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ABUNDANCE AND MORTALITY OF THE PERCH FRY (PERCA FLUVIATILIS, LINNAEUS, 1758) IN THE KLÍČAVA RESERVOIR

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Abstract: The abundance of the perch fry in the Klíčava reservoir during the years 1967, 1970 and 1971 was studied. The number of the fry in August to October 1967 was estimated as 243318, 4827 in August to September 1970, 96657 in August 1971 and 76631 in September 1971. There is a decreasing trend in successive values of all estimations, which is connected beside other factors with the initially great and subsequent lower number of fish captured. The successive estimated values descend to the final known value. On the basis of two consecutive estimations in the year 1971 the value of daily mortality of perch fry was calculated as 0.66%. Mortality values in fry of different fish species when compared among themselves lead to the conclusion that the values in the embryonal and larval development periods are considerably fluctuating. After these periods (in the juvenile period) the values of daily mortality are stable and have attained similar values in different fish species.

INTRODUCTION

Considerable attention is being paid now to the estimation of abundance number and mortality rates of fry in different fish species. Number of the fry is estimated with area method Menšutkin et al. (1968) and Zuromska (1967a). A further suitable method is the mark and recapture method. Problem of the last method consists in durable marking of sufficient amount of fry necessary for the estimation. In this method the fry is usually marked by staining with vital colours (Lawler and Fitz-Earle, 1968; Zuromska, l.c.). Another way for marking of fry are fluorescent colours of tetracyklin preparation, radioactive isotope and fluorescent pigments (see in Peňáz, 1970). In larger perch fry it is possible to apply the common method of fin clipping, which enables the detection of marked fish even after a long time. The knowledge of abundance and mortality rate of fry in the first year of their life has basic significance for the calculation of production. After the findings of Hunt (1966, cited after Chapman, 1968) the production of brook trout (*Salvelinus fontinalis*) amounts to 80—92% (age 0.1) of the whole production value. In perch the proportion of fry production (age 0) to the production of all age groups is 59—92% (Pivnička, 1971).

In view of the fact that the perch is one of the most abundant fish species in the Klíčava reservoir, we started on the estimations of abundance of its fry in this locality in 1967. From two successive estimations in the year 1971 the mortality rates of perch fry was calculated and compared with those of other fish species.

MATERIAL AND METHODS

The estimations of perch fry in the different years 1967, 1970 and 1971 were undertaken in the Kličava reservoir (Central Bohemia) in the strait between the island and north shore of the reservoir (Fig. 1). After hatching the fry is relatively equally placed along the shores of the reservoir, but in the second half of June the fry is concentrated on several places only (Fig. 1) and during the estimation of August to October the fry is gathered mostly in the investigated area of the reservoir near the island. These distributions of the fry follow partly from the test catches

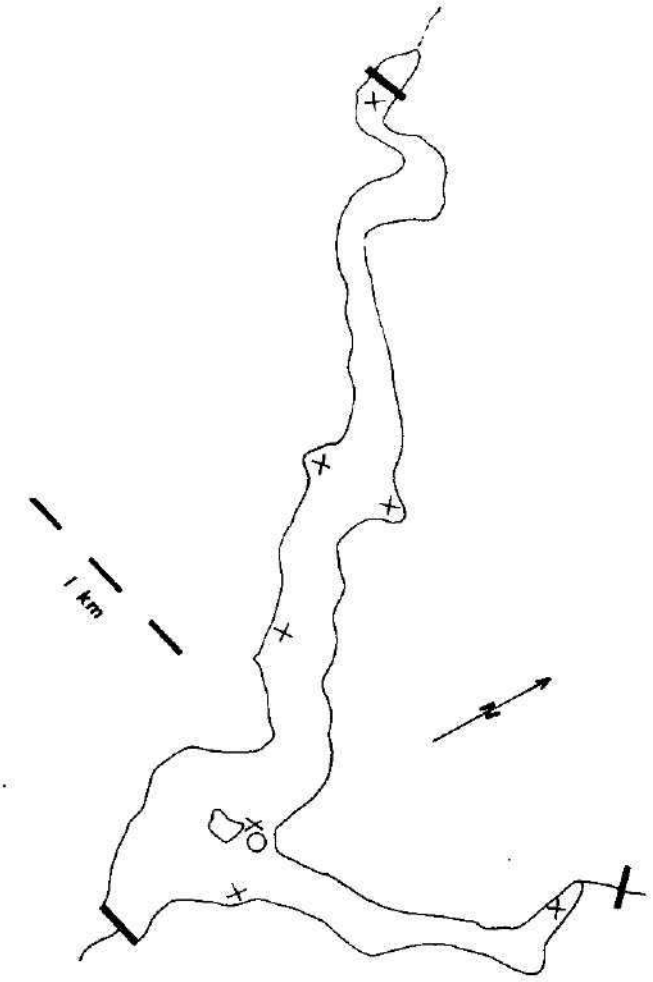

Fig. 1. The map of Kličava reservoir showing the investigated area ○ and places of occurrence of perch fry in the middle of June 1971 +.

in Breder's traps and partly from visual observations which were done in different places of the whole reservoir.

The shore near the island, where the perch fry was captured, when full of water has a mean depth of 2.5 m and a mean area of about 40 ar. Towards the free water the area in question is bordered with increasing depth of water. Most part of the shallow is covered with vegetations *(Ceratophyllum demersum)* in the period of investigations, the bottom is more or less flat. The fry was captured with a large drop net having surface 9 m^2 and mesh size of 10×10 mm. In the middle

part the drop net was strengthened with the silon tissue with mesh size of 1 × 1 mm (surface 4 m²). The data of individual catches are summarised in the Tab. 2.

The captured fry was concentrated in polyetyl baths in which the water was often changed. After concentrating great number the fry were marked using fin clipping method in the years 1967, 1970 and 1971. In 1970 we tried to apply after previous laboratory tests, the staining method using the Bismarck brown as colouring material. Because of great loss, the staining method had been abandoned and the fry was marked by clipping one of the ventral fins.

Schnabel's method was used for the estimations according to formula $\hat{N} = \frac{\sum_{t=1}^{n} C_t M_t}{R}$ where n = number of days in the experiment, M_t = the total number of marked perch fry at the start of day t, C_t = the total sample taken on the day t and R = the total number of recaptures during the experiment through day t (Barr, 1971). The confidence limits were calculated from the equation $N\bar{N} = \frac{B \pm \sqrt{B^2 - 4AC}}{2A}$ where $A = R^2$, $B = (2R + 3.841) \cdot (\sum_{t=1}^{n} C_t M_t)$, $C = (\sum_{t=1}^{n} C_t M_t)^2$. The equation is the same as that used by Oliva and Holčík (1965) only the symbols are different. The values of daily mortality Z were calculated from the equation $Z = \frac{\log_e \hat{N}_0 - \log_e \hat{N}_t}{t}$. The first value of abundance of the perch fry in the year 1971 was established by counting the belts of perch eggs in the whole reservoir. For the calculation of mortality the mean values ($\hat{N}$) of estimations were considered.

RESULTS AND DISCUSSION

Staining of the perch fry

There should be a sufficient number of well marked perch fry for the proper assesment of the population number by the mark and recaptured method. In some species as in perch it is possible to apply the method of fin clipping after the fry attained the size of 3—4 cm. However, in smaller perch fry this method is not applicable. In other fish species such as roach (*Rutilus rutilus*) and chub (*Leuciscus cephalus*) even the fish of about 5—6 cm in size cannot be marked

Table 1. The changes in staining intensity of the perch fry using Bismarck brown during 6 days after staining (concentration 1 : 15,000, time of staning 3 hours).

Day	Colouration
0	All fins intensively brown, the whole body yellowish-brown especially striking on the pale sites of body hips, abdomen, lower part of the head.
1	Without changes.
2	Decreasing in intensity of colouration on the dorsal and ventral parts of the body. All the fins, upper and lower parts of the head intensively brown up to this time.
3	The dorsal and ventral parts of the body without colouration, the other parts show the decrease in intensity of colouration.
6	Only the top of the head faintly coloured.

by fin clipping method for technical reasons. The fry of this species is very slippery, is difficult to hold in the hand and loses the scales easily. The fish which was handled have often the internal injuries, very often get infected with fungi or become easy prey to carnivorous species. The estimation of this

Table 2. Estimation of perch fry in the Klíčava reservoir in 1967, 1970 and 1971 years. D_t — dead fish from the sample C_t, r — recaptured fish in each period.

t	Date	C_t	D_t	C_t-M_t	M_t	C_tM_t	ΣC_tM_t	r	R	$\hat{N}$	Year
0	24. 8.	640	—	640	—	—	—	—	—	—	1967
1	6. 9.	700	—	700	640	448000	—	—	—	—	August–
2	28. 9.	83	—	81	1340	111220	559220	2	2	279610	October
3	4.10.	53	6	47	1421	75313	634533	—	2	317267	
4	11.10.	65	25	39	1468	95420	729953	1	3	243318	
0	31. 8.	415	390	25	—	—	—	—	—	—	1970
1	1. 9.	219	49	169	25	5475	5475	1	1	5475	September
2	2. 9.	542	3	512	194	105148	110623	27	28	3951	
3	3. 9.	361	7	298	706	254866	365489	56	84	4351	
4	4. 9.	36	6	16	1004	36144	401653	14	98	4098	
5	8. 9.	271	3	98	981	265851	667504	52	150	4450	
6	24. 9.	184	6	146	1079	198536	866040	32	182	4758	
7	29. 9.	30	2	23	1225	36750	902790	5	187	4827	
0	9. 8.	1450	—	1450	—	—	—	—	—	—	1971
1	10. 8.	1521	89	1422	1450	2205450	2205450	10	10	220545	August
2	11. 8.	1570	101	1404	2872	4509040	6714490	65	75	89526	
3	12. 8.	1244	267	932	4276	5319344	12033834	45	120	100281	
4	13. 8.	232	50	165	5208	1208256	13242090	17	137	96657	
0	13. 9.	526	11	515	—	—	—	—	—	—	1971
1	14. 9.	354	1	352	515	182310	182310	1	1	182310	September
2	15. 9.	133	—	131	867	115311	297621	2	3	99207	
3	16. 9.	89	7	80	998	88862	386483	2	5	77297	
4	17. 9.	68	5	62	1078	73304	459787	1	6	76631	

11. 10. 1967	$\hat{N}$ = 243 318	C. i.	47997 < $\hat{N}$ < 802126
29. 9. 1970	$\hat{N}$ = 4 827	C. i.	4184 < $\hat{N}$ < 5571
13. 8. 1971	$\hat{N}$ = 96 657	C. i.	82217 < $\hat{N}$ < 113807
17. 9. 1971	$\hat{N}$ = 76 631	C. i.	35124 < $\hat{N}$ < 167182

species is impossible for these reasons. It is necessary to use a method, which involves marking of fish without manual handling. Staining with vital colours is the most suitable one for this purpose. Usually the Bismarck brown is applied. Deacon (1961), Ward and Verhoeven (1963), Zuromska (1966) and Lawler and Fitz-Earle (1968) found that generally the staining with Bismarck brown was of longer resistence and of lower toxic effect than some other vital stains (neutral red, *Nil* blau etc.). From different concentrations recomended we used the concentration 1 : 15,000 with the duration of staining of 3 hours on the basis of laboratory tests. In aquarium with that concentration the colouration of perch fry in the average size of 5 cm was clearly observed during 6 days. Any changes in the behaviour of the fry in the applied concentration and duration of staining of 3 hours was not observed after transfering of fry into clear water and no mortality in the time of

laboratory tests was found either. Changes in colouration of perch fry during each day are summarized in the table 1.

In the field investigations the high value of mortality of stained fry was found from the inception of staining. Using the concentration 1 : 15,000 and 3 hours time of staining the losses were up to 90%, using 2 hours time of staining the losses were still 72%. This high value of mortality was caused firstly by inadequate aeration of water in the staining tubes and secondly by the insoluble Bismarck brown. We abandoned this method of marking and later used the fin clipping method which is used for the body size beginning from about 4 cm. The perch fry tolerates this method of marking well and the losses were small (about 10%). The advantage of this method can be seen from the fact that in the next year it was possible to catch the previously marked fish. For example 25% of first age class caught in the spring 1971 was marked in September of the previous year. This is the same proportion as that between number of caught and estimated perch fry in September 1970.

