties. **: $P < 0.01$, n.s.: difference not significant. n = number of replicates.

Table XI. Development of last instar larvae from eggs placed on slices of roots of turnips and swedes

Variety	No. of replicates	Percent development	t-test[1]
Bangh. V.Ö.	52	42	not sign.
Wilh.burg.	20	33	not sign.
Gry	18	49	not sign.
Foll	20	48	not sign.
Yellow T.	38	52	$P < 0.5$

[1] Compared to Bangholm V.Ö.

percentage of eggs deposited on plants of turnips and swedes changed with the age of the plants. No difference was found with plants one or two months old, but a preference for Bangholm was found when the plants were three months old (Fig. 1).

The percentage of eggs that hatched and developed to mature larvae on slices of roots varied with the variety (Table XI). Development was equally successful or higher in turnips than in swedes. When newly hatched larvae were placed on slices of Bangholm and Yellow Tankard, no difference in development was found (Table XII). After two weeks the average weight of larvae from Yellow Tankard was slightly higher than of those from Bangholm, but the difference was not significant. The percentage of last instar larvae developed was higher from newly hatched larvae than from eggs.

When newly hatched larvae were given the choice between two root tissue cylinders, more larvae were found on the Yellow Tankard and Foll varieties of turnip than on the Bangholm variety of swede (Fig. 2). Compared to cylin-

Table XII. Development of last instar larvae from newly hatched larvae placed on slices of roots of turnip and swede

Variety	No. of replicates	Percent development	Av. weight of larvae (mg)
Bangh. V.Ö.	6	60.4	15.7
Yellow T.	10	61.2	17.5

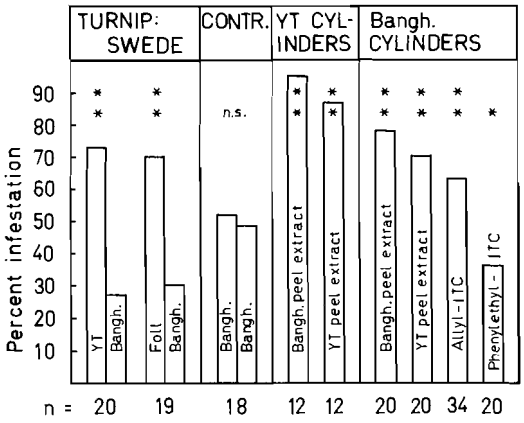

Fig. 2. Percent infestation of newly hatched larvae in root tissue cylinders of swedes and turnips, when the larvae were given the choice between two cylinders. For tests with peel extract or isothiocyanates (ITC), percentage infestation is shown for the treated cylinders only. *: $P < 0.05$, **: $P < 0.01$, n.s.: difference not significant. n = number of replicates.

ders soaked in water, cylinders treated with peel extract were highly attractive to the larvae (Fig. 2). About 95 percent of the larvae were found in Yellow Tankard cylinders treated with Bangholm peel extract, and almost 80 percent of the larvae in Yellow Tankard cylinders treated with Yellow Tankard peel extract. Bangholm cylinders treated with Bangholm or Yellow Tankard peel extracts attracted 70–80 percent of the larvae. From these experiments it appears that more attractive substances are present in the peel than in the inner root tissue.

The larvae also showed a preference for Bangholm cylinders treated with allyl-isothiocyanate, compared to untreated cylinders (Fig. 2). Phenylethyl-isothiocyanate, on the other hand, had a repellent effect.

The number of larvae infesting slices of Bangholm roots when eggs were placed at various distances, varied greatly in individual trials (Table XIII). The average number of larvae infesting the slices, however, decreased with increasing distance. The experiment showed that some larvae can travel at least 18 cm from the location where eggs are deposited.

DISCUSSION

Differences in susceptibility of swedes and turnips to attack by *H. floralis* and other root flies largely depends on oviposition preference and the ability of newly hatched larvae to become established in the root. The presence of such differences between various varieties of swedes and turnips indicates that selection of more resistant varieties may be possible.

Several authors have reported differences in susceptibility to oviposition by *H. brassicae* (Doane & Chapman 1962, Radcliffe & Chapman 1966, Mukerji 1969). The results of the present investigation clearly demonstrate oviposition preference by *H. floralis* in the field. Both physical and chemical factors may contribute to this preference, as discussed by Sömme & Rygg (1972). In agreement with the lower number of eggs found on turnips in the field, female *H. floralis* preferred root slices of Bangholm to Yellow Tankard for oviposition in the laboratory. For the oviposition on plants, the age of the plants appeared to be of importance. The difference may be due to changes in chemical and physical characteristics of the plant during growth, as has been shown in maize (Beck 1965).

Varietal differences in rutabaga regarding development of *H. brassicae* larvae have been found by Swailes (1959). In the present field investigation varietal differences in susceptibility to attack by *H. floralis*, expressed as the larva/egg ratio, are also evident. The lowest larval survival was observed with Yellow Tankard, although the laboratory experiments did

Table XIII. No. of last instar larvae developed from twenty eggs placed in moist sand at various distances from slices of swede

Distance in cm	No. of replicates	Av. No. of larvae per slice	Range
0	10	8.9	1–17
3	3	9.7	5–13
6	3	6.0	4–8
12	12	1.8	0–10
18	9	1.7	0–5

not indicate poorer nutritive value of the inner tissue of the root. The same conclusion was reached by Swailes (1960) regarding resistance to *H. brassicae* in the Wilhelmsburger variety.

In larval preference tests, root cylinders of turnips were actually more attractive than root cylinders of swedes. These and other results show that penetration of newly hatched larvae may be influenced by chemical stimuli, and that the peel contains more attractive substances than the inner tissue. Peel extract of both Yellow Tankard and Bangholm were highly attractive in the present experiments, but under natural conditions larval penetration of the roots may depend on how such substances are available to larval perception. Phenylethyl-isothiocyanate has been isolated from roots of cruciferous plants (Lichtenstein et al. 1962), and may act as a repellent. Other isothiocyanates, which are commonly found in cruciferous plants, may attract or repell the larvae. Depending on chemical composition, the peel could thus be more or less suitable for larval penetration. That resistance factors are situated in the root surface has been demonstrated by Swailes (1968), who studied penetration of *H. brassicae* larvae in different varieties of rutabaga.

As the young larvae normally enter a root near its lower tip, a long-shaped root means a longer distance to crawl before the larvae reach the site of penetration. Yaman (1960) found no increased mortality when eggs were placed 3 cm from cauliflower stalks, but in our laboratory experiment, distances of 6 cm or more reduced the numbers of larvae reaching swede slices. Thus root shape at least partly explains the poor survival rate on Yellow Tankard. A long-shaped turnip variety also showed the lowest infestation (Varis 1958) in Finnish field trials. In addition to root shape, cortex texture and other factors (Yaman 1960) influence larval penetration of the roots.

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Platycheirus monticolus nov. sp., a Northern Species Confused with *P. discimanus* Loew (Dipt., Syrphidae)

TORE RANDULFF NIELSEN

Nielsen. T. R. 1972. *Platycheirus monticolus* nov. sp., a Northern Species Confused with *P. discimanus* Loew (Dipt., Syrphidae). *Norsk ent. Tidsskr. 19,* 91–98.

Platycheirus monticolus nov. sp. is described on material from the Soviet Union. Finland. Sweden and Norway; it has previously been confused with *P. discimanus* Loew by some authors. European distribution and differing characters of the two species is discussed, and a comparison between *P. monticolus* nov. sp. and the allied Nearctic species *P. groenlandicus* Curr. is presented. A lectotype for *P. discimanus* is designated.

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Since Loew described *Platycheirus discimanus* in 1871, this species has been reported from different parts of the Holarctic region. It is known from several European countries. and its characteristic male front tarsus has been figured by various authors.

Interestingly, it has also been announced from subalpine and alpine regions in Sweden (Ringdahl 1936, 1939, 1951) and Finland (Kanervo 1931), and from northern Siberia (Becker et al. 1915, Lundström and Frey 1913. Kanervo 1938).

Recent Norwegian finds of *P. discimanus* from coastal areas (Bergen). together with finds of a related species from mountainous areas, indicate a possible mistake in the reports of *P. discimanus* from these northernmost parts of Europe. Examination of the material concerned (except male reported by Becker (1915), and by Kanervo (1938)). and also additional unpublished material from the area. has verified this suspicion and shown that *P. discimanus* is lacking in this material. and that most of the specimens belong to an allied. resembling species, *P. monticolus* nov. sp.

DESCRIPTION

Platycheirus monticolus nov.sp. belongs to the group with shining thorax. only slightly dilated tip of front tibiae, but much dilated front metatarsus in the males. It is a medium-sized, broad-headed and rather stout species, each of the sexes having dull, silvery-greyish spots on the tergites.

Male

Head. Somewhat broader than high. Eyes naked, touching for a distance about equal to length of vertical triangle. The angle at approximation of eyes 110–120°. Frons and face shining bluish to yellowish black, lightly whitish or yellowish dusted, but less so around central prominence and mouth-edge. Frons rather swollen, rather densely black-haired. Lunulae shining black. Central prominence protruding about as much as upper mouth-edge, face quite 'nosy'. It is mainly black-haired, but upper mouth-edge sometimes with some whitish hairs. Jowls and occiput lightly whitish-yellow dusted, the hairs mainly whitish-yellow, but jowls often with some blackish hairs, and upper ⅓ of occiput with some blackish bristles on each side of vertical triangle. Vertical triangle black-haired. Antennae black or brownish-black; 3rd joint slightly longer than deep. Arista blackish, not long, and thickened at base.

Thorax. Mesonotum shining bronzy-black, only very slightly yellowish dusted. The hairs erect and of same length; yellowish or

brownish-yellow medially on the disk, more dominantly blackish at the sides, the black hairs often with yellowish tips. Scutellum coloured as mesonotum, with blackish and yellowish hairs. Also pleurae bronzy black, but a little more yellowish dusted than mesonotum. The pubescence mainly black on meso- and pteropleurae, but more yellowish on sternopleurae. Legs mainly black. Apical ca. $^1/_7$ of f_1 and f_2, and extreme tip of f_3 yellow. t_1 more or less clearly yellow in entire length, but darkened laterally on apical $^2/_3$; t_2 obscurely yellowish on basal $^1/_3$–$^1/_2$; t_3 yellowish on basal ca. $^1/_5$–$^1/_3$, and sometime yellow at extreme tip. Tarsus$_2$ and tarsus$_3$ blackish; metatarsus$_3$ somewhat thickened. Tarsus$_1$ with the joints 1–3 (or at least 1, 2 and basal half of 3) yellow. The last two joints of tarsus$_1$ (and sometimes also apical half of third joint) greyish-brown. Metatarsus$_1$ broader than t_1 at tip, longish oval and straightly cut at tip. The following joint a little narrower than metarsus; roundish rectangular. Third, fourth and fifth joints considerably narrower than the first two. Legs with pubescence yellow and black. The hairs are long and black behind on f_1 and f_2, long and yellow on front side of f_3. There are longish, black hairs laterally on t_1 and t_2, and also a short row of longish, black hairs medially at apex of f_2. Pubescence otherwise mainly short, yellow or black. Tarsus$_1$ shortly yellow-haired, except metatarsus laterally with short, black hairs. Wings often somewhat smoky greyish-brown tinged, the veins dark greyish-brown on distal $^2/_3$ of wing, more greyish-yellow towards base. Stigma greyish-yellow. Squamulae light to dark greyish, fringe hairs yellowish. Halters greyish to greyish-black.