Estimation of population number

The results of estimations of perch fry populations in the different years are summarised in tab. 2. The estimations from the year 1967, 1970 and partly from the year 1971 show a decreasing trend in their values in successive periods in contrary to the estimations values in successive periods of adult perch, roach and chub in the Klíčava reservoir (Pivnička, 1971). The low number of captured fish (C) and subsequently also the low number of marked fish (M) in the beginning of estimation is the most characteristic fact for the estimations of adult individuals. The first MC products are for this reason too low and the successive values of estimations ascend slowly to the final known value. The two requirements $MC > 4N$ and $M = C$, which are necessary for the Petersen type of estimation are not fulfield (Robson and Regier, 1964). When we estimated the perch fry abundance we found quite opposite relations i.e. just at the beginning of estimations the number of caught (C) fry was great and the value of the first product (MC) was also high. Later in subsequent estimations the number of perch fry in catches decreased and simultaneously the value of R which was not proportional to the MC products in the first periods increased and therefore the values of successive estimations decreased i.e. descending to the known value.

These two types of the course of estimation values i.e. ascending and descending to the known value may be clearly seen in the model (Figs 2., 3., 4). In the model fig, 2. the number of "fish" (500) is known and the number of caught (C) and marked (M) "fish" are low. The successive estimation values ascend to the known value, which is analogous to the course of estimation in adult roach, perch and chub in the Klíčava reservoir. In fig. 3 and 4 the number of "fish" is again known, but the initial value of captured fish (C) in the case of fig. 3 is high and the number of marked "fish" (M) is low in contrast to the situation in fig. 4, where the number of captured fish is low and the number of marked fish is high. In both cases (Figs 3., 4) the products (MC) are high and the successive values of estimate descend to the known value. In the case of perch fry estimations in Klíčava reservoir the situation is to a certain extent the same as those indicated at first in fig. 4 and then in fig. 3. The values of estimation of course depend also on the fulfilment of all the assumptions necessary for the estimations of fish (Lagler, 1959).

Basing on the values of confidence limits it is clear that the most accurate estimations are from the years 1970 and 1971 (August). The estimation from September 1971 is less accurate and the estimation from the year 1967 has only an informative character.

Thus different strenght of individual age groups of perch recruiting the population in the years 1967, 1970 and 1971 is well evident. 243318 perch fry

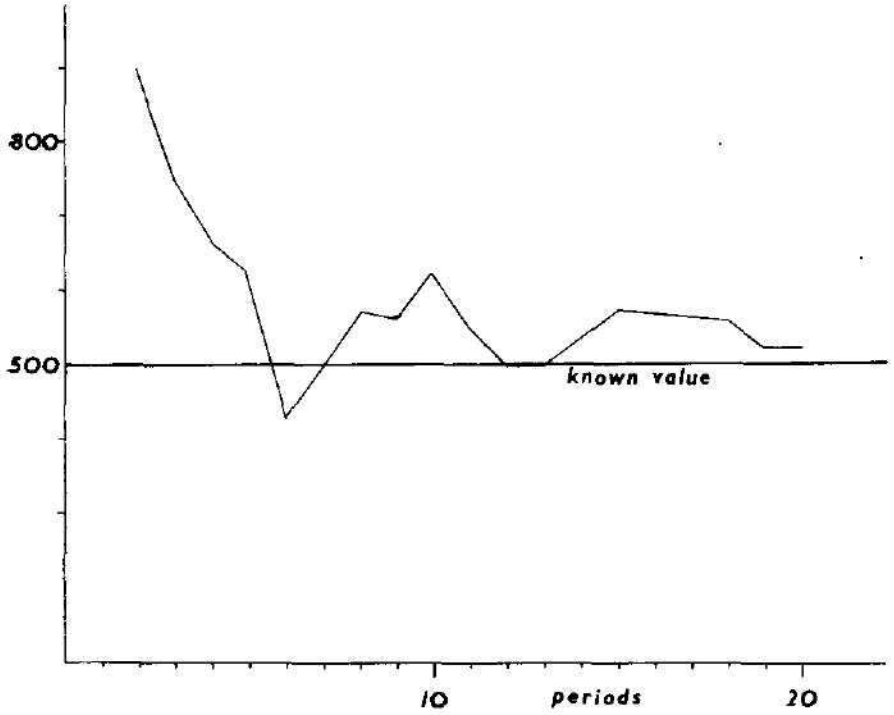

Fig. 4. The estimation values of abundance. N = 500, M = 5, C = 100. The successive values of estimation are descending to the known value.

were estimated in the year 1967, 4827 in 1970 and 76631 perch fry in 1971. From these data it is obvious that the population number of perch fry in 1967 is nearly 50 times higher than that in 1970 and that in 1971 nearly 20 times higher than that in 1970.

Nikolsky (1965) investigating the fluctuation in the population number of individual age groups found that the abundant age groups could be 50—90 times greater than the weak ones e.g. in the genera *Gadus* and *Clupea*. Different strength of individual year classes had also been observed by LeCren (1955), McCormack (1965) and Rudenko (1962) in the case of perch. The duration of the strong age group in population is referred to as "cycle" by Rudenko (l.c.) and this cycle is considered to be 4 to 8 years by him. Rudenko (l.c.) considers the fluctuation in the number of individual perch age groups to be due to the young perchs being devoured by older ones which are numerous. During the successive years the older age groups die and the newly born young are recruited into the population. This cyclic fluctuation in

the perch was observed by Holčík (1969) in the Klíčava reservoir and a 4 year long cycle in the case of the roach was found in the same reservoir by Pivnička (1972). From our results it is obvious that the low abundance of younger individuals cannot be explained only by the presence of numerous older age groups. For example in 1967 in the Klíčava reservoir there were 2924 perchs in the 4th and older age groups and the number of perch fry in October

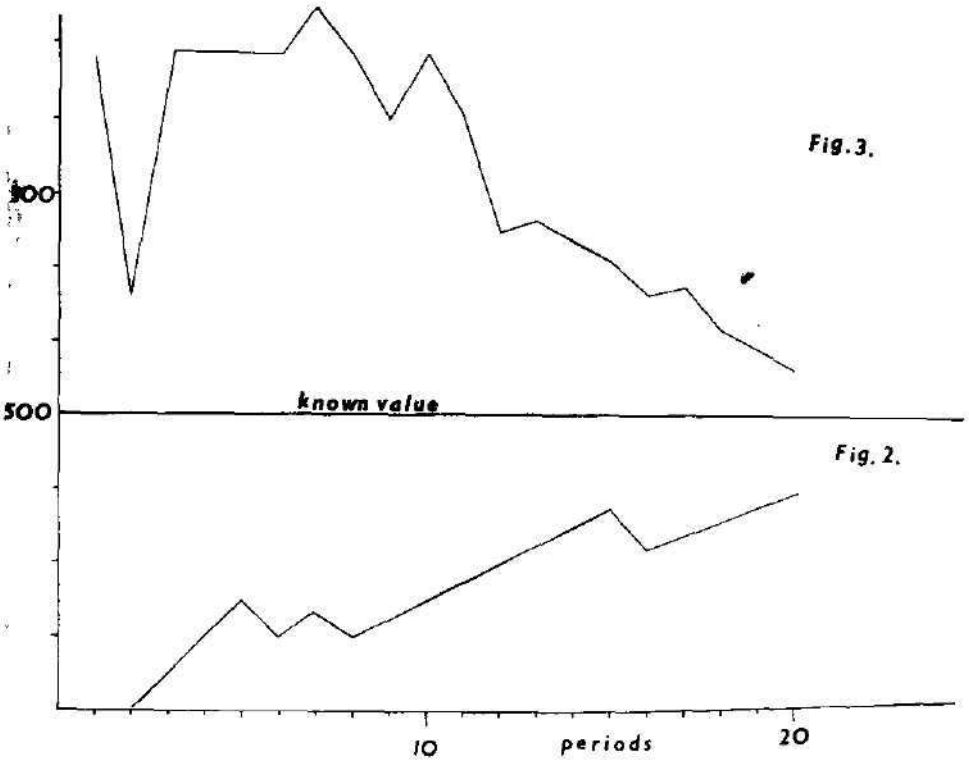

Fig. 3. The estimation values of abundance. N = 500, M = 100, C = 10. The successive value of estimation are descending to the known value.
Fig. 2. The estimation values of abundance. N = 500, M = C = 10. The successive values of estimation are ascending to the known value.

amounted to 243318, 3712 perchs in the year 1970 in 4th and older age groups and the number of fry in September reached 4827. Finally in 1971 there were 2939 perchs in the 4th and older age groups and the number of fry amounted to 76631.

Using food analysis in the perch population and studying the mortality of perch fry Menšutkin et al. (1968) came to the conclusion that cannibalism only could not cause the high mortality rates of perch fry which was in conformity with our findings. It is clear from the great number of observations of different strength in individual fish age groups that this fluctuation is a quite regular phenomenon in the population dynamics of fish. Some factors causing this fluctuation in the strength of age groups will be mentioned further.

Table 3. Mortality of the fry of different fish species during the first year of life

Species	Date	Number of days	Calculation of daily "Z"	Daily "Z" in %	Date of hatching	Remarks
Rutilus rutilus	26. 5. –6. 6. 1971	11	$\frac{\ln 100 - \ln 0}{11}$	41.9	26. 5.	temperature 23° C, starving (Černý, unpublished data)
	26. 5—13. 6. 1971	18	$\frac{\ln 100 - \ln 6}{18}$	16.1	26. 5.	temperature 17° C, starving (Černý, unpublished data)
	26. 5.—13. 6. 1971	18	$\frac{\ln 100 - \ln 40}{18}$	5.1	26. 5.	temperature 17° C, feeding (Černý, unpublished data)
	26. 5. –13. 6. 1971	18	$\frac{\ln 100 - \ln 68}{18}$	2.1	26. 5.	temperature 23° C, feeding (Černý, unpublished data)
Perca fluviatilis	30. 5. – 6. 6. 1966	7	$\frac{\ln 134 \times 10^5 - \ln 23 \times 10^5}{7}$	25.1	before 30. 5.	natural conditions (Menšutkin and al., 1968)
	15. 5.– 2. 6. 1971	18	$\frac{\ln 17 \times 10^6 - \ln 25 \times 10^5}{18}$	10.7	15. 5.	natural conditions (authors' data)
	15. 5.—13. 8. 1971	90	$\frac{\ln 17 \times 10^5 - \ln 95000}{90}$	5.6	15. 5.	natural conditions (authors' data)
	13. 8.—17. 9. 1971	35	$\frac{\ln 96657 - \ln 76631}{35}$	0.66	15. 5	natural conditions (authors' data)
Salvelinus	26. 3.—26. 6. 1961	92	$\frac{\ln 9035 - \ln 976}{92}$	2.42	26. 3.	natural conditions (Latta, 1962)
fontinalis	26. 6.—24. 7. 1961	28	$\frac{\ln 976 - \ln 804}{28}$	0.69	26. 3.	natural conditions (Latta, 1962)
	24. 7.—19. 9. 1961	57	$\frac{\ln 804 - \ln 598}{57}$	0.52	26. 3.	natural conditions (Latta, 1962)
Oncorhynchus	1. 4.—10. 7. 1962	100	$\frac{\ln 65000 - \ln 5000}{100}$	2.57	1. 4.	natural conditions (calculated after the data of Capman, 1965)
kisutch	10. 7.—25. 2. 1963	230	$\frac{\ln 5000 - \ln 1250}{230}$	0.6	1. 4.	natural conditions (calculated after the data of Chapman, 1965)

Mortality rates

The daily mortality values of fry of different fish species are summarized in tab. 3. In the case of perch we had to use, for the first days of their life, the value of mortality in the lake Razdelnoe found by Menšutkin et. al. (1968). The initial abundance of fry after hatching (30. 5. 1966) in this lake was about 13.4 millions. After 7 days (up to 6th June) this abundance decreased to 2.3 millions and from these two values of abundance, the daily mortality was calculated as 25.1%. This value of daily mortality cannot be verified in the conditions existing in Klíčava reservoir but it is possible to compare it with the value of daily mortality found in roach fry in the experimental aquariums under different temperature and food conditions (Tab. 3). One can see the daily mortality in perch fry found by Menšutkin et al. (1968) under natural conditions is very high during the first 7 days of their life. After 18 days of life the value of daily mortality of perch fry decreased to the value of 10.7%, which can be obtained by interpolation as in fig. 5. This value of mortality is between the values of 5 1% and 16.1% obtained for roaches which were fed and starved respectively and reared under experimental conditions (temperature 17°C). The relatively high value of daily mortality of perch fry was influenced by a number of factors which were eliminated in aquarium conditions.