Abdomen. Mainly dullish black with three pairs of silvery greyish spots. Tergite 1 dullish black. Tergite 2–4 dull black on disk, but more metallic shining towards side-margins and tergite 4 also at hind margin. Tergite 2 with a pair of smallish, not always well limited, roundish spots lying laterally in the middle of the segment; the spots are well isolated from the side-margins. Tergite 3 and 4 each with a pair of well limited and widely separated, longish triangular to rectangular spots that do not reach the side-margins. Tergite 5 and genitalia shining metallic bluish or yellowish black. The pubescence is mainly whitish yellow, longish at the sides of tergites 1–2, and at base of tergite 3; otherwise short. Some short, black hairs may be seen medially on the tergites. Sternites shining metallic bluish to yellowish black; the hairs yellow.

Female

Head. Eyes naked. Frons at vertical triangle about as broad as width of an eye, widening downwards to about base of antennae and so giving a maximum width of frons larger than height of it. Below a shining black or metallic black area of frons, lying on each side of frons and narrowly in front of it, a faint dust-belt spread inwards from the eye-margins, following a shallow groove in the middle of frons. This dust-belt is whitish along eye-margins, but become more yellowish to yellowish brown in the middle. Lunulae and frons ahead of this belt, on each side of the antennae, undusted and shining black. Frontal hairs all brownish-black. Face below antennae with the sides almost parallel, in profile protruding rather a lot, and with central prominence rather 'nosy' and produced about as much as upper mouth-edge. It is lightly whitish or yellowish dusted, except on central prominence and mouth-edge; the hairs all whitish yellow apart from some black hairs at the level of antennae. Jowls and occiput somewhat dulled by whitish-yellow dusting, but occiput more shining on upper third; the hairs on both parts all whitish-yellow. Vertical triangle black-haired. Antennae brownish-black or black; 3rd joint only slightly longer than deep, but larger than in the male. Arista black, about as long as the antennae, and a little thickened at base.

Thorax. Mesonotum brightly shining metallic black, slightly whitish dusted at sides, in front of transeverse suture; otherwise undusted. Pubescence obliquely erect, shorter than in the male; whitish to whitish yellow. Also scutellum glittering metallic black; the hairs whitish. Pleurae evenly dulled by whitish dusting, pubescence whitish-yellow. Legs mainly as in

the male, but t_1 distinctly darkened on apical ⅔; tarsi brownisn-black on all joints. Pubescence more yellowish than in the male; black hairs restricted to upper side of tarsus$_3$. The hairs are mainly short, but they are long behind on f_1 and f_2 and on front side of f_3. Wings slightly greyish tinged, but never smoky as sometimes in the male. The veins greyish-brown on apical ⅔ of wing, more purely brownish towards base; stigma greyish yellow. Squamulae whitish to greyish-yellow, fringe hairs whitish-yellow. Halters light brown to greyish-brown, the knob usually darkened.

Abdomen. Tergites shining black, tergite 2–5 with greyish dust-spots, none of which quite reach the side-margins. Tergite 1 shining black, slightly dulled by faint whitish dusting. Tergite 2 with two more or less well defined, squarish or subrectangular spots lying towards base of tergite and occupying ½–⅔ of length of it. Tergite 3 and 4 with well separated, rectangular spots lying at base of the segments; tergite 5 with the spots longish triangular. The following segments quite black. The pubescence mainly follows the ground colours, short and black on the black parts of the tergites, otherwise mainly short and whitish yellow. The hairs are, however, long at the sides of tergite 1 and 2. Sternites shining, only very lightly whitish dusted; sternite 1–2 varying from deep yellow to dark brown, the following sternites brownish black. The pubescence is short and whitish yellow.

MATERIAL

The type material totals 186 specimens.
Norway. Holotype: Male specimen dated Ustetind, Bv: Hol, 3 July 1970, Tore Nielsen leg. Allotype: Female specimen dated same locality, 2 July 1970, Tore Nielsen leg.

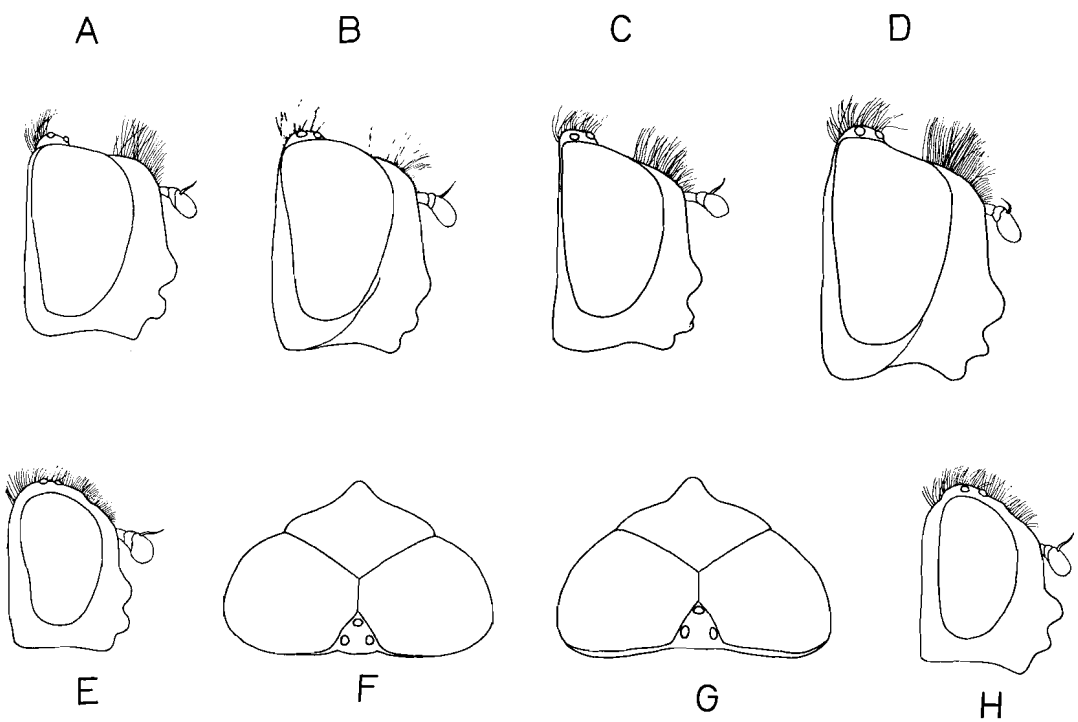

Fig. 1. A–E, H: heads in profile. A) *Platycheirus discimanus* Loew male, lectotype. B) Male (from Bergen). E) Female (from Bergen). C) *Platycheirus monticolus* nov.sp. male, holotype. D) Male, paratype. H) Female, allotype. F–G: heads seen from above. F) *P. discimanus* Loew. G) *P. monticolus* nov.sp.

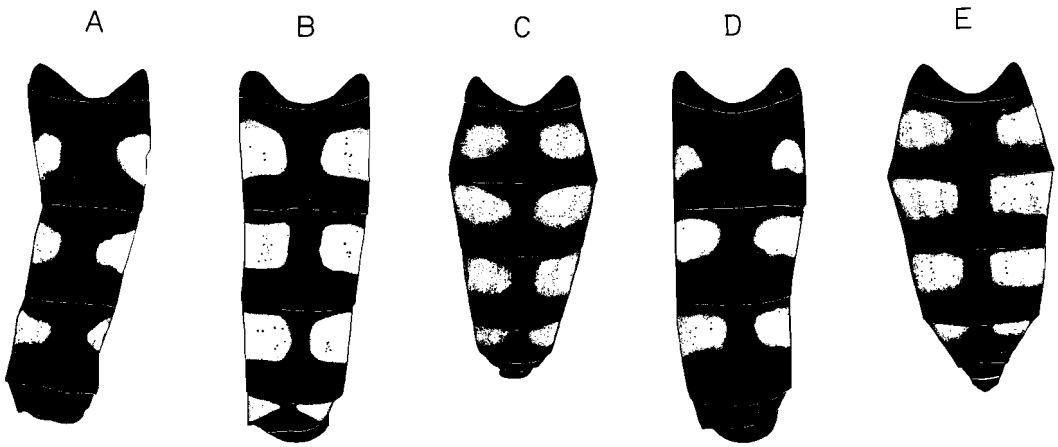

Fig. 2. Abdomens. A) *Platycheirus discimanus* Loew male, lectotype. B) Male (from Bergen). C) Female (from Bergen). D) *Platycheirus monticolus* nov.sp., male. E) Female.

Paratypes: Vedalen, 1000 m a.s.l., Bv: Hol, 27 June 1970 (1♀); v/Ustetind, 1250 m a.s.l., Bv: Hol 2 July 1970 (4♂♂, 23♀♀); 3 July 1970 (9♂♂, 16♀♀); 1 July 1971 (15♂♂, 24♀♀); Prestholtseter, 1240 m a.s.l., Bv: Hol, 3 July 1971 (2♂♂, 3♀♀); 4 July 1971 (3♂♂, 5♀♀); Lö-a, Haugastöl, 1100 m a.s.l., Bv: Hol, 21 Aug. 1967 (1♀), A. Löken leg.; Rjoto, ca. 1000 m a.s.l., H0i: Eidfjord, 20 July 1967 (6♀♀); 21 July 1967 (6♀♀); 21 July 1968 (1♂, 31♀♀ (2♀♀ Inger Nielsen leg.)); 22 July 1968 (9♀♀); 23 July 1968 (3♀♀); Hallaskard, 1150 m a.s.l., H0i: Ullensvang, 17 July 1968 (1♀); 18 July 1968 (1♀); Fljodal, 900 m a.s.l., H0i; Eidfjord, 24 July 1968 (3♀♀), Inger Nielsen leg.; Stavali-omr., 900–1000 m a.s.l., H0i: Kinsarvik, 25 July 1968 (1♀); 3 Aug. 1968 (1♀), A. Fjellberg et al. leg.; Vårstigen, 780 m a.s.l., STi: Oppdal, 20 July 1966 (1♀); Kongsvoll, 1000 m a.s.l., STi: Oppdal, 21 July 1966 (1♀), Elina Nielsen leg. Most of the paratypes above have been collected by the author.

Sweden. Paratypes: Ottfjäll, 900–1265 m a.s.l., Jämtland, 12 July 1935 (1♂), O. Ringdahl leg.; Undersåker, Jämtland, 23 July 1932 (1♂), O. Ringdahl leg.; Stordalen, Torneträsk Lappmark, 18 July 1957 (1♀), P. I. Persson leg.

Finland. Paratypes: Kilpisjärvi (1♀), A. Nordman leg.; mountain Malla, near Kilpisjärvi (1♀), A. Nordman leg.; Saana near Kilpisjärvi (1♀), R. Frey leg.

Soviet Union. Paratypes: Lapp., Petsamo, 8 July 1929 (1♀), Håkan Lindberg leg.; Fennia, Petsamo, Petsamontuturit (1♀), Erkki Kanervo leg.; Vaitolahti (= Vajda-Guba), nr. 737 (1♀), W. Hellén leg.; Kanin (5♂♂), B. Poppius leg.

Holotype, allotype and a number of paratypes are deposited in the collections of Zoological Museum, University of Bergen. Paratypes will also be deposited in the collections of the University Zoological Museum, Helsinki, in the Zoological Institute, Lund, and in my own collection.

COMPARISON WITH *P. DISCIMANUS* LOEW AND *P. GROENLANDICUS* CURR., AND DESIGNATION OF LECTOTYPE

The material of *Platycheirus monticolus* nov. sp. has been compared with both type specimens and ordinary material of *P. discimanus* Loew. The differing characters found are presented in Table I and Figs. 1–3.