Under natural condition in the Klíčava reservoir over the whole shore 1205 belts of perch eggs were counted which would amount to 17 millions eggs and larvae in the whole reservoir if the mean fecundity is taken as 14,100 eggs (Rejnek, 1969). This initial number of larvae decreased after 7 days to 2.94 millions perch larvae (calculated using 25.1% as daily mortality). We assume May 15th as the day of hatching and consequently on 22. 5. 1971 there were 2.94 millions of perch larvae in the reservoir. The first estimation of perch fry starting on August 13th gave the number of fry as 96657. There was an interval of 83 days from the 22nd of May to this date and the value of mortality during this period was calculated as 4.1%. The second estimation of abundance (76631) was completed by September 17th. The value of daily mortality between both estimations was calculated as 0.66%. If we consider this value to be approximately constant till the spring of the next year we can expect 15,000 perch fry in the spring 1972 (Fig. 5.).

For example 4827 of perch fry were estimated in the year 1970 to the date September 29th. Considering a daily mortality of 0.66% this number gives about 1000 specimens of first age group in the spring 1972. In reality only 560 specimens of the first age group in this year were estimated, which was probably caused by the fact that the first age group was usually underestimated because the females belonging to this age group were absent in the spawning shoals. The comparison of daily mortality values in different fish species during their first year of life is very interesting. The high values of mortality which occurs in the first days after hatching decrease gradually. One can see this decreasing trend from the mortality curve (Fig. 5.), This is very obvious when the embryonal and larval periods pass on to the next stage which falls approximately on the beginning of July. Řepa (1969) collected perch fry corresponding to the beginning of juvenile period in Klíčava reservoir also at the same time. It seems, that the decrease of daily mortality is connected with transition to the juvenile period. If we calculate the daily mortality of perch fry during the period from the date of hatching that is May

15th to August 13th (90 days), we obtain 5.6% as the value of daily mortality on the assumption that 100% of the larvae hatch and the daily mortality of 5.1% on the assumption that 65% of the larvae hatch. Chapman (1965) also assumed that 65% larvae hatch in coho salmon (*Oncorhynchus kisutsch*), and found 2.57% value of daily mortality in the first 100 days after hatching. In the case of brook trout (*Salvelinus fontinalis*) Latta (1962) calculated the

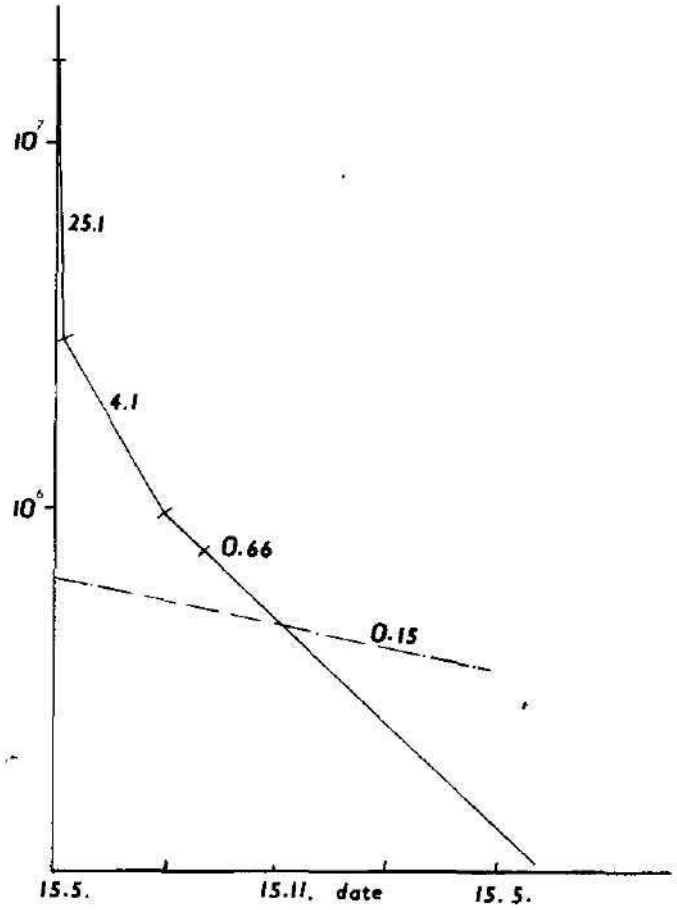

Fig. 5. The course of daily mortality values of perch fry during the first year of their life. Broken line with dots indicates the course of daily mortality in adult individuals of perch (2nd-8th age groups).

value of daily mortality as 2.42% in the first 92 days after hatching. Thus the daily mortality in this phase of perch fry was found considerably higher than that in the salmonoid fish. From the three types of mortality curves mentioned by Marr (1956) the course of the mortality curve of perch fry is the type which can be characterised by great decrease in abundance during some days after hatching. In salmonoid fish it can be observed that there is a more or less slow decrease in abundance during this time of life. Besides the drastic decrease in

abundance during the first days after hatching, considerable fluctuation in strength of different age groups occurs, too. The species with fluctuation in strength of different age groups exhibit the type of mortality curve referred to above and it is in agreement with the findings of Nikolsky (1965).

In further period, after roughly three months of life the values of daily mortality considerably decreased and attain similar value as in different fish species. The perch fry from the Klíčava reservoir reaches the mortality value of 0.66%. Latta (1962) has established the value of daily mortality for brook trout fry as 0.69% and 0.52% and Chapman (1965) has found a daily mortality of 0.60% for coho salmon. The value of daily mortality of older perch age groups (2—8) reaching 0.15%.

The causes of high mortality values in the first several days after hatching in fry of different fish species are explained in different ways. Zuromska (1957a, b) and Dechnik et al. (1970) consider the vertebrate and invertebrate predators as the most important factors causing the high value of fry mortatality. Balon (1956, 1961) Menšutkin et al. (1968) and others emphasize the influence of food insufficiency in the period of transition from the endogen to exogen feeding. The last author pointed out from the model experiments that the mortality of perch fry in the case of three different types of constant temperature and amount of food was closely connected with the initial number of fish stock. Within the framework of this different fish stock, mortality appears very inconsistant and can be estimated within 100% variability. Menšutkin et al. (l.c.) attributes the highest significance to the amount of food. However, it has been ascertained experimentally that the mortality in transition from endogen to the exogen feeding had increased also under experimental conditions with the sufficient amount of food, where the larvae normally accept the food (Vladimirov, 1964; Peňáz and Štěrba 1969). Vladimirov (l.c.) assumes that the main cause of high mortality of fry in their early development stages consists in the bad quality of sexual products of parental fish. A certain correlation between air temperature in the period of approximately 20 days after spawning and the amount of newly born roaches was also found by Pivnička (1971) in the Klíčava reservoir. In the years 1960, 1963 and 1967 when the temperature uniformly increased the newly born age groups were most numerous. The lowest values of zooplankton concentration in the corresponding years was established by Straškraba (1967). The influence of temperature on perch fry was studied also by Kudrinskaja (1970). She stated that under lower temperature in spite of sufficient amount of food, the development of perch fry retarded and therefore a higher mortality might be expected. From these facts it follows that in initial life periods of perch fry the mortality is influenced by many factors; the importance of which have been interpreted differently by many authors. These factors, however, act together in different degrees of importance in different localities (Peňáz, 1970). These periods having been overcome, the mortality stabilizes and shows very similar values in different fish species. In the first days of life it is then impossible to predict the mortality trend of fry, knowing the number of eggs but after two or three months we can consider the estimate value of mortality as approximately constant till the end of the first year of life.

SUMMARY

1. The abundance of the perch fry in Klíčava reservoir was estimated as 243318 in the year 1967, 4827 in the year 1970, 96657 in August 1971 and 76631 in September 1971. We found a high fluctuation in the abundance of first age group in different years.

2. The values of all estimations have a decreasing trend in the course of the estimation and descend to the known value which is contrary to the course of estimations in adult individuals of the perch, roach and chub in Klíčava reservoir during the years 1967 to 1971.

3. The fin clipping method can be applied for the estimation of perch fry beginning with the body size of 4 cm. Marking by Bismarck brown cannot be used without through aeration of staining solution in the case of fish longer than 4 cm.

4. From the two estimations in the year 1971 the value of daily mortality was calculated as 0.66%. From the date of hatching (May 15th) to the date of first estimation (August 13th) i.e. after 90 days, the value of daily mortality reached the values of 5.6% and 5.1% on the assumption that 100% and 65% of the larvae hatched, respectively. During the same period after hatching the daily mortality of 2.57% was attained in the case of coho salmon and 2.42% in the case of brook trout.

5. The high initial value of daily mortality of the perch fry decreased very clearly after overcoming the juvenile period of life which corresponds approximately to the beginning of July under the conditions in Klíčava reservoir. The values of mortality in this period are very similar in different fish species and are very stable (perch 0.66%, coho salmon 0.60%, brook trout 0.69%). This fact has a great importance in the calculation of production values of fish of the first age group.

6. The fluctuation of strength in different age groups is caused by great difference in the values of daily mortality of the fry, which is influenced by many factors. The degree of importance of their activity can be different in different years.

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ABHÄNGIGKEIT DER ENTWICKLUNG DER EMBRYONEN DER PLÖTZE, RUTILUS RUTILUS (LINNAEUS, 1758) VON DER WASSERHÄRTE

STANISLAV FRANK

Eingegangen am 21 August 1972

Abstrakt Die Plotze ist ein in den europaischen Suss und Brackwässern haufig vor kommender Karpfenfisch (Cyprinidae) Trotz ihrer betrachtlichen geografischen Verbreitung und ihrer ausserordentlich grossen Anpassungsfahigkeit an ihr Lebensmilieu ist die Sterblich keitsrate der Plotzenembryonen wahrend der Entwicklungsperiode von der Eibefruchtung bis zum Freischwimmen der Brut stark von der Wasserharte abhangig Aus unseren Experimenten geht hervor, dass der optimale Wasserhartebereich fur die Entwicklung ihrer Eier und Larven bei 7—10° dGH liegt Bei einer Herabsetzung der Wasserharte auf 1,8° dGH betragt die Mortali tat bereits 41%, und bei einer Erhohung der Wasserhärte auf 18° dGH steigt sie sogar auf 54%, wobei die Erhohung der Karbonatharte einen viel negativeren Einfluss auf die Entwicklung ausubt als eine Erhohung der Sulfatharte bzw Nichtkarbonatharte

EINLEITUNG

Susswasserfische sind Bewohner der verschiedensten Wassertypen Die einzelnen Arten stellen vor allem im Jugendstadium, zum Teil aber auch als erwachsene Fische, verschiedene Anforderungen an die Wasserzusammensetzung. Die Mehrzahl der tropischen und subtropischen Fischarten ist dem Leben in weichem Wasser angepasst, und ihre Eier und Larven entwickeln sich nur in Wassern eines bestimmten Hartebereiches An eine besonders niedrige Wasserharte sind sowohl Fischarten aus den Gewassern des tropischen Regenurwalds als auch solche aus periodischen Gewassern gewohnt

Bei den Fischen der gemassigten geographischen Zone wurde bisher dem Einfluss der Wasserzusammensetzung auf die Entwicklung der Eier und der Brut noch keine genugende Aufmerksamkeit gewidmet Wenn man von ausgesprochen giftigen Stoffen, die das Susswasser in Form von Industrieabwassern verunreinigen, absieht, ist das Haupthindernis fur die Entwicklung aller Susswasserfische die Wasserharte und die praktisch in allen Oberflachengewassern in verschiedenen Mengen enthaltenen Nitrite Bei unseren Beobachtungen haben wir unsere Aufmerksamkeit lediglich auf den Einfluss der Wasserharte auf die Sterblichkeitsrate der Embryonen und Larven der Plotze beschrankt

MATERIAL UND METHODIK

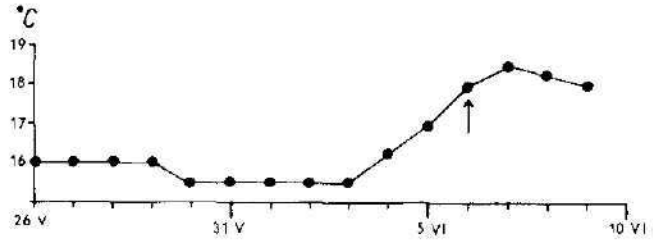
Vierzehn Tage vor dem Ablaichen der Plotze im Klčava Stausee stellten wir sechs gleich grosse Vollglasbecken (36 × 23 × 26 cm, das zuletzt genannte Ausmass ist die Hohe) bereit, die wir mit je 15 Liter Wasser fullten Wahrend der ganzen Versuchszeit war die Durchluftung in allen sechs Becken gleich stark und die Temperatur gleich hoch (siehe graphische Darstellung 1) Die Aquarien enthielten weder Bodengrund noch Wasserpflanzen Wahrend der Entwicklung der Eier und der Brut wurde kein Desinfektionsmittel beigegeben

Das Wasser verschiedener Harte wurde bereits am 12 Mai 1972 auf folgende Weise vorbereitet Als Basis diente das Wasser des Klicava Stausees, das am selben Tag entnommen wurde Es wies eine Gesamtharte von 18° auf Fur das Experiment Nr 1 wurde dieses Wasser mit Schneewasser auf 1,8° dGH verdunnt Fur das Experiment Nr 2 wurde Wasser aus einem Zufluss in den Teich nahe von Jevany mit einer Gesamtharte von 6° verwendet Fur das Experiment Nr 3 wurde das Klicava Wasser mit Schneewasser auf eine Harte von 9° dGH eingestellt Beim Kontroll experiment Nr 4 wurde zum Verdunnung des Klićava Wassers anstelle von Schneewasser destiliertes Wasser verwendet, das nun ebenfalls eine Gesamtharte von 9° aufwies Das Experiment Nr 5 basierte auf Prager Leitungswasser, das an diesem Tag eine Gesamtharte von 13° hatte Fur das Experiment Nr 6 schliesslich wurde Originalwasser aus dem Klicava Stausee von 18° dGH in einer Entfernung von etwa 30 m von der Sperrmauer dicht unterhalb der Wasseroberflache entnommen Genaue Angaben uber die Wasserzusammensetzung enthalt die Tabelle 1 Alle Wasser der verschiedenen Hartegrade wurden vor dem Einbringen der Eier in die Versuchsbecken 14 Tage lang durchluftet Sie waren ausnahmslos kristallklar

Am 26 Mai 1972 wurden an verschiedenen ufernahen Stellen, an denen die Plotzen zu dieser Zeit ablaichten, kleine Steinchen mit den daran festhaftenden Eiern eingesammelt Die Gesamthar te (dGH in der Tabelle und den graphischen Darstellungen) des Wassers betrug an diesen Stellen 15,7°, die Karbonatharte (dKH) 7,3°, die Nichkarbonatharte (dNKH) 8,4°, wobei Sulfate mit etwa 90% und Chloride mit lediglich etwa 10% vertreten waren Der pH Wert betrug 8,1, Nitrite waren nur mit 0,01 mg/l enthalten Das Ablaichen begann im Stausee am Vortage, d h am 25 Mai Das Alter der Eier von ihrer Zeitigung ab betrug daher maximal 24 Stunden Es wurden nur solche Steine gesammelt an denen die Eier auf der Oberseite in einer einzigen Schicht und moglichst weit voneinander entfernt angeklebt waren Damit wurde einer moglichen Verpilzung gesunder, sich entwickelnder Eizellen durch abgestorbene entgegengewirkt Die in der Eihulle abgestorbenen Embryonen bzw die verpilzten Eier wurden wahrend der ganzen Entwicklungsdauer ein bis zweimal taglich gezahlt und gleichzeitig mittels eines Glasrohrchens entfernt

ERGEBNISSE UND DISKUSSION

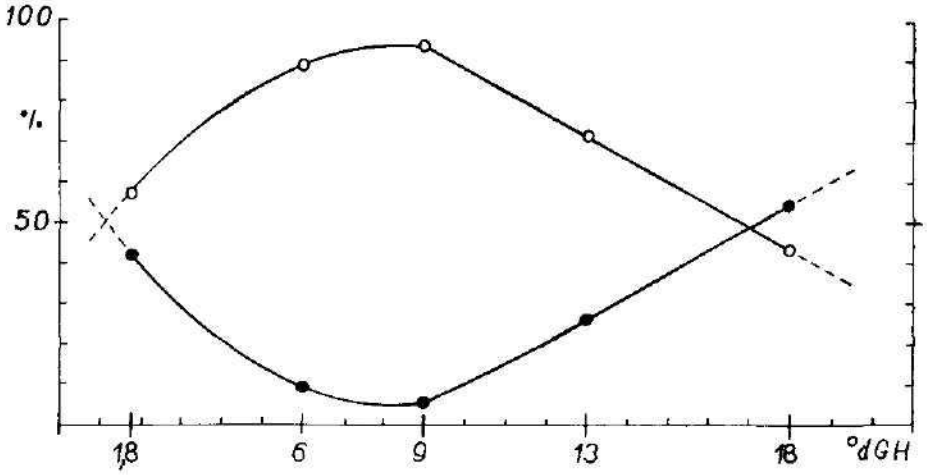
Die Entwicklung der Eier ging bei einer normalen Wassertemperatur von 15—16 °C vonstatten. Zur Zeit des Schlupfens und des Freischwimmens der Brut steigt die Temperatur dann gewohnlich auf 17—21 °C an Bei unseren Versuchen erschien auch ein solcher optimale Temperaturanstieg (siehe graphische Darstellung 1) Die Anzahl der unbefruchteten Eier betrug



Graphische Darstellung 1 Durchschnittliche Tagestemperaturwerte im Verlauf der Entwicklung der Plotzenembryonen, die in allen sechs Versuchsbecken mit verschiedener Wasserharte einheitlich waren (Der Pfeil zeigt das Ende des Schlupfens der Larven an)

bei den Experimenten Nr 1—6 in keinem Falle mehr als 2% (siehe Tabelle 1) Aus der Tabelle 1 und der graphischen Darstellung 2 ist die Abhangigkeit der Entwicklung der Plotzenembryonen von der Gesamtharte des Wassers deutlich ersichtlich Die fur die Entwicklung der Eier optimale Wasserharte beträgt etwa 8—9° dGH, bei einer solchen Harte liegt die Mortalitatsrate nur bei etwa 5% Sowohl darunter, als auch daruber steigt die Sterblichkeit stark an Bei 1,8° dGH wurde eine Mortalität von 41,4% und in einem Wasser mit 18° dGH schliesslich von sogar 54,4% festgestellt

Die Mortalitätsrate in der graphischen Darstellung 2 verläuft im linken und rechten Teil verschieden. Diese Schwankung wurde offensichtlich vom verschiedenen Grad der Karbonathärte beeinflusst. In den Experimenten Nr. 1 und 2 war die Karbonathärte sehr niedrig (nur 0,8 bis 1° dKH — siehe Tabelle 1), während sie bei den Experimenten Nr. 5 und 6 mit einer Gesamt-



Graphische Darstellung 2: Prozentuelles Gesamtverhältnis der sich normal entwickelnden und abgestorbenen Plötzenbrut während der Entwicklung, d. h. von der Befruchtung der Eier bis zum Übergang der Larven zur exogenen Nahrungsaufnahme je nach dem Wasserhärtegrad. (● = Mortalität, ○ = freischwimmende Brut.)

härte von 13 bzw. 18° höhere Anteile aufwies (im ersten Falle 7°, im zweiten Fall 8° dKH). Die Embryonen der meisten tropischen Fischarten sind im Verlauf ihrer Entwicklung gegen höhere Karbonatanteile sehr empfindlich, weniger dagegen gegen Sulfate oder andere im Wasser gelöste Salze (Chloride, Nitrate, Phosphate). Aus der graphischen Darstellung 2 geht deutlich hervor, dass auch die Embryonen der Plötze gegen Karbonate empfindlicher sind als gegen Sulfate. Dabei zeigt sich, dass die Karbonate ihre Entwicklung viel ungünstiger beeinflussen können als irgendwelche andere Salze.

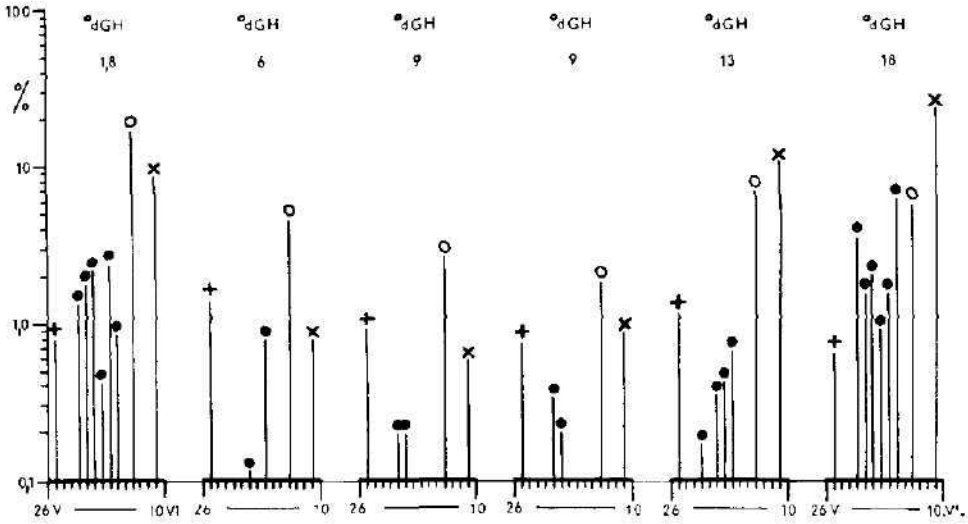
Die Wasserhärte nimmt ferner auch auf die Schlüpfdauer der Larven Einfluss. In sehr weichem, aber auch in zu hartem Wasser, also in beiden vom Optimum abweichenden Richtungen, konnte ein unregelmässiges und vorzeitiges Schlüpfen noch nicht vollentwickelter Larven hervorgerufen werden (siehe graphische Darstellung 4). In einem Wasser mit 9° dGH (also der Optimalhärte dieser Fischart) schlüpfte die Brut fast gleichzeitig in einem kurzen Zeitabschnitt von etwa 24 Stunden. Das Schlüpfen begann in den Nachmittagsstunden des 5. Juni, wobei die letzten Larven in den Vormittagsstunden des 6. Juni aus den Eihüllen fielen.

Im Wasser einer Gesamthärte von 9° dGH füllten sich die Schwimmblasen der Brut kurz danach bereits in 4—6 Stunden. Unmittelbar darauf begannen sie freizuschwimmen und gingen sofort zu exogener Nahrungsaufnahme über. In weicherem und härterem Wasser schlüpfte eine ungleichmässig entwickelte Brut. Ein Teil davon lag noch mit einem grossen

Tabelle 1

Experiment			1	2	3	4	5	6
Wassergemisch			Klíčava + Schneewasser	Zufluss in den Teich bei Jevany	Klíčava + Schneewasser	Klíčava + destiliertes Wasser	Prager Leitungswasser	Klíčava am Staudamm
°dGH			1,8	6	9	9	13	18
mval/l			0,64	2,14	3,22	3,22	4,64	6,43
°dKH			0,8	1	4	4	7	8
mval/l			0,28	0,36	1,43	1,43	2,50	2,86
°dNKH			1	5	5	5	6	10
mval/l			0,36	1,79	1,79	1,79	2,14	3,57
Nitrite — NO_2 mg/l			0,00	0,02	0,008	0,008	0,00	0,016
pH-Wert			6,8	7,2	7,2	7,3	7,4	7,9
Gesamtzahl der Eier zu Beginn des Experiments			822	760	870	774	1003	641
% der unbefruchteten Eier			1,—	1,7	1,1	0,9	1,4	0,8
Mortalitätsrate der Ebryonen während der Entwicklung im Ei in %	L a r v e n	5.—11. Tag	10,5	1,—	0,5	0,6	2,—	19,—
		12. Tag (Abschluss der Schlüpfzeit)	19,8	5,1	3,1	2,2	8,2	6,7
Mortalitätsrate vom Schlüpfen d. h. vom 12. bis zum 15. Tag der Entwicklung in %		mit nicht gefüllter Schwimmblase	6,8	1,—	0,7	1,—	12,8	21,7
		mit Bauchwassersucht	3,3	—	—	—	0,9	9,6
		mit Wirbelsäulenverkrümmungen	—	—	—	—	1,4	5,8
% der ausgeschlüpften Larven (ohne Rücksicht auf die Mortalität)			67,7	90,3	94,1	95,3	87,8	72,7
Mortalitätsrate im Verlauf der gesamten Entwicklung (im Ei und nach dem Schlüpfen)			41,4	8,9	5,4	4,8	26,6	54,4
Anzahl der freischwimmenden Exemplare mit gefüllter Schwimmblase in %			57,6	89,4	93,5	94,3	72,—	44,8