Loew's series of syntypes consist of 7♂♂ and 1♀,

Table I. A comparison between the sexes of *Platycheirus monticolus* nov. sp. and *P. discimanus* Loew.

P. monticolus nov. sp. (Figs. 1C–D, G–H; 2D–E; 3C, E)	*P. discimanus* Loew (Figs. 1A–B, E–F; 2A–C; 3A–B, D)
♂	♂
Central prominence of face usually more protruding; face quite 'nosy'.	Central prominence of face usually less protruding; face less 'nosy'.
Head seen from above: sides of face sloping evenly towards edges of eyes.	Head seen from above: sides of face sloping quite steeply towards edges of eyes.
Front metatarsus more slender than in *discimanus:* all whitish yellow.	Front metatarsus very broad at tip; it is whitish yellow, often with a dark patch near apex, and laterally with some longish, strong, angular hairs.
Mid pair of legs with all tarsal joints dark.	Mid pair of legs with tarsal joints 1 and 2 brightly yellow: the following joints darkened.
Hind pair of legs with metatarsus quite slender.	Hind pair of legs with metatarsus distinctly swollen.
Squamulae greyish to greyish black.	Squamulae white.
Halters greyish brown.	Halters yellow.
Lateral hairs at base of tergite 2 about $2^1/_2$ × longer than hairs at base of tergite 4.	Lateral hairs of tergite 2 are 3–4 × longer than hairs at base of tergite 4.
The greyish abdominal spots somewhat darker, and proportionally smaller than in *discimanus:* the spots on tergite 2 often rather indeterminate in shape.	The greyish abdominal spots somewhat whiter, and proportionally larger than in *monticolus;* the spots on tergite 2 also more determinate in shape.
♀	♀
Central prominence of face usually more protruding; face quite 'nosy'.	Central prominence of face usually less protruding; face less 'nosy'.
Frons faintly greyish-yellow dusted. Frontal hairs all dark.	Frons shining black, not at all dusted. Frontal hairs dark on upper half, whitish-yellow on lower half.
Face somewhat dulled by light yellowish dusting, especially on upper half. This dusting is almost lacking on a transverse belt just above the antennae, thus leaving a shining black area between the dusted frons and upper face.	Face brightly shining, only very faintly dusted, also on upper half.
3rd antennal joint proportionally smaller than in *discimanus*.	3rd antennal joint proportionally larger than in in *monticolus*.
Squamulae greyish-white to greyish-brown, darkened at margin.	Squamulae white.
Halters darkened; greyish brown.	Halters yellow to yellowish brown.
Abdominal spots rather dull, greyish white. They are narrower than in *discimanus*, at the sides occupying about ½ length of the tergite.	Abdominal spots usually more shining, metallic grey. They are broader than in *monticolus*, at the sides occupying about ⅔ length of the tergite.

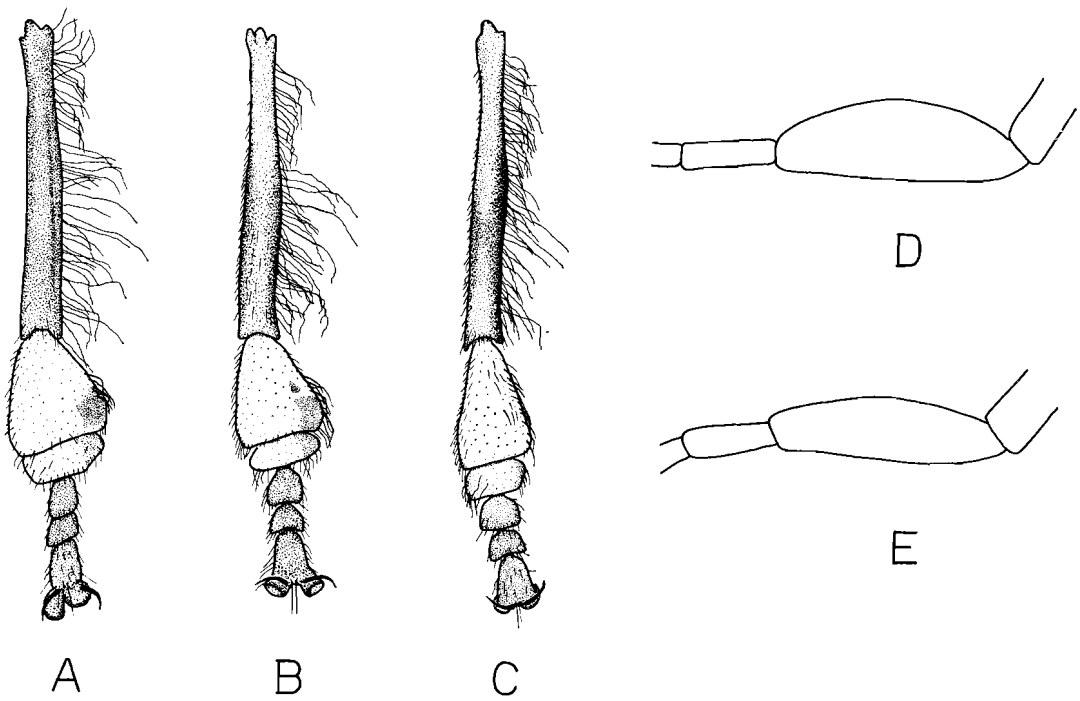

Fig. 3. A–C: male front tibiae and tarsi. A) *Platycheirus discimanus* Loew, lectotype. B) Do. (from Bergen). C) *Platycheirus monticolus* nov.sp. D-E: hind metatarsus. D) *P. discimanus* Loew. E) *P. monticolus* nov.sp.

and are deposited in the collections of Zoologisches Museum der Humbolt-Universität zu Berlin, 104 Berlin, DDR. I have designated as lectotype a male specimen labelled Bergün 5.6., Coll. H. Loew. The specimen is characteristic in holding its wings in a right-angled position, and with its abdomen slightly bent to the left. Abdomen and left front tarsus is figured in Figs. 2A and 3A, respectively.

Platycheirus monticolus nov.sp. also seems to be nearly related to the northern Nearctic *P. groenlandicus* Curran. I have made a comparison between the two species, based on 3♂♂ and 3♀♀ of the latter, in Table II.

ECOLOGY AND DISTRIBUTION

Little is known about the ecology of the two species. However, *P. discimanus* seems to be a true early spring species, with peak in numbers in April-May (my own finds are mainly from the beginning of May), which indicate activity in, and tolerance of lower temperatures. On the basis of the published finds, it also seems to be a predominant low-land species, not climbing to high altitudes.

Loew's discription was based on material from Böhmen in Central Germany (now western Czechoslovakia). I have examined further material from Czechoslovakia, and also specimens from Holland, Great Britain and southern Finland (1♀ from Helsinki). Séguy (1961) and Stackelberg (1970) figure material from France and the Soviet Union, respectively, and it has recently been found in Norway, as mentioned above. In all, it seems to have a rather wide European distribution.

P. monticolus nov.sp. seems, in contrast, to be a typical mountainous/arctic species with probable occurrence in most of the high mountain areas of Scandinavia and northern

Table II. A comparison between the sexes of *Platycheirus monticolus* nov. sp. and *P. groenlandicus* Curr.

P. monticolus nov. sp.	*P. groenlandicus* Curr.
♂	♂
Angle of frons at approximation of eyes 110–120°.	Angle of frons at approximation of eyes practically 100°.
Eyes touching for a distance equal to 1¼ the distance between front and lateral ocelli.	Eyes touching for a distance which is scarcely as long as the distance between front and lateral ocelli.
Groove of touching between eyes, between eyes and frons, and eyes and face shallow; these areas of head quite flat.	Groove of touching between eyes, between eyes and frons, and eyes and face distinctly deeper; these areas of head more variable in protrusion.
Lunulae shining black.	Lunulae dulled by whitish dusting.
Front metatarsus slimmer.	Front metatarsus broader, but not as broad as in *P. discimanus* Lw.
Spots on tergite 2–4 greyish white, and quite distinct.	Spots on tergite 3–4 dark greyish yellow, vague and indistinct; that on tergite 2 almost invisible.
♀	♀
Frons lightly dusted in young specimens, but always glittering black between eye and vertical triangle, and just in front of the latter.	All frons somewhat dulled by even, light dusting, also areas between eye and vertical triangle, and just in front of the latter.
3rd antennal joint more elongate, not as deep as long.	3rd antennal joint roundish, as deep as long.
Abdominal spots greyish white, much contrasting with the black ground colour.	Abdominal spots greyish yellow, vague and rather indeterminate in shape, and not much contrasting with the black ground colour.
Medium-sized species.	Small species.

Finland, and in the mountains and on the tundra of northern Siberia. For distribution, see Fig. 4.

In Norway and Sweden it has been observed at altitudes of 800–1260 m a.s.l., in subalpine forests and (in greatest numbers) in the alpine region. In the type locality (at Ustetind near Geilo), a partly humid *Carex-Salix-Betula nana* community at 1250 m a.s.l., the species was found rather commonly on different flowers in the beginning of July. In 1970 and 1971 no specimens were found at the end of June at these altitudes; the main hatching must have taken place during the beginning of the following month. The insects, many of which were still soft and not fully pigmented (1–3 July), sought after the remaining *Salix* catkins. Some days later they were also seen visiting the still more flowering *Ranunculus acris* L. and *Sedum rosea* (L.) Scop.

No exact ecological measurings were made, but it was obvious that the species was active at rather low temperatures. Even on rather cold days with wind and shifting weather, the insects could be seen in the flowers after a very short period of sunshine, and they were

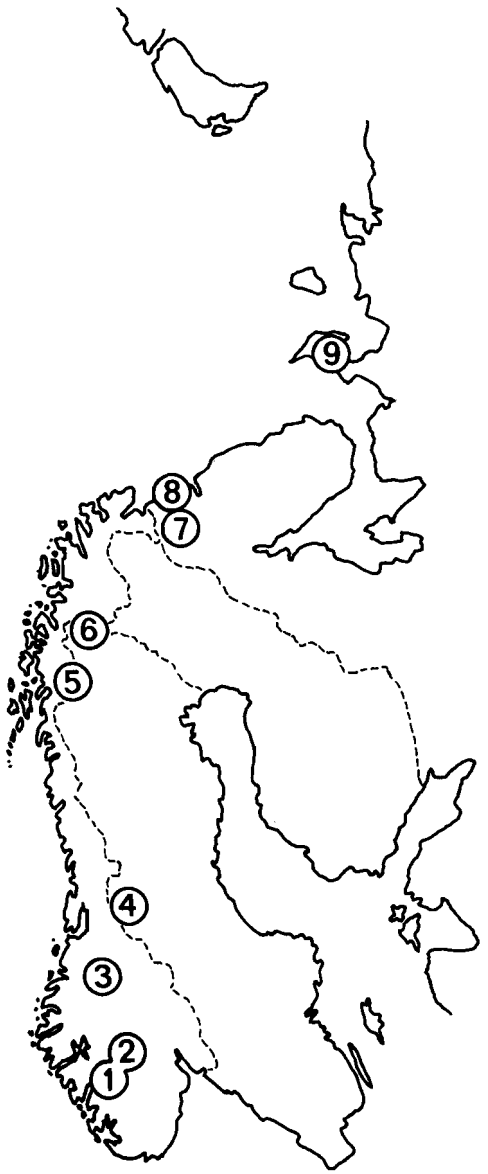

Fig. 4. Records of *Platycheirus monticolus* nov.sp. – 1) Stavali-omr., Fljodal, Rjoto and Hallaskard. 2) Ustetind (type locality), Prestholtseter, Vedalen (all in Geilo district) and Haugastöl. 3) Vårstigen and Kongsvoll. 4) Mountain Ottfjäll and Undersåker, Jämtland, Sweden. 5) Stordalen, Torneträsk Lappmark, Sweden. 6) Kilpisjärvi, Saana and mountain Malla, Finland. 7) Petsamo and Petsamontuturit, U.S.S.R. 8) Vaitolahti, U.S.S.R. 9) Kanin peninsula, U.S.S.R.

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still active in the flowers for a period when the weather got colder and more cloudy.

P. monticolus nov. sp. has been found in the period 27 June – 21 Aug.

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Contribution from the Norwegian IBP/PT – UM Sections, Stigstuv Group

Quantitative Invertebrate Studies in Mountain Communities at Hardangervidda, South Norway. I.

TORSTEIN SOLHÖY

Solhöy, T. 1972. Quantitative Invertebrate Studies in Mountain Communities at Hardangervidda, South Norway. I. *Norsk ent. Tidsskr. 19*, 99–108.

Quantitative data on invertebrate populations both from the vegetation (including the foerna) and soil layer are given from three high mountain communities at Stigstuv, Hardangervidda, S. Norway. In the vegetation layer. Collembola and Acari (mostly Oribatei) accounted for more than 90% of the total number found. Other important groups of primary consumers were Thysanoptera, Coccoidea, and Aphidoidea. All the groups mentioned are found to be highly aggregated, indicated by high SD values. The most important predators were Carabidae and Araneae. Araneae showed a quite even distribution within the sites. 80% or more of the soil Acari and soil Collembola were found in the upper 3 cms both on the dry and the wet meadow. On the lichen heath the percentage varied from 55% to 91 %. A drought period in August 1969 is shown to have had a pronounced negative effect on the number of Collembola and Acari on the dry meadow. especially in the vegetation layer. On the wet meadow, the Collembolan population increased markedly in the same period, while the number of Acari in the vegetation remained constant and the number of soil Acari even decreased.

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Quantitative data from the Norwegian mountain areas on soil and litter organisms are almost completely lacking. Even knowledge of the species composition of several important groups is very scanty. Within the scope of the Tundra Project of the Norwegian IBP, an intensive study of three high mountain sites at Stigstuv, Hardangervidda (60°18′ N. L., 7°40′ E.) is in progress. This account summarizes the preliminary results from the 1969 sampling series. As the tables only deal with higher taxonomic units, only a brief discussion of the seasonal fluctuations of the more important groups seems to be justified at this point.

SAMPLE SITES

The sites studied are situated in the upper part of the low alpine zone.

Dry meadow

Altitude 1275 m a.s.l. Gentle slope facing south. Morainic soil, profile iron podsol. pH (0–5 cm): 5.4. Chemical analysis (0–5 cm, mg/100 g dry soil): P = 9.0, K = 56.6, Ca = 805, Mg = 23.3.

48 spp. of vascular plants, 14 spp. of bryophytes, 17 ssp. of lichens. Common vascular plants: *Salix herbacea, S. reticulata, Anthoxantum nipponicum, Poa alpina, Phleum commutatum, Festuca ovina, Alchemilla vulgaris, Astragalus alpinus, Dryas octopetala* (in patches not sampled for invertebrates), *Euphrasia frigida, Polygonum viviparum, Ranunculus acris, Saussurea alpina, Silene acaulis, Thalictrum alpinum, Veronica alpina.* Common bryophytes: *Dicranum fuscescens, Mnium orthorrhynchum.* Common lichen: *Stereocaulon alpinum.*

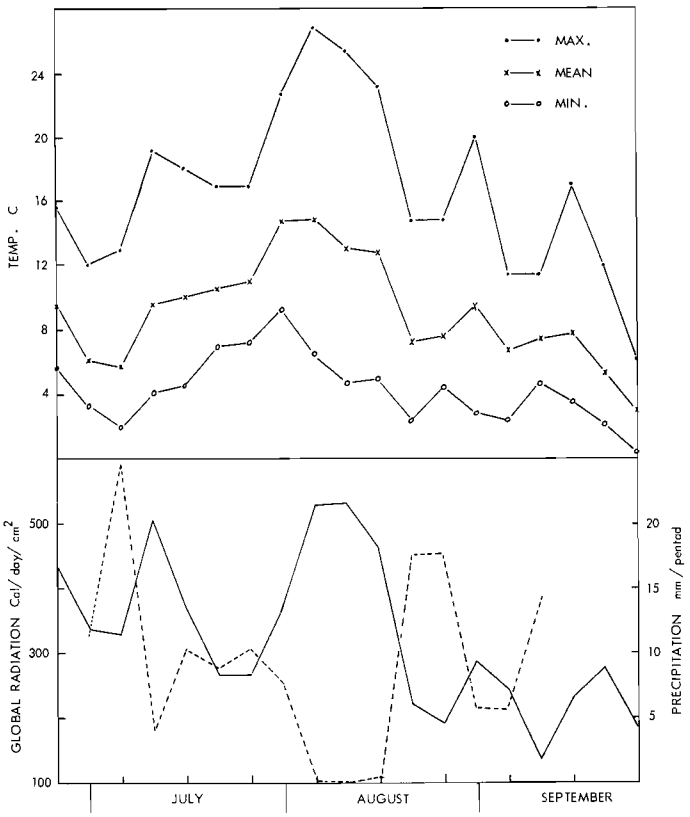

Fig. 1. Some meteorological observations (see text). Upper part: surface temperature (max., mean, min.). Lower part: Global radiation (whole line) and precipitation (stippled line). Temperature and radiation are given as pentad means, precipitation as pentad sums.

Wet meadow

Altitude 1320 m a.s.l. Almost horizontal, but sloping slightly south. Peat soil, organic origin. pH (0–5 cm) : 5.3. Chemical analysis (0–5 cm, mg/100 g dry soil): P = 1.4, K = 49.0, Ca = 514, Mg = 13.8.

30 spp. of vascular plants, 28 spp. of bryophytes, 5 spp. of lichens. Common vascular plants: *Carex nigra* (dominant) *Salix herbacea, S. lapponum, Phleum commutatum, Leontodon autumnalis, Pedicularis lapponum, Veronica alpina, Equisetum palustre, Comarum palustre, Ranunculus acris.* Dominant bryophytes: *Drepanocladus revolvens, Paludella squarrosa, Philonotis fontana.* Common lichen: *Peltigera canina.*

Lichen heath

Altitude 1225 m a.s.l. Horizontal and well drained to all sides. Glacifluvial soil, profile iron podsol. pH (0–5 cm): 4.1. Chemical analysis (0–5 cm, mg/100 g dry soil): P = 2.8, K = 16.0, Ca = 55, Mg = 9.0. 7 spp. of vascular plants, 7 spp. of bryophytes, 22 spp. of lichens. Common vascular plants: *Empetrum hermaphroditum, Vaccinium vitis-idea, Carex bigelowii.* Common bryophytes: *Polytrichum piliferum, Dicranum fuscescens.* Common lichens: *Cetraria nivalis, C. crispa, Cladonia mitis, C. rangiferina.*

METEOROLOGICAL OBSERVATIONS

Surface temperature (min., mean, max.), global radiation and precipitation data are given in Fig. 1. Radiation data are from Finse (1215 m a.s.l.) about 33 km NNW of Stigstuv. Precipitation measurements are from a station about 1 km WNW of the dry meadow. The measurements of the surface temperature are from the dry meadow. The temperature curves from the wet meadow show a similar trend but the max-

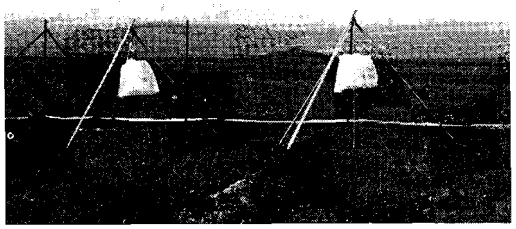

Fig. 2. The 'Quick Traps' in catching position. Wet meadow 25 Aug. 1970. (Photo T. Solhöy).

imum data are considerable lower. Temperature and radiation data are given as pentad means, precipitation as pentad sums.

METHODS

Invertebrates in the vegetation layer (including the foerna) on the dry and wet meadow were captured by aid of 'Quick Traps' (Fig. 2.) and collected from the sample plots by a suction pump (Kauri et al. 1969) On the lichen heath modified Ökland frames (Ökland 1929) were used. The lichen vegetation within the frame were completely removed by the suction apparatus.

Modified Tullgren funnels were used for extraction of the samples from the vegetation layer. The funnels are constructed on principles given by Dietrich et al. (1959) and Southwood (1966, p. 145).

Soil samples were taken from the same plots sampled by the 'Quick Trap'. A split core tool with three internal PVC rings was used. The internal area of a ring is 16.6 cm^2 and the height is 3 cm. Sample depth was 6 cm, thus two rings were filled with soil. The soil was kept undisturbed in the rings until extraction was completed. The samples were extracted in a high gradient apparatus (modified from Macfadyen 1961, 1962).

FAUNA

The fauna of the vegetation layer

The numerical composition is given in Tables I, II, III and the seasonal trends in the populations are shown in Fig. 3. The most abundant arthropod groups were Acari and Collembola. On the three sites they accounted for more than 90 % of the total number collected. Some of the other invertebrate groups

Table I. Dry meadow. Number of animals in the five sampling series from the vegetation layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 6 samples. Sample size 0.5 m^2. * denotes < 1/0.5 m^2.

	1 July		17 July		8 Aug.		26 Aug.		18 Sept.	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Acari	4638	1549.9	2083	893.3	1186	332.3	2478	773.2	4030	1816.0
Araneae	20	8.1	23	18.4	24	9.2	19	9.8	28	10.5
Opiliones	3	1.5	2	1.8	*	–	–	–	*	–
Collembola	4702	1489.2	5854	2653.6	178	114.6	2429	1110.9	2160	597.1
Hemiptera	292	110.3	250	109.5	242	170.7	190	209.3	140	101.7
Thysanoptera	289	385.4	607	740.1	35	24.8	30	42.3	40	15.7
Mecoptera	–	–	–	–	–	–	1	0.7	1	0.7
Psocoptera	*	–	–	–	–	–	*	–	–	–
Coleoptera	7	6.9	4	2.3	2	1.4	4	2.7	7	5.5
Lepidoptera	7	3.8	13	12.9	2	1.1	3	1.6	6	7.9
Diptera	25	9.5	42	27.6	11	10.9	22	10.1	7	4.7
Hymenoptera	19	11.0	6	4.9	8	3.1	4	1.9	1	1.1
Tardigrada	–	–	–	–	–	–	1	2.3	1	0.7
Enchytraeidae	66	18.6	24	15.7	–	–	4	4.8	9	13.8
Gastropoda	–	–	–	–	–	–	*	–	*	–
Insect pupa	–	–	*	–	*	–	–	–	*	–
Σ	10068	2306.9	8907	2169.4	1689	534.4	5195	1897.4	6430	1665.3

Table II. Wet meadow. Number of animals in the five sampling series from the vegetation layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 6 samples. Sample size 0.5 m². * denotes < 1/0.5 m².