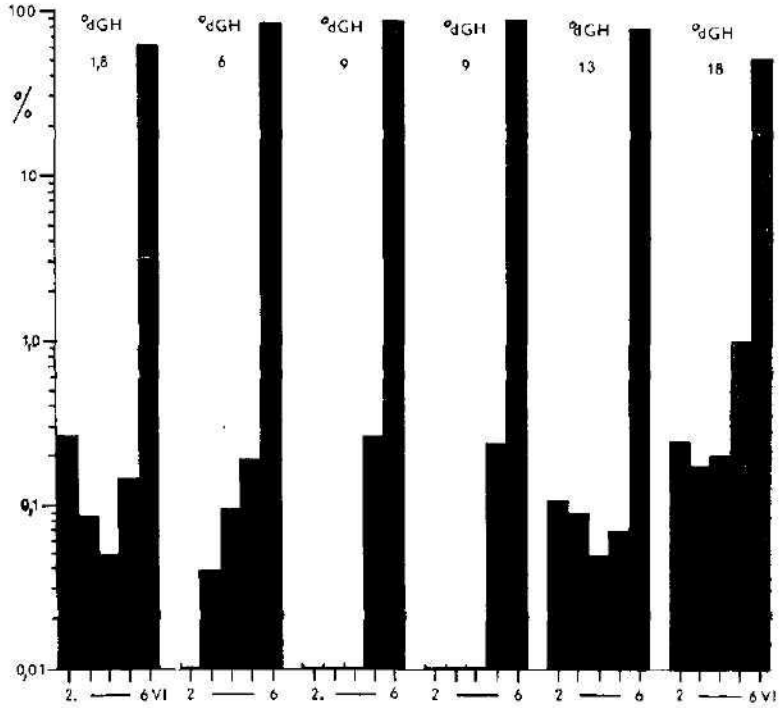
Dottersack am Boden oder hing an den Wänden des Beckens. Auch die Gasaufnahme in die Schwimmblasen verlief unregelmässig. Im Wasser mit 1,8, 6, 13 und 18° dGH schwammen manche Larven erst zwei Tage nach dem Schlüpfen frei, d. h. am 13. und 14. Tag der Entwicklung nach der Eibesamung. Alle Larven, die am fünfzehnten Tag noch nicht freischwammen, begannen zwar Futter zu fangen, bewegten sich mit lehren Schwimmblasen jedoch ruckartig nur mit Hilfe der Flossen sprunghaft schräg mit dem Kopf nach oben vorwärts und waren lebensuntüchtig.



Graphische Darstellung 3: Schwankende tägliche Mortalitätsrate der Embryonen im Verlauf der Entwicklung von der Befruchtung der Eier bis zum Freischwimmen je nach Wasserhärtegrad. (+ = Prozentsatz der unbefruchteten Eier, ● = Mortalität der Embryonen während ihrer Entwicklung im Ei, ○ = erhöhte Mortalität am Ende des Schlupfens, × = Exemplare, die die Schwimmblase bis zum Abschluss der Zeit des Freischwimmens nicht anfüllten.)

In weichem Wasser (1,8° dGH) wurde die höhste Mortalitätsrate der Brut gegen Ende der Schlüpfzeit festgestellt, während in hartem Wasser die Mortalität zur Zeit des Freischwimmens auffallend anstieg, da viele Larven nicht imstande waren, ihre Schwimmblase zu füllen. Sie konnten dadurch nicht freischwimmen und waren nicht in der Lage exogene Nahrung aufzunehmen (siehe graphische Darstellung 3). Unter den Exemplaren, die ihre Schwimmblase nicht anfüllen konnten, waren auch solche Larven, die bereits seit dem Schlüpfen verschiedene Schädigungen der Rückensaite und der zu diesem Zeitpunkt noch nicht verknöcherten Wirbelsäule aufwiesen. Sie waren teils mit der hinteren Körperhälfte nach oben, teils nach unten, dorsoventral verkrümmt oder aber zeigten eine seitliche gekrümmte Wirbelsäule. Die konstitutionelle Bauchwassersucht trat nicht nur in sehr weichem Wasser auf, wie sie gewöhnlich in einer solchen hypotonischen Lösung vorkommt, sondern wurde, wenn auch weniger häufig, auch im Wasser mit 13 und 18° dGH verzeichnet (siehe Tabelle 1). Es ist interessant, dass sich, von unbefruchteten Eier abgesehen, die Embryonen während der ersten fünf

Tage nach der Befruchtung der Eier im Wasser verschiedenen Härtegrades ziemlich regelmässig entwickelten. Erst während des 5.—11. Tages traten nach und nach Störungen in der Entwicklung auf. Die Mortalität war jedoch während dieser Zeit (5.—11. Tag) im Vergleich zu der gegen Ende des Schlüpfens, also am 12. Tag der Entwicklung, in allen Experimenten mit



Graphische Darstellung 4: Verlauf des Schlüpfens der Larven bei verschiedener Wasserhärte vom 8. bis 12. Tag der Entwicklung (vom 2. bis 6. Juni 1972). Der prozentuelle Anteil der vorzeitig ausgeschlüpften Larven in sehr weichem und zu hartem Wasser ist bedeutend höher.

Ausnahme des Experiments Nr. 6, niedriger. Im letztgenannten Falle im Wasser mit 18° dGH nämlich war sie im Gegensatz dazu etwa dreimal so hoch (siehe Tabelle 1).

Nach dem Freischwimmen nahm die Plötzenbrut lebende Nahrung (Rädertierchen, *Cyclops*-Nauplien) zu sich und wurde nicht weiter beobachtet. Es ist ja bekannt, dass plötzliche und beträchtliche Veränderungen der Wasserhärte selbst auf die empfindlichsten tropischen Fischarten, die an sehr weiches, nahezu härteloses Wasser gebunden sind, nach dem Freischwimmen schon keine negative Wirkung haben.

SCHLUSSFOLGERUNG

Aus dargelegten Experimenten geht hervor, dass nicht nur Fische, die einem bestimmten Lebensmilieu angepasst sind, hohe Ansprüche an die Wasserzusammensetzung stellen. Die Plötze ist demgegenüber eine Fischart,

von der bisher angenommen wurde, dass sie sich sehr leicht den verschiedensten Umweltverhältnissen anzupassen in der Lage ist. Nichtsdestoweniger folgt aus den dargelegten Versuchsresultaten eindeutig, dass eine optimale Entwicklung der Brut nur in dem kleinen Bereich von 7—10° dGH möglich ist. Bei höherer und niedrigerer Wasserhärte steigt dagegen die Mortalität der Larven im Verlauf der Entwicklung bis zum Übergang auf exogenen Nahrungserwerb beträchtlich an. Die optimalen Wasserverhältnisse sind demnach zweifellos sehr wichtige Faktoren, die die jährlichen Schwankungen in der Anzahl der Exemplare der verschiedenen Altersgruppen verursachen. Diese Abhängigkeit wird wohl auch für viele weitere Arten unserer einheimischen Fische Geltung besitzen, wenn auch bei den einzelnen Fischarten die Ansprüche an die optimalen Wasserverhältnisse unterschiedlich sein können.

Den Herren Dr. K. Pivnička und Dr. K. Černý danke ich sowohl für ihre Hilfe bei den Freilanduntersuchungen, als auch für ihre Hinweise bei der Anfertigung des Manuskriptes. Herrn V. Šafránek bin ich für seine Mithilfe bei den Beobachtungen im Labor, ebenso wie Herrn Z. Šlosar, dem Leiter des Chemischen Dienstes des OVHS Kladno, zu Dank verpflichtet. Letzterer überliess mir mit aussergewöhnlicher Bereitwilligkeit viele Angaben über die jährlichen Veränderungen im Wasserchemismus des Klíčava-Stausees, von denen einige in diese Arbeit aufgenommen wurden. Letzten Endes möchte ich Herrn Dr. H.-J. Franke aus Gera für seine Hilfe beim Ausfeilen des textlichen Ausdrucks meiner Aufzeichnung ganz herzlich danken.

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THE PREPARATION OF REPRODUCTIVE STAGES OF ENTOMOPHTHORA EXITIALIS HALL ET DUNN

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Abstract: The larvae of *Galleria mellonella* were infected by injection of a hyphal suspension of the fungus *Entomophthora exitialis* Hall et Dunn. Morphological stages of the fungus, such as rhizoids, hyphal bodies, conidiophores, and conidia developed. From the taxonomical point-of-view it was possible to identify reliably the fungus according to the conidia. The dead insects, on which the fungus had sporulated, were furthermore successfully used for infectious transmissions by conidia

INTRODUCTION

A variety of species of the genus Entomophthora show in vitro rather great differences in forming morphological stages of their developmental cycle. Thus for instance certain species form no or almost no conidia and resting spores on the common nutritive soils, they only grow vegetatively by forming hyphae. *Entomophthora exitialis* Hall et Dunn (Hall and Dunn, 1957) from our collection also belongs to this group. The fungus of this mode of growing can be neither reliably classified in vitro from the view-point of taxonomy nor used in the biological control. We, therefore, examined whether it would be possible to obtain reproductive stages.

MATERIAL AND METHODS

A culture of the fungus *Entomophthora exitialis* Hall et Dunn took its origin in the Department of Biological Control at the University of California, Riverside California USA, and has been for long in our collection. On coagulated yolk, on Sabouraud's agar with glucose or maltose, as well as in a submerged culture on a shaker in soil of our own combination, it grew only in the form of hyphae (Krejzová, 1970 and 1971a). None of the above mentioned soils produced conidia or resting spores.

Agglomerates of hyphae from a submerged culture four weeks old were torn to pieces and cut with Wecker's scissors. The material obtained was injected as a suspension in a 0.01 ml amount into *Galleria mellonella* at the beginning of the last developmental instar (Krejzová, 1971 c).

The dead larvae were placed in Petri dishes on moist filterpaper. After 8, 16, 24 and 36 hours subsequent to death, their surface as well as the dissected material was examined under the microscope. Some larvae were fixed, embedded into paraffin and after sectioning stained with Heidenhein's haematoxyline.

RESULTS

The larvae died two to three days after injection. The course of infection was followed on histological sections. In the body of the dead larvae, hypha

bodies appeared first in the adipose tissue (Fig. 1 , 2.) after 8 to 12 hours, later after 10 to 24 hours in the muscular tissue (Fig. 3., 4.). After 24 to 36 hours the larvae were wholly filled with short, branched hyphal bodies (Fig. 5.), with the exception of the digestive tract. The dead larvae were on their lower part attached to the moist filter-paper on the bottom of the Petri dish by rhizoids. Conidiophores penetrated to the surface of the larvae and on them ellipsoid conidia, characteristic of this fungus (Fig. 6., 7., 8.), were formed in the average about 20 μm long and 6 μm broad (Hall et Dunn 1957). On the slides in a moist environment it was possible to obtain a "halo" of the discharged conidia.

DISCUSSION AND CONCLUSION

Formerly the external application of pathogenic material of the representatives of the genus *Entomophthora*, proved to be most successful for both, the natural host (Krejzová, 1972) and the insects on which these fungi have not yet been found in nature (Krejzová, 1971 b, 1971 d). To make the infection penetrate through the integument by its own force, conidia are necessary, or at least resting spores. The hyphal bodies or hyphae may be pathogenic only if being injected into the haemocoele (Krejzová, 1971 a).

Despite the origin of the fungus or its host in nature, it is possible to evoke by injection in the larvae of *Galleria mellonella* the occurrence and development of the infection to such an extent that there will develop and form typical morphological stages of the fungus, hyphal bodies, conidia and rhizoids. We may, therefore, compare on a single host the species and the strains incomparable on different hosts, and thus prove the uniformity and the variability of various stages of the fungus and its peculiarities. This possibility is of great importance for the taxonomy of the genus *Entomophthora*.