	2 July		18 July		9 Aug.		26–27 Aug.		18–19 Sept.	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Acari	1455	831.8	1616	1053.1	4401	2273.1	4107	1799.6	5080	2121.3
Araneae	31	11.3	22	9.3	36	12.3	41	15.8	26	12.8
Opiliones	3	1.4	2	2.0	1	0.9	1	0.7	*	–
Collembola	3392	1266.2	1985	608.6	1829	1069.5	4971	1296.7	2993	1049.2
Hemiptera	3	7.1	6	7.0	11	5.8	31	13.5	18	16.5
Psocoptera	*	–	*	–	–	–	*	–	*	–
Thysanoptera	9	18.3	23	24.0	17	35.7	53	107.5	7	8.2
Trichoptera	–	–	–	–	*	–	–	–	–	–
Coleoptera	16	12.0	13	2.7	2	1.1	6	3.0	7	2.9
Lepidoptera	*	–	*	–	–	–	1	0.7	*	–
Diptera	18	9.0	12	6.9	8	6.8	8	4.6	13	8.4
Hymenoptera	3	1.5	3	3.1	5	2.1	4	2.3	1	1.3
Tardigrada	2	3.7	–	–	1	2.0	3	2.5	12	13.5
Enchytraeidae	31	17.0	21	9.3	6	7.1	12	4.8	15	6.6
Lumbricidae	*	–	–	–	–	–	–	–	–	–
Gastropoda	–	–	–	–	–	–	*	–	–	–
Insect pupa	*	–	*	–	–	–	*	–	*	–
Σ	4964	1487.2	3703	1829.1	6317	2688.1	9239	1717.5	8172	2539.8

listed may exceed them in biomass. However, considering the metabolism it is probably much higher in Acari and Collembola than any of the other groups. So from an energetic point of view they are of far greater importance than any other group listed.

Table III. Lichen heath. Number of animals in the two sampling series from the vegetation layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 16 samples. Sample size 1/16 m².

	10 Aug.		19 Sept.	
	$\bar{x}$	SD	$\bar{x}$	SD
Acari	260	144.7	1345	459.1
Araneae	–	–	5	3.9
Collembola	137	160.1	405	330.4
Hemiptera	5	4.8	5	4.3
Thysanoptera	–	–	–	–
Psocoptera	1.5	5.4	1	2.5
Coleoptera	–	–	1	1.2
Lepidoptera, larvae	–	–	–	–
Diptera, larvae	–	–	4	7.8
Hymenoptera, larvae	–	–	–	–
Enchytraeidae	–	–	–	–
Σ	413	257.6	1767	576.4

The next most abundant group on the dry meadow was Hemiptera (Cicadoidea, Aphidoidea, Coccoidea) with the highest density number in July and the beginning of August (about 500/m²). On the wet meadow and the lichen heath this group was of much lesser importance.

Thysanoptera showed a density peak (about 1200/m²) in the middle of July on the dry meadow. The number decreased markedly in the August–September samples (about 75/m²). On the contrary, the number was highest in the autumn on the wet meadow (about 100/m²). In both Hemiptera and Thysanoptera the SD values are high, indicating a high degree of aggregation. This aggregation can probably be explained by a certain plant specificity of the different species. Studies of plant specificity of the species of Aphidoidea and Thysanoptera are in progress.

Coleoptera (mainly Carabidae and Staphylinidae) were most abundant in the early summer (14/m² on the dry and 32/m² on the wet mesdow). Minimum figures were found in the beginning of August (4/m² on both sites). In September the densities on both sites were 14/m².

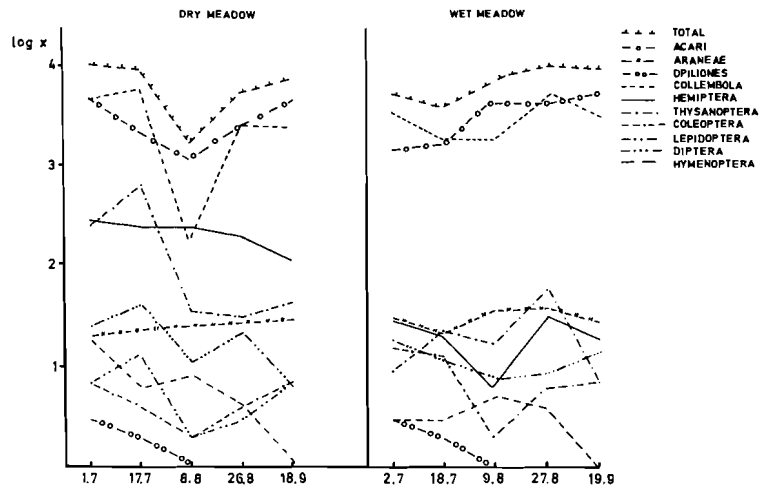

Fig. 3. The seasonal trend of the most important invertebrate groups during the sampling period. The values of x are given in Tables I, II.

Lepidoptera were only occasionally found on the wet meadow. On the dry meadow a maximum was found in July (about 20/m²), a minimum in August (4/m²) and a new peak in September (14/m²).

The highest number of Diptera on the dry meadow was found in July (84/m²) and the lowest number in September (14/m²). The number on the wet meadow was highest at the beginning of July (36/m²), smallest in August (16/m²) and 26/m² in September.

The number of Hymenoptera on the dry meadow showed a marked peak on 1 July (38/m²). Only 8/m² were found in the end of August and in September the number had decreased to 2/m². On the wet meadow only a few (2–10/m²) were found during the whole sampling period.

Araneae showed a remarkable constancy in numbers during the season both on the dry and wet meadow. The SD values are quite low which should indicate a more or less even distribution within the two sites (Kauri 1971). On the lichen heath there occurred an autumn peak, but since material was lacking from the first part of the summer no definite conclusion can be reached about the seasonal trend on this site.

Enchytraeidae, Lumbricidae, Tardigrada and Gastropoda were occasionally encountered in the samples. The three first mentioned mostly occur in the soil and none are effectively sampled by the suction apparatus. Gastropoda, Lumbricidae and Tardigrada seem to be rare on the sites, so no special sampling procedures for these groups were carried out. The important group Enchytraeidae was sampled quantitatively from 1970 onwards.

As mentioned earlier, only two sampling series were taken from the vegetation layer on the lichen heath. The total number of arthropods increased from 6610/m² on 10 August to 28280/m² on 19 September (Table III). This increase was mainly caused by Collembola and Acari. The number of Collembola increased about three times and that of Acari about five times. Notice that the low number in August coincided with the minimum found on the dry meadow.

The fauna of the soil layer

During 1969 only Collembola and Acari were effectively sampled from the soil layer (Tables IV, V, VI). Occasionally some other groups (mostly Coccoidea and larvae of Diptera and Coleoptera) were extracted from the soil cores. But the effectiveness of extraction upon these groups is highly questionable and they are therefore omitted in the present tables.

Both on the dry and wet meadow 80 % or more were confined to the upper 3 cm of the soil. This percentage remained fairly constant during the whole season. On the lichen heath

Table IV. Dry meadow. Number of Collembola and Acari in the five sampling series from the soil layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 6 samples. Sample size 16.6 cm². N/0.5 m² (0–6 cm) estimated from $\bar{x}$. dl.

	1 July*		17 July		8 Aug.		26 Aug.**		18 Sept.	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Collembola										
0–3 cm	4.0	2.8	49.0	24.0	160.7	117.9	75.8	43.5	176.3	114.6
3–6 cm	0.5	0.7	9.5	7.3	6.0	5.8	15.3	19.2	18.7	31.0
0–6 cm	4.5	3.5	58.5	24.1	166.7	119.2	91.1	61.8	195.0	105.7
N/0.5 m²	1350		17,610		50,180		27,420		58,700	
Acari										
0–3 cm	40.0	36.8	233.0	154.2	145.5	41.1	105.5	65.0	183.2	65.2
3–6 cm	0	–	24.3	12.1	17.5	16.6	12.0	9.9	33.5	22.0
0–6 cm	40.0	36.8	257.3	151.0	163.0	50.7	117.5	62.7	216.7	55.3
N/0.5 m²	12,040		77,450		49,060		35,370		65,230	

* 2 samples ** 4 samples

only 55 % of Collembola but 91 % of Acari were found in the upper 3 cm of the soil in August. In September the percentages were 71 and 76 respectively. Milne (1962) has pointed out that the extraction of the lower soil layers in a high gradient apparatus may give an underestimation of the actual densities. Because of the firmer texture (lesser pore volume) in these layers the animals can be trapped more easily during the drying process. But Edwards & Fletcher (1970) have shown that the different flotation and washing techniques used instead of the high gradient apparatus do not give a better result.

The degree of aggregation varied during the season and was greater in Collembola than in Acari. The animals were more aggregated in the lower soil layer (3–6 cm). On the lichen heath even the animals in the upper 3 cms were highly aggregated.

THE SEASONAL FLUCTUATIONS OF COLLEMBOLA AND ACARI ON THE DRY AND WET MEADOW

It must be stressed that discussion above species level will turn out to be more or less speculative owing to the different ecology of the

Table V. Wet meadow, Number of Collembola and Acari in the five sampling series from the soil layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 6 samples. Sample size 16.6 cm². N/0.5 m² (0–6 cm) estimated from $\bar{x}$.

	2 July*		18 July		9 Aug		27 Aug.**		19 Sept.	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Collembola										
0–3 cm	8.7	5.0	10.5	6.1	66.5	25.5	75.6	55.6	79.3	12.0
3–6 cm	1.0	0.7	0.2	0.4	12.8	14.2	13.0	14.1	8.8	10.4
0–6 m²	9.7	5.9	10.7	6.4	79.3	36.9	88.6	–	88.2	15.8
N/0.5 m²	2920		3220		23,870		26,670		26,550	
Acari										
0–3 cm	12.0	8.2	41.7	13.4	71.3	36.6	26.7	9.7	33.3	10.1
3–6 cm	2.0	0	8.7	8.1	5.5	4.2	6.0	8.5	4.2	3.1
0–6 cm	14.0	8.2	50.4	18.5	76.8	39.8	32.7	–	37.5	11.3
N/0.5 m²	4210		15,140		23,120		9840		11,290	

* 3 samples ** 3 samples 0–3 cm, 2 samples 3–6 cm.

Table VI. Lichen heath. Number of Collembola and Acari in the two sampling series from the soil layer. Mean ($\bar{x}$) and Standard Deviation (SD) of 6 samples. Sample size 16.6 cm². N/0.5 m² (0–6 cm) estimated from $\bar{x}$.

	10 Aug.		19 Sept.	
Depth	$\bar{x}$	SD	$\bar{x}$	SD
Collembola				
0–3 cm	20.2	18.2	29.3	17.1
3–6 cm	16.2	20.4	12.2	18.8
0–6 cm	36.4	33.8	41.5	26.5
N/0.5 m²	10,950		12,490	
Acari				
0–3 cm	50.3	32.8	65.8	36.1
3–6 cm	4.8	4.0	20.5	30.4
0–6 cm	55.1	34.8	86.3	46.6
N/0.5 m²	16,590		25,980	

various species. But with this in mind some general trend in the seasonal fluctuations of the two groups will be pointed out.

Considering Collembola from the vegetation layer of the dry meadow, a drastic drop in density from 9700/m² on 17 July to 360/m² on 8 Aug. (Fig. 4 A) was found. In the same period the number of soil Collembola increased from 34,000/m² to 100,000/m² (Fig. 4 B). Most of the period the weather was unusually dry and sunny (Fig. 1), but on 8 Aug. the water content of the soil was still 63 % (Fig. 4 C). On the wet meadow the population density of the vegetation layer remained almost constant from 18 July to 9 Aug., but from 9 to 26 Aug. there was a marked increase (Fig. 5A). The soil population increased from 6400/m² on 18

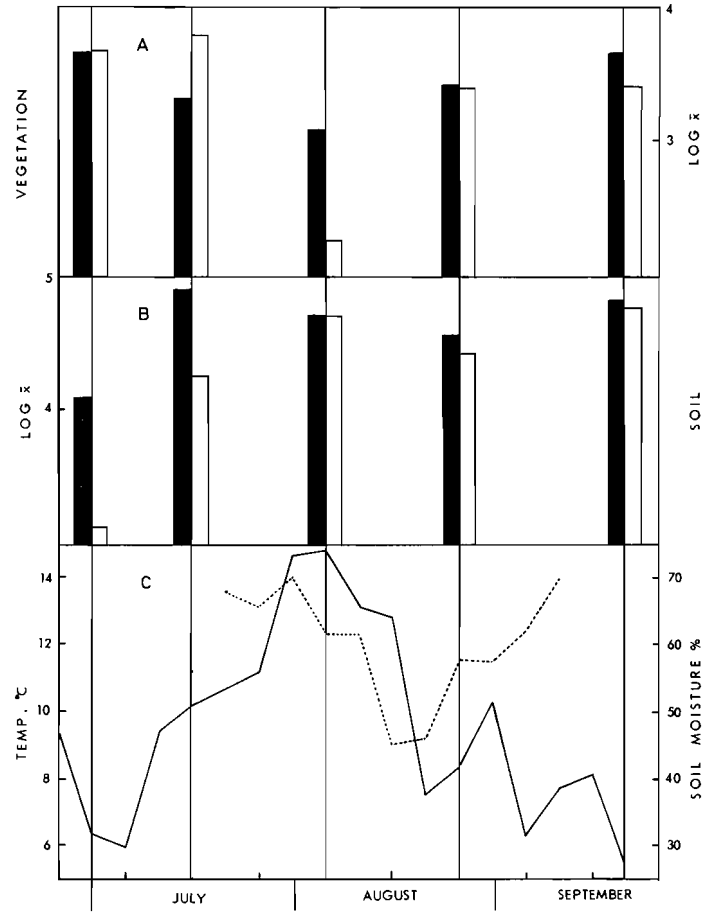

Fig. 4. The seasonal variations on the dry meadow in the number of Collembola (white columns) and Acari (black columns) in the vegetation layer (A) and in the soil layer (B). The mean surface temperature (whole line) and soil moisture (stippled line) are shown in C. Vertical lines denote the sampling days (compare Tables II and III).

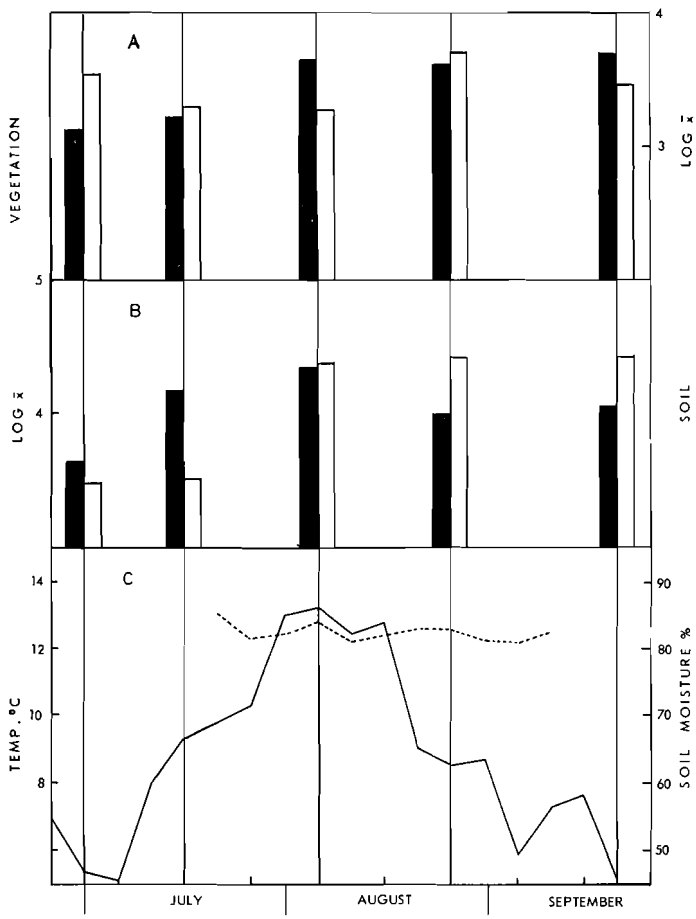

Fig. 5. The seasonal variations on the wet meadow in the number of Collembola and Acari. For explanations see Fig. 3.

July to 48,000/m² on 9 Aug. (Fig. 5B). The two following soil sample series (26 Aug. and 19 Sept.) gave about the same number. The water content of the soil remained almost constant (about 80 %) during the whole summer (Fig. 5C).

Agrell (1941) and Hale (1967) state that the most important factor governing the distribution and number of Collembola is the humidity. The data outlined above seem to be in good accordance with this view. Dessiccation in the vegetation of the dry meadow may have caused a high mortality or forced the animals into the soil layer. The increase in the soil population in the same period must be due to hatching, probably accelerated because of the high temperature and suitable moisture conditions. Vertical movement from the vegetation layer cannot account for these pronounced increases. When the soil moisture decreased further in the middle of August, a certain mortality seemed to occur in the soil population too.

As mentioned above the moisture conditions on the wet meadow were not affected by the dry weather. The increase in number of Collembola in August both in the vegetation and in the soil can only be explained by hatching. While the populations on the dry meadow were affected in a negative way by the draught, the wet meadow population seemed to be affected positively.

The number of Acari (mostly Oribatei) in the vegetation layer on the dry meadow followed mainly the same trend as found in Collembola (Fig. 4A). The highest number was found on 1 July (9280/m²), and the lowest in

the beginning of August (2370/m²). It will be seen that the decrease in number during the draught period was not so drastic as that of Collembola, which may suggest a better tolerance against draught conditions. The soil Acari also seemed to be slightly affected by the decrease in soil moisture which occurred in August (Fig. 4B), but here the effect is more questionable. The number actually decreased from the middle of July to the beginning of August too. However, the SD value of the July figure is rather high and the decrease mentioned may be accidental.

On the wet meadow the seasonal trend of the population of Acari in the vegetation was also similar to that of Collembola except that the increase in the population number had already occurred from 17 July (3230/m²) to 8 Aug. (8800/m²). Thus increase occurred prior to the dry period in August. The two sample series following gave about the same number as that at the beginning of August. Also the soil Acari on the same site showed the greatest density (46,200/m²) at the beginning of August (Fig. 5B). Surprisingly, the number decreased markedly on the following two sampling occasions (about 20,000/m²). So in the soil population there must actually have been a certain mortality during this period.

CONCLUSIONS

The fauna of the vegetation layer on the three sites is shown to be dominated by the Collembola and Acari (Fig. 3 and Table III). During the drought period in July/August a pronounced drop in population occurred on the dry meadow and the lichen heath, while the population on the wet meadow was positively affected. The trends in the total number during the season were chiefly governed by the variations in these two groups.

Fig. 3 shows that different insect groups also showed minimum figures on the same date: On the wet meadow the groups Hemiptera, Coleoptera and Diptera and on the dry meadow Thysanoptera, Lepidoptera and Coleoptera. Thysanoptera showed an early summer peak on the dry meadow but a late summer peak on the wet meadow. The number of the other groups mentioned were found to be quite similar in July and September.

It is interesting to note that the number of Hymenoptera and Opiliones (only one species: *Mitopus morio)* decreased from early summer towards the autumn and that the trends are almost identical on both the dry and wet meadow. It is possible, however, that the extraction of Opiliones from the late summer and autumn samples are incomplete owing to their larger body size at that time.

On the dry meadow also the number of Hemiptera and Diptera showed a decreasing trend toward the autumn.

On both sites the number of spiders showed a slight increase toward the autumn.

ACKNOWLEDGEMENTS

This work was carried out at the Zoological Museum, University of Bergen. My most sincere thanks are due to Professor Hans Kauri, Director of the Zoological Museum and leader of the project, for valuable help, advice and criticism. I am indebted to the following persons for permission to use some of their results: Cand. mag. A. Skartveit, Geophysical Institute, University of Bergen (meteorology), cand. agr. A. K. Veum, Pedological Institute, Vollebekk (soil analysis), Assistant Professor F. E. Wielgolaski and Cand. hort. S. Kjelvik, Botanical Laboratory, University of Oslo (plant cover and soil moisture). The technical assistance of Björn Rosenlund was greatly appreciated during the field and laboratory work.

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Short Communications

Macroplea appendiculata Panz. (Col., Chrysomelidae) New to Norway

JOHN O. SOLEM

Macroplea appendiculata Panz. is reported new to Norway. Larvae and adults were found in lakes in South Tröndelag. The adults show greatest locomotoric activity during the daytime.

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The genus *Macroplea (Haemonia)* was first reported to belong to the Norwegian fauna by Fjellberg (1970), who found fragments of specimens belonging to this genus in the stomachs of two Slavonian grebes *(Podiceps auritus)*. The species in question may be, according to Fjellberg, *Macroplea (Haemonia) mutica* F. var *lapponica* Hellen.

During investigations of the bottom fauna of the lakes Jonsvannet, Trondheim, and Målsjöen, Klæbu. South Tröndelag, *Macroplea appendiculata* Panz. has been found in both lakes.

Larvae of the chrysomelids, which certainly represent both the genera *Donacia* and *Macroplea*, occurred down to the depth of 2 m in both lakes.

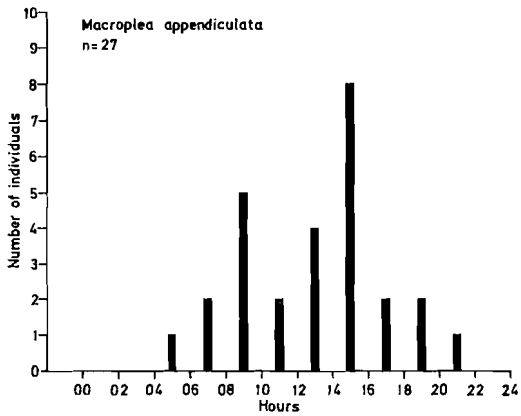

Fig. 1. Diel rhythm of adults of *Macroplea appendiculata* during June and July 1971.

Cocoons of *M. appendiculata* were found attached to *Potamogeton natans*. The species of *Donacia* and *Macroplea* are more or less monophagous (Illies 1967), and Hansen (1927) reports *M. appendiculata* to occur on *Myriophyllum spicatum, Potamogeton perfoliatus,* and *P. lucens,* and perhaps also on *P. natans* and *P. pectinatus.*

Free-living adults of *M. appendiculata* were collected in 1971 from primo June to ultimo July, and preliminary results on the diel rhythm are reproduced in Fig. 1. The greatest locomotoric activity is during the daytime, and it appears that the species has two peaks of activity, but the numbers of individuals collected are to small to make certain conclusions. The method used to measure the locomotoric activity is a modified method of that described by Pieczynski (1961), and the traps were emptied every second hour in the 24-hour periods of investigation.

M. appendiculata is known from Finland, Sweden, and Denmark (Hansen 1927, Lindroth 1960).

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Parasemidalis fuscipennis Reuter (Neuroptera, Coniopterygidae) ny for Norge

KAARE AAGAARD & JOHN O. SOLEM

Parasemidalis fuscipennis Reuter is reported new to Norway. One male was collected in a light trap at Målsjöen, Klæbu, Sör-Tröndelag, 1–5 July 1971.