The method may be very well applied to the first stage of preparing pathogenic material of these fungi to be used in the biological control. From several specimens infected by injection it is possible to gain a considerable amount of material that may be applied on a larger scale.

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The plates will be found at the end of this issue.

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Zoologische Abteilung des Nationalmuseums, Prag

OCTOLASIUM CROATICUM (ROSA) VAR. ARGOVIENSE (BRETSCHER, 1899) UND DENDROBAENA PLATYURA (FITZ., 1833) VAR. ? (OLIGOCHAETA: LUMBRICIDAE) — ZWEI ZUM ERSTENMAL IN BÖHMEN GEFUNDENE ARTEN

MARIE MIKULOVÁ

Eingegangen am 26. September 1972

Bei der faunistischenforschung des geschützten Böhmerwaldgebietes wurden im Material aus Horská Kvilda 2 Exemplare der Art *Octolasium croaticum* var. *argoviense* und im Material aus dem Gebiete Stožec 5 adulte und 10 juvenile Exemplare der Art *Dendrobaena platyura* var. ? gefunden. Diese beiden Arten gehören in die Zone der Endemiten.

Octolasium croaticum (Rosa) var. *argoviense* Bretscher, 1899

Diese Varietät lebt nach Zicsi (1965) und Wilcke (1968) in der Schweiz, Österreich, in der ČSSR und in Polen. Auf dem Gebiete der ČSSR wurde sie jedoch bisher nur in der Slowakei gefunden, und zwar zum erstenmal in der Niederen Tatra bei der Gemeinde Jasenie (Zajonc, 1961), ferner bei Srdiečko unter Chopok (bisher nicht publiziertes Material aus der Exkursion der zoologischen Abteilung des Nationalmuseums 1967) und in Belanské Tatry (Zajonc, 1970).

Das Vorkommen dieser Form ist typisch für grössere Seehöhen (in Belanské Tatry bis 2000 m). Sie befindet sich auf Erdböden mit Kalkunterlage (Zicsi 1965, Wilcke 1968 und Zajonc 1970), in den oberen humusreichen Erdschichten in der Nähe von Wasserstrassen. Diese ekologische Charakteristik entspricht völlig auch unserem Fund. Horská Kvilda im Böhmerwald liegt etwa 1000 m ü. M. Der Ort, an dem unsere Exemplare gefunden wurden, ist das überwiegend mit Ebereschen (*Sorbus* sp.) bewachsene Ufer des Hommerbaches, mit dunkler Humuserde, die mit herabgefallenem Laub, alten gestürzten Baumstämmen und grösseren Steinen bedeckt ist.

In der gleichen Lokalität wurden folgende Arten gefunden:

Lumbricus rubellus Hoffm.	11 Ex.
Dendrobaena octaedra (Sav.)	4 Ex.
Lumbricus baicalensis Mich.	3 Ex.
Dendrobaena rubida (Sav.)	3 Ex.
Allolobophora rosea (Sav.)	3 Ex.
Octolasium lacteum Örley	1 Ex.
juv. Ex. der Gattung *Lumbricus*	23 Ex.
juv. Ex. der Gattung *Dendrobaena*	12 Ex.
juv. Ex. der Gattung *Allolobophora*	5 Ex.

Diese Form beschrieb Bretscher (1899) als eine selbständige Art *Allolobophora argoviense*. Seither wurde die Ansicht sowohl über ihre Gattungszugehörigkeit als auch über den Artstatus einigemal geandert. Vom Michaelsen (1900) wird die Art *Octolasium croaticum* der Art *Octolasium lissaense* beigeordnet, spater (Michaelsen, 1902) als eine selbständige Art anerkennt und Octolasium argoviense als ihre Varietat angeführt. Černosvitov (1935) verbindet die Arten *O. complanatum*, *O. transpadanum*, *O. lissaense* und *O. croaticum* in eine einzige Art unter der Benennung *Octolasium complanatum* (Dug.) mit einer grossen Variationsweite der einzelnen Merkmale und fuhrt die Varietät *O. complanatum* v. *argoviense* in der Auffassung Michaelsens an (Zajonc, 1965). Der erste Fund dieser Art aus dem Gebiete der ČSSR ist unter der Benennung *Octolasium lissaense* (Mich.) publiziert (Zajonc, 1961).

Unser Material der Art *O. croaticum* v. *argoviense* aus Horská Kvilda im Böhmerwald bilden 2 adulte rotviolett gefärbte Exemplare. Ihre Längen sind 50 und 60 mm, der breiteste Körperdurchmesser 3mm, die Segmentzahlen 88 und 97, die Lage des Clitellum 28—34, l/n 27—34, die Lage der Pubertätswälle 28—35, l/n 27—35. Das Prostomium in beiden Fällen tanylobisch, der erste Rückenporus in der Intersegmentfurche 12/13, die Borsten getrennt, die männlichen Poren auf dem 15. Sg. ohne Papillen, undeutlich. Samensäcke 4 Paare im 9.—12. Sg., Samentaschen 6 Paare im 6, 7, 8, 10, 11, 12 mit der Mündung in den Intersegmentfurchen 6/7—11/12 in der Linie c. Diese Merkmale der beiden Exemplare liegen also in den von Zicsi (1965) und Wilcke (1968) bestimmten Variationsgrenzen.

Zajonc (1965) reiht die Art *O. croaticum* v. *argoviense* in den zoogeographischen Typ der alpen-illyrischen karpatischen Verbreitung ein. Während diese Art im Gebiet der Karpaten nur sehr selten vorkommt, ist sie im alpen-illyrischen Gebiete stark verbreitet. Zicsi (1965) führt eine ganze Reihe von österreichischen und schweizer Lokalitäten an, in denen diese Art laufend vorkommt. An dieses Gebiet knüpft geographisch der Böhmerwald an. Horská Kvilda im Böhmerwald ist offensichtlich vorläufig der nördlichste Ausläufer des alpen-illyrischen Gebietes, wo bisher diese Art festgestellt wurde. Ob sie noch nördlicher in das Gebirge des Grenzgebietes eingreift, bleibt vorläufig eine Frage weiterer faunistischer Forschung.

Beide Exemplare aus Horská Kvilda sind in den Depositensammlungen der zoologischen Abteilung des Nationalmuseums unter Inventarnummer 850, Kat. III der Weichtiere aufbewahrt.

Dendrobaena platyura (Fitz., 1833) var. ?

Die Art *Dendrobaena platyura* (Fitz., 1833) ist nach Pop (1943), Zajonc (1965) und Wilcke (1968) in der Ukraine, in Rumänien, Ungarn, Österreich, Jugoslawien, Italien, in der ČSSR, in Deutschland und Polen verbreitet. Ihr Areal ist demnach bedeutend grösser als bei der vorgenannten Art. Bei uns wurde sie gleichfalls in einer Reihe von Lokalitäten der Slowakei und Mährens gefunden (Zajonc, 1965). Sie kommt laufend in drei Varietäten vor: f. *typica*, v. *depressa* und v. *montana*. Die Beziehungen dieser 3 Varietäten löst sehr ausführlich Pop (1943). Bei allen drei Varietäten ändert sich die Anzahl der Paare der Samensäcke und Samentaschen, und zwar in verschiedener Kombination von 2 bis 4. Nach der Kombination dieser 2 anatomischen Merkmale bestimmt Pop (1943) insgesamt 7 Typen der Art *Dendrobaena platyura*.

Zajonc (1968) führt den Fund von Exemplaren der Art *D. platyura* v. ? mit einer weiteren Kombination dieser Merkmale an. Unser Material mit 2 Paaren Samensäcken und 2 Paaren Samentaschen ergänzt die letzte theoretisch mögliche Kombination, die durch die Ziffern 2, 3, 4 gegeben ist.

Tab. 1. Variabilität der Anzahl von Paaren der Samensäcke und Samentaschen bei der Art Dendrobaena platyura.

	Anzahl der Paare der Samensäcke	Anzahl der Paare der Samentaschen	Varietät
I (Pop)	4	2	f. typica
II (Pop)	4	4	v. depressa
III (Pop)	3	2	f. typica
IV (Pop)	3	4	v. depressa
V (Pop)	3	3	v. depressa
VI (Pop)	2	3	v. montana
VII (Pop)	2	4	v. montana
VIII (Zajonc)	4	3	v. ?
IX (Mikulová)	2	2	v. ?

Nach den übrigen von Pop (1943) als wichtig für die Systematik dieser Art bezeichneten Merkmale (Pigmentation, Lage der Drüsenpapillen rund um das Clitellum der Geschlechtsborsten) und den Merkmalen, die die einzelnen Varietäten weniger ausgeprägt unterscheiden (Grösse, Segmentzahl, Lage des 1. Rückenporus) nähern sich unsere Exemplare am meisten der von Černosvitov (1932) als *Octolasium montanum* beschriebenen Varietät *montana*. Zum Unterschied von der ursprünglichen Beschreibung Černosvitovs sind jedoch die Samensäcke des 12. Segments nicht grösser als die Säcke des 11. Segments und greifen nicht in das Segment 13. ein.

Alle Stücke haben eine braungraue Farbe, Drüsenpapillen rund um die Borsten a des 25. Segmentes, getrennte Borsten, kleine männliche Poren ohne Papillen auf dem 15. Segment, ein epilobisches Prostomium, den 1. Rückenporus in 8/9, das Clitellum auf 25—30, die Pubertätswälle auf l/n 25, 26—29. Die Längen sind 90—165 mm, der breiteste Körperdurchmesser 7—8 mm, Anzahl der Segmente 138—179.

Die für die einzelnen Varietäten von Zajonc (1965) angegebenen ökologischen Unterschiede können mit Rücksicht darauf, dass das Material aus einer einzigen Lokalität stammt, in unserem Fall nicht benützt werden. Der Ort des Fundes ist eine sehr feuchte, stellenweise sumpfige Wiese unter dem Stožec, mit einem durchfliessenden kleinen Bach (hohe Ansprüche an Feuchtigkeit sind typisch für alle Varietäten der Art *D. platyura*).

Gleichzeitig mit 5 adulten und 10 juvenilen Stücken der Art *D. platyura* wurden gefunden:

Octolasium lacteum Örley	15 Ex.
Allolobophora rosea (Sav.)	9 Ex.
Dendrobaena octaedra (Sav.)	8 Ex.
Dendrobaena rubida (Sav.)	5 Ex.
Lumbricus rubellus Hoffm.	2 Ex.
Dendrobaena sp.	1 Ex.
juv. Ex. der Gattung *Lumbricus*	19 Ex.
juv. Ex. der Gattung *Octolasium*	5 Ex.
juv. Ex. der Gattung *Dendrobaena*	4 Ex.
juv. Ex. der Gattung *Allolobophora*	3 Ex.

Das Material der Art D. platyura aus Stožec ist unter Inventarnummer 936 des Katalogs *III* der Weichtiere aufbewahrt.

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FIVE NEW SPECIES OF PROTURA FROM BRAZIL

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Abstract: In this paper the following new species are described: *Eosentomon huetheri*, *Eosentomon ruseki*, *Brasilidia tropica*, *Silvestridia kunsti* and *Brasilentulus huetheri*.

In the course of an investigation of the soil and litter fauna in Brazil during the years 1964—1965 a number of Protura species were found by Dr. W. Hüther which appear to be undescribed. These will be treated by genera beginning with Eosentomon, Brasilentulus, Berberentulus, Brasilidia and Silvestridia.

Eosentomon huetheri sp. n.

Figs 1 A—H

Holotype ♀ from Manaus, Flores, secondary young forest, a sample was taken on humid place from forna + 5 cm of B-horizon, 30. 11. 1964. Dr. W. Huther leg.

Description: Length of body 1400 μm, foretarsus without claw 92 μm.

Head. — Head capsule oval, mouthparts with strong lobus externus and curious mandibles with 7—8 strong teeth on apex. Both apexes are parallel-sided with the median line of head (Fig. C). Clypeal apodeme invisible. Pseudoculus very indistinct (Figs. D, E), PR = 15.

Thorax. — Foretarsus with very long sensillae, especially a' and d. Sensillae e, g and f_1 spatulate. Praetarsal sensilla s with short and big "head". Dorsal sensilla t_3 is very thin (Figs. A, B). The ratio of sensillae on foretarsus in exterior view $a : b : x : c : d : e : f_1 : f_2 : g$ as 15 : 16 : 32 : 21 : 28 : 16 : 13 : : 8.5 : 18; in interior view $a' : b' : c'$ as 35 : 12 : 11.5. TR = 6.0, BS = 1.3, UE = 0.9. Spiracles smaller than pseudoculus (Fig. F). The hind tarsus with strong dorsal spine (Fig. G).

Abdomen. — The central lobe of praecosta VI—VII not incised. Squama genitalis ♀ is very similar to that of *Eosentomon denisi* Condé, 1947. Filum short (Fig. H). Four openings of dermal glands are present on the posterior part of tergite IX and four one on the posterior part of tergite X.

Chaetotaxy in Tuxen system:

	I	II—III	IV	V—VI	VII	VIII	IX—X	XI	XII
terg	6*/10	10/16	10/16	6/16	6/16	6/9	8	8	6/3
stern	4/4	6/4	6/10	6/10	6/10	2/7	4	8	8/4

* the lateral seta may be a sensilla.

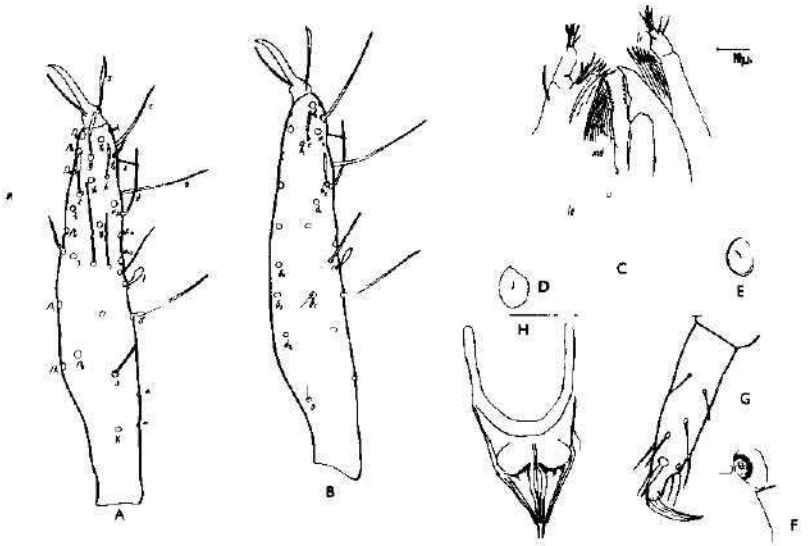
Derivatio nominis. Named in honour of well-known entomologist Dr. W. Hüther, Bochum.

Affinity. This species belongs to the "*wheeleri*" group.

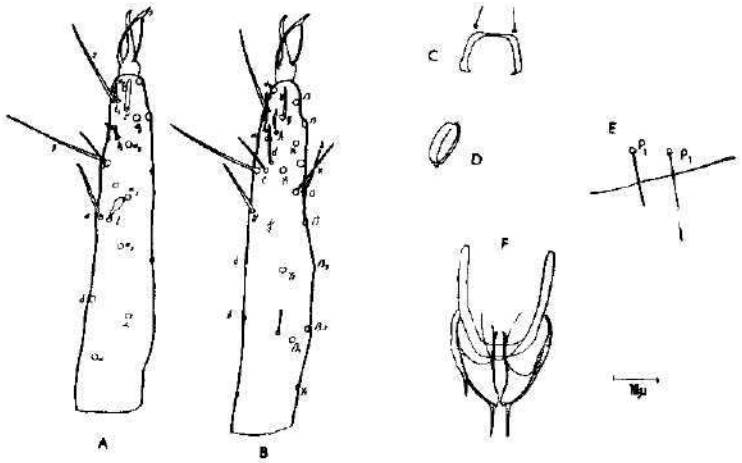
Eosentomon ruseki sp.n.

Figs 2A—F

Holotype ♀ from Itatiaia, Parque Nacional, dense forest with bamboo-trees in undergrowth, 1100 m alt. A sample was taken from B-horizon, humid sandy loam, 26. 2. 1965 Dr. W. Hüther leg.



Figs 1 A—H *Eosentomon huetheri* sp. n. (♀ holotype): A — foretarsus in exterior view, B — Foretarsus in interior view, C — forehead: md = mandible, li = lobus internus, le = lobus externus of maxilla, D and E — pseudoculi, F — metathoracic spiracle, G — tarsus III, H — squama genitalis ♀.



Figs 2 A—F *Eosentomen ruseki* sp. n. (♀ holotype): A — foretarsus in dorsal view, B — foretarsus in ventral view, C — clypeal apodeme, D — pseudoculus, E — the ratio of p_1 and p_1' setae on terg. III, F — squama genitalis ♀.

Description: Length of body 1000 μm, foretarsus without claw 86 μm.

Head. — The clypeal apodeme with side rods connected anteriorly (Fig. C). The pseudoculi rather small, PR = 14 (Fig. D). Mandible with few teeth at apex and dorsal striation.

Thorax. — Foretarsus is first and foremost characterized by the missing sensilla *e*, and *g* being only a weak seta, not spatulate, and strong cylindric sensilla *c'* (Figs. A, B). The ratio of sensillae on foretarsus in exterior view $a : b : x : c : d : f_1 : f_2 \cdot g$ as 9 : 18 : 24 : 16.5 : 15 : 9.5 : 7 : 11.5; in interior view $a' : b_2' : c'$ as 23 : 8 : 12. TR = 6.5, BS = 1.3, EU = 0.9.

Abdomen. — Central lobe of praecosta large not incised. p_1' greatly by-passing p_1' in terg. I—VI (Fig. E). Squama genitalis ♀ is characterized by weakly sclerotized caput (Fig. F).

Survey of chaetotaxy in Tuxen system:

	I	II—III	IV—VI	VII	VIII	IX—X	XI	XII
terg.	4 10	10 12	8 14	6 16	6 9	8	6	6 3
stern.	4 4	6 4	6 10	6 10	7	4	8	8 4

Derivatio nominis. Named in honour of Dr. J. Rusek, Prague who has contributed to the knowledge of Central European Apterygotan fauna.

Affinity. This species belongs to the "*maya*" group. It is closely related to *Eosentomon pumilio* Bonet, 1950 but differs from it in squama genitalis ♀, TR, and BS.PR is also deviating.

Brasilidia g.n.

Diagnosis: Acerentomids with three setae on abdominal legs II—III, reduced labial palpi with 4 setae and a sensilla. Canal of maxillary gland with relatively short proximal part, proximally tripartite. Sensilla t_3 in foretarsus cylindric, rounded at apex, t_1 claviform. Abdominal sternite VIII with 4 setae and no posterior setae near the hind border. Striate band on abd. VIII reduced, yet with distinct, dispersed striae in the band area proceeding from the proximal border. Hind tarsi 1.7 times the length of its claw.

Distribution: Brazil.

Type species: *Brasilidia tropica*. sp. n.

Brasilidia tropica sp.n.

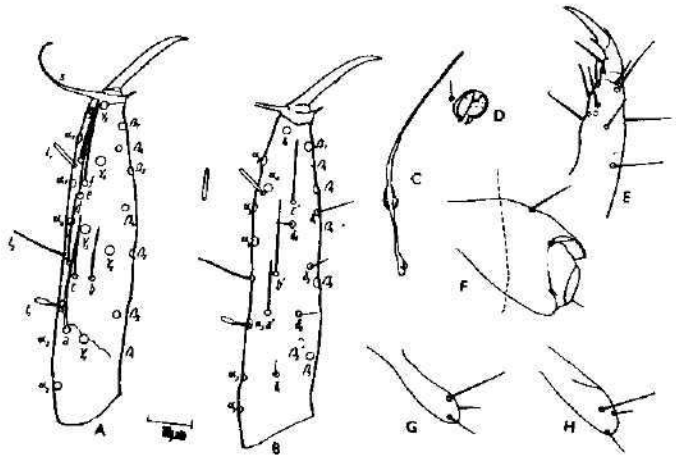
Figs 3 A—M

Holotype ♀ from Foz do Iguaçu Parque Nacional, secondary forest with very dense herbaceous stratum (herbs and brackon); a sample was taken from forna on slightly humid place, 6. 2. 1965 Dr W. Huther leg.

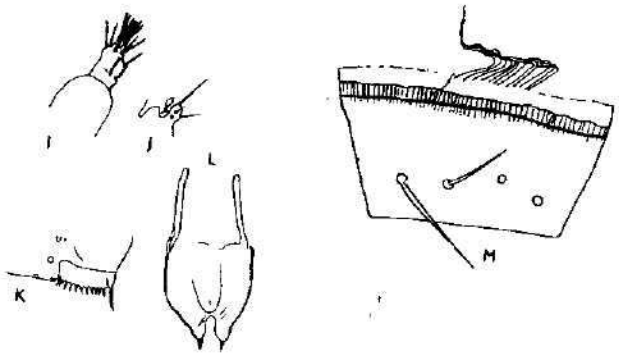
Description: Length of body 900 μm, foretarsus without claw 76 μm. Integument yellow pigmented.

Head. — Mouthparts small, the sensillae of palpi spindle-shaped (Fig. I), sensilla of labial palpi claviform. Labial palp reduced with 4 setae and a sensilla (Fig. J). Pseudoculus circular, PR = 18 (Fig. D). Canal of maxillary gland proximally tripartite with relatively short proximal part (Fig. C).

Thorax. — The foretarsus is characterized with cylindric parallel-sided sensilla t_3, setaceous t_2 and claviform t_1 sensillae, unguis with an inner tooth. The ratio of sensillae on foretarsus in exterior view $a : b : c : d : e : f : g$ as 37 : 21 : 24 : 27 : 29 : 31 : 25.5; in interior view $a' : b' : c'$ as 20 : 28 : 24. All sensillae are very fine, a is a little broadened, mainly in the first half



Figs 3 A—H *Brasilidia tropica* sp. n. (♀ holotype): A — foretarsus in exterior view, B — foretarsus in interior view, C — canal of maxillary gland, D — pseudoculus, E — tarsus III, F — abdominal leg, I, G — abdominal leg II, H — abdominal leg III.



Figs 3 I—M *Brasilidia tropica* sp. n. (♀ holotype): I — maxillary palp, J — labial palp, K — comb VIII, L — squama genitalis ♀, M — sternite VIII.

(Figs. A, B). TR = 3.3, BS = 0.5, EU = 0.14. Tarsus III 1.7 times the length of its claw (Fig. E).

Abdomen. Abdominal leg I two-segmented with 4 setae, abd. legs II—III uni-segmented with 3 setae (Figs. F, G, H). Comb VIII with 10 sharp teeth, small pectinae present (Fig. K). Between the stern. VII and VIII a group of dermal glands is present (Fig. M). Squama genitalis ♀ tripartite (Fig. L).

Survey of chaetotaxy in Tuxen system:

	I	II—III	IV—VI	VII	VIII	IX—X	XI	XII
terg.	6/10	8/14	10/14	6/18	6/16	12	6	9
stern.	3/4	3/5	3/8	3/8	4/0	4	4	6

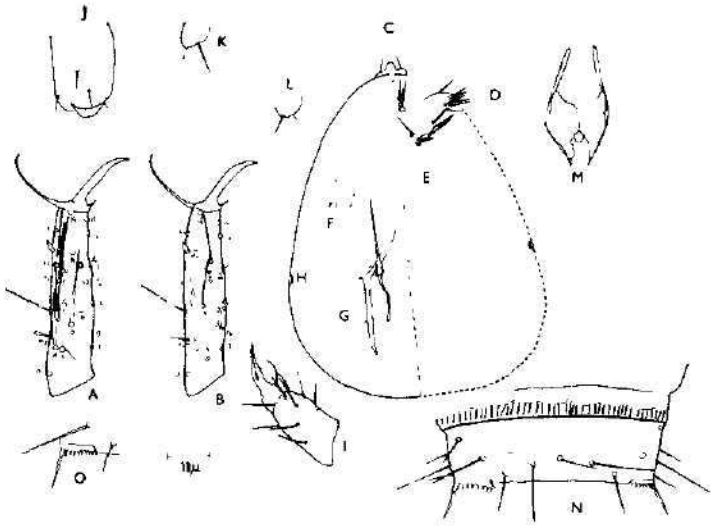
Affinity. This genus is related to *Acerentulus* but differs from it by absence of posterior setae on stern. VIII, by reduced labial palp and by the form dorsal of sensilla t_3.

Silvestridia kunsti sp.n.