K. Aagaard & J. O. Solem, Universitetet i Trondheim, Det Kgl. Norske Videnskabers Selskab, Museet, N-7000 Trondheim, Norway

I et lysfellemateriale samlet ved Målsjöen, Klæbu, Sör-Tröndelag sommeren 1971, ble en hann av *Parasemidalis fuscipennis* Reuter funnet. Individet ble fanget i tidsrommet 1. til 5. juli. Arten er tidligere ikke funnet i Norge.

Det ble satt opp 2 lysfeller i området og begge vendte ut mot Målsjöen, men var på alle andre kanter omgitt av barskog. Arten er kjent som en nåletresart.

P. fuscipennis er funnet i Syd-Finland, Syd-Sverige, de baltiske provinser, sentral-Europa og Storbritannia (Killington 1936, Meinander 1962, Greve Jensen pers. medd.). *Parasemidalis* er en liten slekt, og i tillegg til Europa er den representert i Egypt, Nord- og Sör-Amerika, Java og Australia (Killington 1936).

I følge L. Greve Jensen (pers. medd.) er det med *P. fuscipennis* funnet 59 arter av Neuroptera i Norge. Kjönnsbestemmelsen av individet er foretatt av L. Greve Jensen, som også har verifisert vår bestemmelse.

Mottatt 10. februar 1972

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Nye funn av saksedyr (Dermaptera) i Norge

KAARE AAGAARD

The present paper reports new records of the three Norwegian species of Dermaptera. *Chelidurella acanthopygia* (Géné), previously only known from Os: Lunner, is reported from Bö: Hönefoss, VAy: Lyngdal, and STy: Snillfjord. *Labia minor* (L.) and *Forficula auricularia* L. are both reported from Tröndelag. Earlier records of *L. minor* are restricted to the south-eastern part of Norway, while *F. auricularia* is known to be common north up to Tröndelag.

K. Aagaard, Universitetet i Trondheim, Det Kgl. Norske Videnskabers Selskab, Museet, N-7000 Trondheim, Norway

Dermaptera, eller saksedyr, er i Norge representert med tre arter, *Labia minor* (L.), *Forficula auricularia* L. og *Chelidurella acanthopygia* (Géné). For disse tre artene gir Knaben (1943) følgende utbredelsesområder, som også er gjengitt av Semb-Johansson (1971): *L. minor* er funnet på Östlandet, *F. auricularia* er utbredt nord til Tröndelag, og *C. acanthopygia* er bare kjent fra (Os) Lunner i Nordmarka, hvor 2♂♂ ble funnet 17. november 1937 av konservator H. Thambs-Lyche.

Ved en revisjon av dermaptersamlingen ved Zoologisk avdeling, Det Kgl. Norske Videnskabers Selskab, Museet (DKNVS, M), ble flere nye lokaliteter for alle de tre artene påvist.

Av *C. acanthopygia* inneholdt samlingen 2♀♀ merket (Bö) Hönefoss, aug. 1916, leg. R. Iversen: 1♂, merket (VAy) Lyngdal, leg. CD (Carl Dons): og 1♂ fra STy: Snillfjord, 17.–18. aug. 1971. Den siste inngår i et IBP-materiale, innsamlet av Dag Dolmen. IBP har vennligst gitt tillatelse til publisering av funnet.

C. acanthopygia er et typisk lövskogsdyr, som i Sverige er kjent nord til Dalarne (Holst 1970). Funnet fra STy: Snillfjord er det nordligste i

Skandinavia, og det har tydeligvis sammenheng med de spredte forekomster av mer varmekrevende lövskog som forekommer rundt Trondheimsfjorden.

Av *L. minor* finnes det i DKNVS, M's samling 1♂ fra NTi: Frosta, funnet av Bjarne Lysholm. Funnet er ikke overraskende, da *L. minor* finnes i de fleste svenske landskaper nord til Lappland (Holst 1970). Arten er kjent for å være varmekjær og trives best ved möddinger og komposthauger. *L. minor* er et av de få saksedyr som kan treffes flygende.

Det vanlige saksedyret, *F. auricularia*, er kosmopolitisk i sin utbredelse. Museets samling inneholder dyr fra flere lokaliteter i Tröndelag, den nordligste er STy: Hitra, Fjellværöy, funnet 5. aug. 1965 av A. Foss.

Mottatt 10. februar 1972

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Notes on Norwegian Spiders, III

ERLING HAUGE

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Working with a small collection of spiders deposited at the Zoological Museum, Bergen, by Mrs. Helene Tambs-Lyche, I have identified a female of the species *Syedrula innotabilis* (Cambr.). The specimen was caught in a yellow tray 10 July 1954, Vollebekk (AK: Ås), eastern Norway.

The species has not previously been recorded in Norway. Its distribution in Europe is, according to Wiehle (1956), England, France, Switzerland and the Balkan peninsula. It is also known from Denmark (Larsen & Böggild 1970).

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Syrphidae (Dipt.) from Ormtjernkampen National Park

TORE RANDULFF NIELSEN

A small material of Syrphid flies, showing 23 species, is reported from Ormtjernkampen National Park, Central Norway.

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Ormtjernkampen is one of the smallest national parks of Norway, covering only about 9 square kms, and located 33 km WNW of Lillehammer, Central Norway. It is a mountainous area, rising 774 m to 1127 m a.s.l. Its vegetation is mainly *Betula nana* and lichen fields on the tops, and dominated by spruce and birch forests in the lower regions.

The reported Syrphid material was collected during a short stay in the park in July 1970; a few specimens collected at Kittilbu Tourist Station near the park are also enclosed in the material. Twenty-three species were found:

Platycheirus albimanus (Fabr.) 1781. Ormtjernkampen 14 July (1♂); Kittilbu 10 July (1♂).

P. latimanus Wahlbg. 1844. Ormtjernkampen 14 July (3♀♀).

P. manicatus (Meig.) 1822. Kittilbu 10 July (1♀). on *Ranunculus acris* flower.

P. peltatus (Meig.) 1822. Ormtjernkampen 14 July (2♀♀); Kittilbu 10 July (1♀).

Melanostoma dubium (Zett.) 1838. Ormtjernkampen 12 July (3♀♀), above the tree limit. Alpine species.

M. mellinum (L.) 1758. Kittilbu 10 July (1♂).

M. scalare (Fabr.) 1794. Ormtjernkampen 14 July (1♂).

Sphaerophoria picta (Meig.) 1822. Kittilbu 10 July (1♂).

Syrphus ribesii (L.) 1758. Ormtjernkampen 14 July 2♂♂, 2♀♀).

S. sexmaculatus (Zett.) 1838. Ormtjernkampen 12 July (1♂), at 1000 ma.s.l.

S. torvus Ost.-Sack. 1875. Ormtjernkampen 14 July (4♂♂, 2♀♀).

Metasyrphus nitens (Zett.) 1843. Ormtjernkampen 14 July (1♂), sunning on spruce branches.

Metasyrphus sp. Ormtjerkampen 14 July (1♀).

Dasysyrphus lunulatus (Meig.) 1822. Ormtjernkampen 12 July (1♂).

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D. venustus (Meig.) 1822. Ormtjernkampen 14 July (1♀).

Melangyna coei Niels. 1971. Ormtjernkampen 14 July (1♂). It is the second recording of this species, which was described from Jæren, SW Norway (Nielsen 1971).

Phalacrodira lineola (Zett.) 1843. Ormtjernkampen 14 July (2♀♀); Kittilbu 10 July (1♀).

Megasyrphus annulipes (Zett.) 1838. Ormtjernkampen 14 July (1♂, 4♀♀), sunning on spruce branches in forest glades.

Chrysotoxum arcuatum (L.) 1758. Ormtjernkampen 14 July (♂); Kittilbu 10 July (1♀).

Pipiza bimaculata Meig. 1822. Kittilbu 10 July (1♀), on *Ranunculus acris* flower.

Cheilosia albitarsis (Meig.) 1822. Kittilbu 10 July (3♀♀), on flowers of *Ranunculus acris*.

C. longula (Zett.) 1838. Ormtjernkampen 12 July (1♂).

Sericomyia lappona (L.) 1758. Ormtjernkampen 14 July (1♂), at 1000 m a.s.l.

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Bokanmeldelser

Landin, Bengt-Olof. 1970–71. *Insekter 2* (Del 1 og 2). Fältfauna. 1053 sider, 1919 figurer. Natur och Kultur, Stockholm

Det har gått tre-fire år siden bind 1 av Landins Insekter, Fältfauna ble utgitt, men med det enorme materiale bind 2 inneholder, kan man også forstå at utgivelsen må ta tid. Bak en oversikt av denne typen, som tar sikte på å dekke alle insektordner, ligger et kolossalt arbeid.

Mens bind 1 tok for seg de fjorten første ordnene, til og med Hemiptera, omfatter bind 2 bare tre ordner: Coleoptera Strepsiptera og Hymenoptera. Allikevel har bindet blitt nesten tre ganger så stort som det første. Av denne grunn var det nødvendig å dele bind 2 i to bøker. Den første delen omhandler de fleste familier av Coleoptera, og den andre resten av Coleoptera (bl.a. Cerambycidae, Chrysomelidae og Curculionidae) og Hymenoptera. Strepsiptera opptar en beskjeden plass med bare 10 sider.

Bøkene inneholder bestemmelsestabeller som fører frem til alle kjente svenske slekter innen hver orden. For billenes vedkommende er det i mange tilfelle også mulig å komme frem til art, enten i selve nøkkelen, eller i korte bestemmelser under hver slekt. Av de ca. 4100 biller, som er kjent fra Sverige, kan således 1520 identifiseres til art. I sitt utvalg av arter har forfatteren særlig lagt vekt på grupper som tidligere er forholdsvis dårlig behandlet i annen, tilsvarende, svensk litteratur. Når en slekt bare inneholder en art, er artsnavnet alltid oppgitt.

For vepsenes vedkommende må man rimligvis nøye seg med å komme frem til slekt i de fleste tilfelle. Denne delen av bind 2 er allikevel spesielt verdifull, fordi den gir en samlet oversikt over denne vanskelige gruppen av insekter. Her har man mulighet for å finne frem til slekt, enten det gjelder bladveps, snylteveps, gallveps eller andre Hymenoptera. Med den betydning mange Hymenoptera har i anvendt entomologi, er det viktig at en slik bestemmelsestabell er lett tilgjengelig. Forfatteren gir i sitt forord uttrykk for at han håper denne introduksjon til vepsenes systematikk vil inspirere til mer detaljerte studier av de forskjellige gruppene. Ordenen opptar over 500 sider av bind 2, noe som i første rekke skyldes det store antall slekter den omfatter, men også at det ofte er nødvendig med særskilte tabeller for hanner og hunner.

Forfatteren har lagt stor vekt på å illustrere morfologiske detaljer av betydning for identifikasjonen av de forskjellige insektene. Bøkene er spekket med klare og tydelige strektegninger, slik at det i del 1 og 2 tilsammen fins det imponerende antall av 1919 figurer. Det store antallet illustrasjoner øker bøkenes bruksverdi betraktelig, siden man stadig har noe å se etter. Dertil er det lettere å bruke tabellene uten store kunnskaper i morfologisk terminologi, når illustrasjonene tydelig viser hvilke deler det er tale om.

En stor fordel ved Landins Insekter er at man her i en og samme serie får en samlet oversikt over alle insektordner. Det bindet som gjenstår vil også danne avslutningen på serien, og bl.a. omfatte de store ordnene Lepidoptera og Diptera. Bøkene vil være til stor nytte for alle som har behov for å identifisere insekter, uten at det i første rekke alltid er nødvendig å komme frem til art. Serien vil være like nyttig i Norge som i Sverige, og den kan anbefales til håndbiblioteket i skoler, høyskoler og universiteter.

Lauritz Sømme

Schneirla, T. C. 1971. *Army Ants. A Study in Social organization.* (Edited by H. R. Topoff). 349 pp. W. H. Freeman & Co., San Francisco. Pris $ 12.00

Vandremaur er kanskje ikke det mest aktuelle studieobjekt for norske entomologer, siden man må temmelig langt fra våre breddegrader for å finne dem. Det viktigste utbredelsesområdet for underfamilien Dorylinae omfatter særlig tropiske og subtropiske strøk mellom 45° N og 45° S både i den nye og den gamle verden. Dette forhindrer imidlertid ikke at T. C. Schneirlas bok både er fascinerende lesning, og dessuten kan lære oss en mengde om de prinsipielle sider ved insektenes oppførsel.

Vandremaurene utmerker seg bl.a. ved at de ikke bygger permanente reder, men veksler mellom en nomadisk tilværelse og en midlertidig stasjonær fase. De er beryktet for sine hærtokter, hvor svermer på utallige individer stormer frem og fortærer alle mindre dyr, som kommer i deres vei. Byttet omfatter i første rekke insekter, men noen arter kan også gå løs på mindre virveldyr. Under fremrykkingen skremmes tallrike insekter frem fra sine skjulesteder og faller også lett som bytte for fugler, som følger vandremaurene.

Midlertidige reder settes opp for kortere eller lengere tid, og noe forskjellige for de forskjellige artene. Afrikanske og asiatiske arter fører tildels en underjordisk tilværelse, mens de syd-amerikanske artene er mer tilpasset overjordisk liv. Disse setter opp sine reder under en veltet trestamme, el.l., og veggene i redet formes av arbeiderne som henger seg opp i hverandre i et flettverk. I slike reder, eller 'bivuakker' har dronningen sitt kammer, og her fores larvene opp. Når kolonien flytter fra ett sted til et annet, bringer den yngelen med seg.

Det er spørsmålene om hvilke faktorer som

regulerer vandremaurenes eiendommelige oppførselsmønster, som har opptatt T. C. Schneirla. I mer enn 35 år, har han studert de stimuli som får koloniene til å reagere på forskjellig vis. Boken blir en oppsummering av dette arbeidet, som er basert på feltobservasjoner og laboratorieforsøk. Forfatterens konklusjoner er at den sosiale organisering hos vandremaurene er et samspill mellom genetiske faktorer og innflytelse fra omgivelsene. Maurenes oppførsel er sterkt influert av duftstoffer fra andre medlemmer av kolonien og dannelsen av forskjellige kaster, og arbeidsmaurenes størrelse reguleres bl.a. gjennom deres tilgang på næring i larvestadiet. Disse detaljerte studiene av de mange faktorer som virker inn på vandremaurenes oppførsel, er ikke bare av interesse for en liten gruppe spesialister, men gir et verdifullt bidrag til forståelsen av andre dyrs, og kanskje menneskenes egen oppførsel.

T. C. Schneirla døde i 1968, og boken ble fullført av en av hans elever, Dr. H. R. Topoff. Boken er rikt illustrert med diagrammer og fotografier, og inneholder dertil 8 fargeplansjer.

Lauritz Sømme

Høeg, Ove Arbo. 1971. *Vitenskapelig forfatterskap.* (2nen utgave). 131 sider. Universitetslaget, Oslo. Pris kr. 18.50.

Når 'Vitenskapelig forfatterskap' foreligger i ny utgave allerede etter tre år, tyder det på at den er mye brukt. Denne velskrevne boken fortjener også stor utbredelse, fordi den inneholder en mengde opplysninger til nytte for nye og gamle forfattere. Skrivning av en vitenskapelig avhandling kan være en vanskelig prosess, full av fallgruver bl.a. når det gjelder nøyaktighet og konsekvens i fremstillingen. Med professor Høegs bok har man en god guide gjennom mange av vanskelighetene.

Boken innledes med en beskrivelse av avhandlingens hovedledd, og hva de forskjellige ledd fra abstract til referanselisten bør inneholde. Et kapittel om språk og stil inneholder en mengde nyttige detaljer om språkføring, bruk av forkortelser, tall, datoer, tegnsetning, og meget annet.

Prinsippene for litteraturfortegnelsen er viet stor oppmerksomhet med diskusjon av de enkelte ledd i referansen. Som forfatteren fremhever, vil reglene variere noe for forskjellige tidsskrifter, slik at man alltid må følge det tidsskrift hvor avhandlingen skal trykkes. Professor Høegs regler avviker ikke meget fra de som benyttes i Norsk ent. Tidsskr., men det ville vært en fordel om Universitetsforlaget gikk inn for et ensartet system i sine bøker og tidsskrifter.

Kapitlene om manuskriptets endelige utforming, og hvorledes illustrasjonene bør lages er meget viktige. Tabeller og figurer er vanskelige deler av avhandlingen, og bør være vel gjennomtenkt før de presenteres til trykning. Et godt manuskript kan spare redaktøren for meget arbeid og professor Høegs veiledning vil her være til stor nytte. Boken avsluttes med gode råd om hvorledes man bør lese korrektur og eksempler på hvorledes korrekturtegnene skal brukes i praksis.

Den nye utgaven av 'Vitenskapelig forfatterskap' skiller seg tilsynelatende ikke meget fra den første, men inneholder ved nærmere ettersyn en rekke mindre forandringer og tilføyelser. Av større tilføyelser er et nyttig avsnitt om de juridiske spørsmål en forfatter kan stilles overfor, skrevet av dosent Birger Stuevold Larsen. Boken er stort sett grei å finne frem i, men personlig savner jeg et noe mer utførlig stikkordregister. Det ville gjort det enda lettere å finne frem til spesielle detaljer.

Det vil være å ønske at boken finner sin plass i enhver forfatters hylle, til glede for ham selv og for de redaktører som skal motta hans produkter.

Lauritz Sømme

In memoriam

REIDAR BREKKE

Tidligere preses for Direksjonen ved Det Kgl. Norske Videnskabers Selskab, Museet, direktør Reidar Brekke, gikk bort i oktober 1971, 83 år gammel.

Direktør Brekke var en allsidig mann og et av hans store interesseområder var fiske etter laks og ørret. Hans mange fisketurer, sammen med hans alltid søken etter ny kunnskap, førte ham over i entomologien, da han fattet interesse for å øke sin viten om døgn-, stein- og vårfluer. Det viste seg snart at det her til lands var dårlig hjelp innenfor de nevnte grupper, og derfor søkte han hjelp i utlandet. Hans grundighet og store intuisjon i mange taxonomiske spørsmål førte til en utstrakt og vid korrespondanse, og en av dem han hadde regelmessig kontakt med i forbindelse med døgnfluetaxonomien var den svenske entomologen Simon Bengtson. Hans interesse for de nevnte gruppene førte til tre arbeider som gir en oversikt over utbredelse av døgn-, stein- og vårfluene i Norge. I døgn- og steinfluearbeidene finnes også taxonomiske bemerkninger til enkelte arter.

Entomologien ble en av direktør Brekkes store hobbyer som han ofret mesteparten av sin fritid på. Han var en utmerket taxonom, men av andre problemer som opptok ham i forbindelse med døgn-, stein- og vårfluene var deres adferd. Dette var ting han ikke fikk skrevet noe om, men han gjorde flere interessante iakttagelser, i krigsårene da han satt som fange på Falstad fangeleir. I denne tiden var entomologien, som han selv ut-

trykte det, til stor hjelp og inspirasjon, da den holdt tankene borte fra fangelivets problemer.

Den store kunnskap som Reidar Brekke etter hvert erververt seg, det meste ved selvstudium, men også med en utstrakt korrespondanse med forskere over hele verden, forsøkte han å formidle til alle som var interesserte i hans dyregrupper. Han gikk således bevisst inn for å lære opp personer som kunne bearbeide hans innsektgrupper videre. Arbeidet med døgn-, stein- og vårfluene avsluttet han i 1965, men helt til det siste fulgte han interessert med i hva som skjedde av arbeid innenfor det som han regnet som sine innsektgrupper.

For DKNVS, Museet, var Reidar Brekkes arbeid av stor betydning, da han bygde opp samlingene av døgn-, stein- og vårfluer. Også sin samling av særtrykk ga han til Museet.

Reidar Brekkes viktigste publikasjoner er:

1938. The Norwegian Mayflies (Ephemeroptera). *Norsk ent. Tidsskr., 5:* 55–73.
1941. The Norwegian Stoneflies. Plecoptera. *Norsk ent. Tidsskr., 6:* 1–24.
1946. Norwegian Caddisflies (Trichoptera). *Norsk ent. Tidsskr., 7:* 155–163.
1955. Bidrag til kunnskapen om Norges døgn-, sten- og vårfluer (Ephemeroptera, Plecoptera, Trichoptera). *Norsk ent. Tidsskr.,13:* 11–15.

I tillegg har han flere små artikler om nye funn innenfor de nevnte dyregruppene samt artikler om laks og laksefiske som er publisert i forskjellige årbøker/tidsskrifter.

John O. Solem

OLE BERNHARD LUNDETRÆ

Lærer Ole Bernhald Lundetræ døde 17. august 1971 etter flere måneders sykeleie, nær 72 år gammel. Han var født på Os i Hordaland, tok artium på Voss Off. Landsgymnas 1921, ble uteksaminert fra Stord Lærerskole 1924, var lærer i Djønno i Hardanger 1924–42 og på Utne 1943–1956 hvor han også var kirkesanger 1943–1969.

Det var i gymnasieårene på Voss, hvor Ole B. Lundetræ var elev av entomologen, lektor Nils Grønlien og klassekamerat av senere førstekonservator Nils Knaben, at de naturhistoriske interessene ble rettet mot insektene og etterhvert forankret i lepidopterne. Sin lærergjerning i Djønno kombinerte han med en livlig entomologisk aktivitet og samlet inn et stort materiale. Lepidopterne stod ham alltid nærmest, men han hadde også et våkent blikk for andre insekter hvilket bl.a. resulterte i forbausende funn av maurløven *Myrmeleon formicarius* Linnaeus (jfr. Norsk Ent. Tidsskr. 5, 1939), tidligere bare kjent fra områder ved Oslofjorden. Etterat han flyttet til Utne måtte de entomologiske interessene stadig vike for offentlige og private plikter. Selvom han nok fortsatt samlet og bearbeidet sine samlinger så forble hans innerlige ønske om å publisere lepidopterfaunaen i Hardanger desverre en drøm. Det store materiale som han med reisestipendier fra daværende Bergens Museum samlet i begynnelsen av førtiårene og hans vakkert preparerte og determinerte privatsamling, som hans enke så generøst har forært Zoologisk Museum i Bergen, vil imidlertid for alltid vitne om hans forskerinnsats.

Ole Bernhard Lundetræ var allerede fra 1938 medlem av Norsk Entomologisk Forening, men nevnte ofte at det var bakvendt å bo så isolert at han ikke fikk mere kontakt med entomologer. Vi som var så heldige å få lære ham å kjenne vil alltid minnes den lune, beskjedne og flittige kollega.

Astrid Løken

ERRATUM: Vol. 18, No. 2, 1971
Text to Fig. 7, page 83 should read: Ventral view of head of *Phryganea bipunctata* (a) and *Agrypnia obsoleta* (b).

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