Figs 4 A—O

Holotype ♀ from Itatiaia, Parque Nacional, secondary forest with luxuriant undergrowth mainly of *Pteridium aquilinum*, 800 m alt. Samples were taken on a wet place from förna and detritus, 28. 2. 1965 Dr. W. Hüther leg.

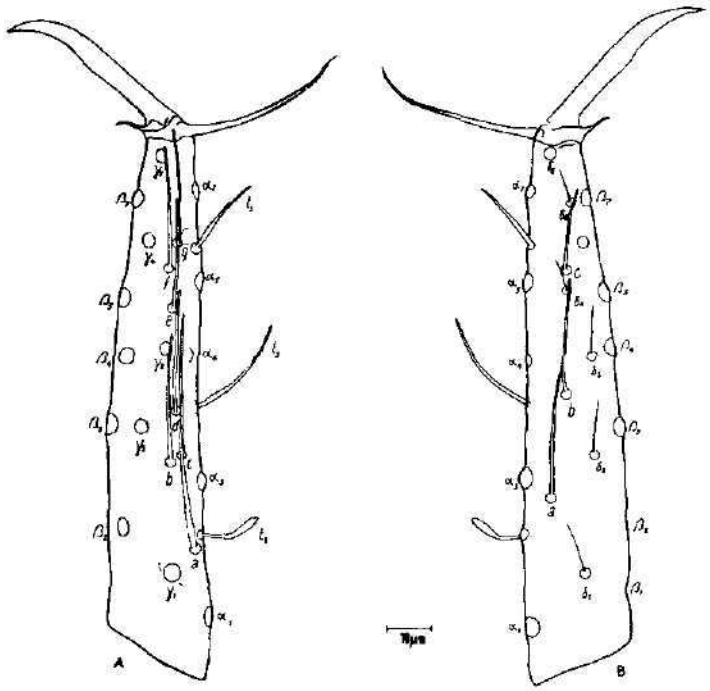
Description: Length of body 650 µm, foretarsus without claw 45 µm. Integument weak and soft, almost semitransparent but slightly light yellow pigmented in several distal segments of abdomen.



Figs 4 A—L *Silvestridia kunsti* sp. n. (♀ holotype): A — foretarsus in exterior view, B — foretarsus in interior view, C — labrum with labral setae, D — maxillary palp, E — labium with the labial palp, F — pseudoculus with guard seta, G — canal of maxillary gland, H — sensory organ, I — tarsus III, J — abdominal leg I, K — abdominal leg II, L — abdominal leg III, M — squama genitalis ♀, N — terg. VIII, O — comb VIII.

Head. — Mouthparts very small, the maxillary sensillae spindle-shaped (Fig. D), labial palp highly reduced with two setae and one sensilla. Labium as in *Bolivaridia* (Fig. E). Labrum with incisions giving a parallel-sided appearance (Fig. C). Pseudoculus circular with two lids (Fig. F), PR = 15. Canal of maxillary gland simple and thin, proximally bipartite (Fig. G). On each side of the head a sensory organ is present (Fig. H).

Thorax. — Foretarsus is characterized with a' sensilla which is shaped as an old Roman vase, with sword-like sensillae a and b. b sensilla is remarkably long, its apex surpassing the base of γ_4, c and d close to each other. Dorsal sensillae: t_1 is claviform, t_2 setaceous, t_3 knob-like (Figs. A, B). The ratio of sensillae on the exterior side of foretarsus $a : b : c : d : e : f : g$ as 25.5 : 30 : 18.5 : 19 : 23.5 : 21.5 : 16; on interior side $a' : b' : c'$ as 21 : : 20.5 : 19. TR = 2.7, BS = 0.47, EU = 0.16. In the hind leg the tarsus is not much longer than claw plus praetarsus; the ratio 1.1 (Fig. I).



Figs 5 A—B *Brasilentulus huetheri* sp. n. (♀ holotype): A — foretarsus in exterior view, B — foretarsus in interior view.

Abdomen. — Abdominal leg I with 4 setae (Fig. J), abd. legs II—III with two setae (Figs. K, L). This body mark not agrees with the status of genus *Silvestridia* but I am of opinion that the number of setae on abdominal legs may be variable as, e.g., in genus *Acerentomon*. Comb VIII with 7—8 sharp teeth and small pectinae (Fig. O). Between the tergites VII and VIII 4 group of openings of dermal glands occur (Fig. N). On sternites IV—VII one sensilla near p_3 occurs. Striate band on the VIII segment similar that in *Silvestridia artiochaeta* Bonet, 1942 (Fig. N). Squama genitalis of female (Fig. M) is tripartite and has long, pointed acrostyli and relatively long basal apodeme. Squama genitalis ♀ is very similar that of *Silvestridia kaguya* Imadaté, 1969 known from Japan.

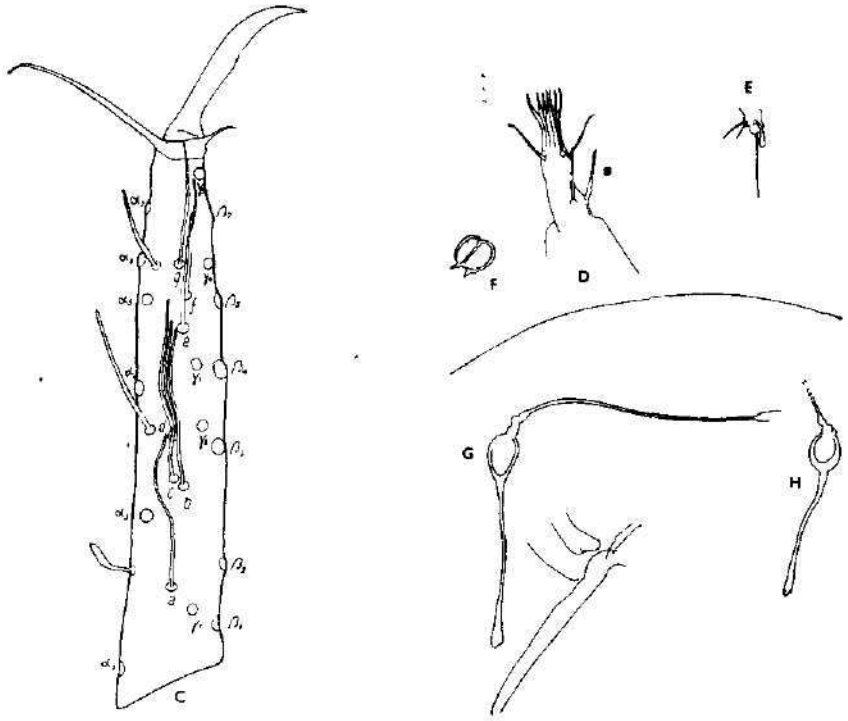
Survey of chaetotaxy in Tuxen system.

per.	I	II—III	IV—VI	VII	VIII	IX—X	XI	XII
terg.	4/12	6/14	6/14	2/18	4/15	12	6	9
stern.	3/2	3/5	3/8	3/8	4	4	4	6

Derivatio nominis. Named in honour of Prof. Dr. M. Kunst, Prague who has contributed extensively to the taxonomy and ecology of oribatid mites.

Affinity. The new species is closely related to *Silvestridia artiochaeta* Bonet, 1942 but differs from it in BS, TR and in presence of two setae on abdominal legs II—III.

Remark. The genus *Silvestridia* was established by Bonet (1942) for an acerentomid proturan found in central Mexico which was described as



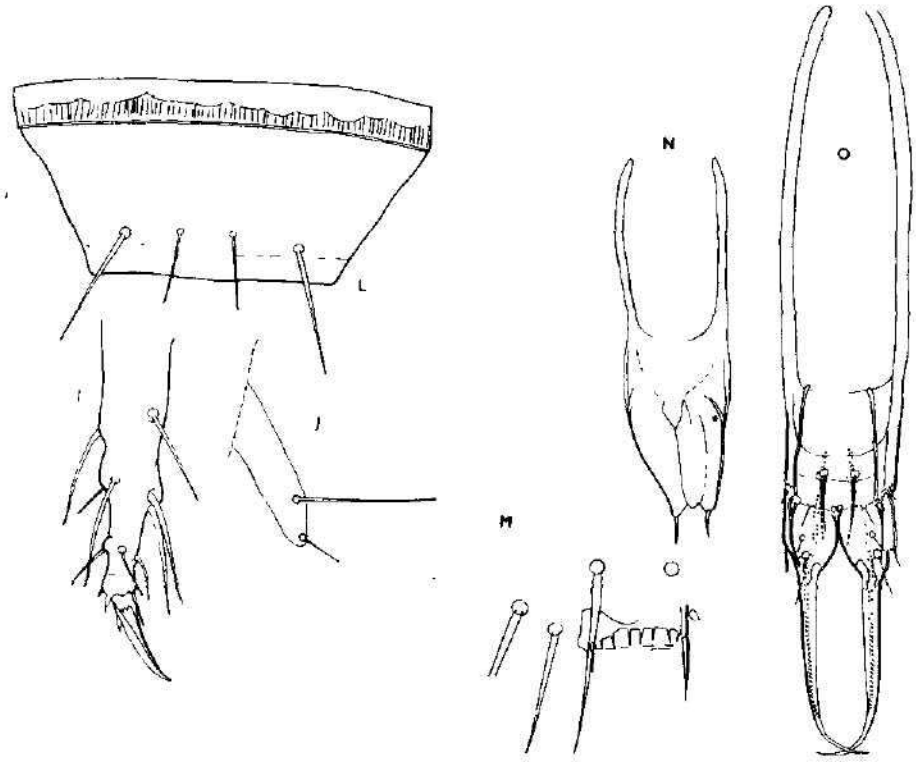
Figs 5 C—H *Brasilentulus huetheri* sp. n.: C — foretarsus in exterior view (allotype ♂), D — maxillary palp (♀ holotype), E — labial palp (♀ paratype), F — pseudoculus (♂ allotype), G — canal of maxillary gland (♀ paratype), H — canal of maxillary gland (♂ allotype).

Silvestridia artiochaeta. The second species was described from Guadalcanar of the Solomons as *Silvestridia solomonis* (Imadaté, 1960). The third species *Silvestridia hutan* Imadaté, 1965 is known from Borneo and Java. The fourth species *Silvestridia kaguya* Imadaté, 1969 was found in Japan and the last species *Silvestridia kunsti* sp.n. in Brazil. On the basis of present knowledge we can conclude that distribution of genus *Silvestridia* is restricted to Neotropic and Oceanic regions.

All holotypes mounted in Swan's medium are kept in Muséum d'Histoire Naturelle de Genève.

Brasilentulus g.n.

Diagnosis: Acerentomids with one long and one short seta on abdominal legs II—III. Reduced labial palps with only three setae and one sensilla. Canal of maxillary glands with heart shaped calyx and long proximal part, proximally tripartite. Foretarsus with strong unguis, extremely long needle-like sensilla t_3, t_2 setiform, t_1 slightly claviform and the distal half bent



Figs 5 I—J *Brasilentulus huetheri* sp. n. (♀ holotype): I — tarsus III ventrally, J — abdominal leg III, L—O *Brasilentulus huetheri* sp. n.: L — ster. VIII (♂ allotype), M — comb VIII (♀ paratype), N — squama genitalis ♀ (holotype), O — squama genitalis ♂ (allotype).

forwards in a rather sharp angle. All lateral sensillae are present on foretarsus, empodial appendage long. Complete striate band on segm. VIII. Sternite VIII with $\frac{4}{0}$ setae.

Distribution: Brazil.

Type species: *Brasilentulus huetheri* sp.n.

Brasilentulus huetheri sp.n.

Figs 5 A—O

Holotype ♀ from Serra do Navio Amapá, North Brazil, approximately 52° 5′ 32′ W-l., 0° 51′ 32′ N-w., primeval forest with dense undergrowth 1. 11. 1964 leg. Hüther. Holotype ♀ and allotype ♂ with some paratypes mounted in Swan's medium kept in Muséum d'Histoire Naturelle de Genève.

Description: Length of body 1400 μm, length of foretarsus without claw 130 μm.

Head. — Maxillary palpi with seta-like sensillae (Fig. D), labial palpi highly reduced little more than a knob with three setae and a foliaceous sensilla (Fig. E). Pseudoculus broader than long (Fig. F), PR = 13. Canal of maxillary glands with heart shaped calyx and long proximal part (Figs. G, H).

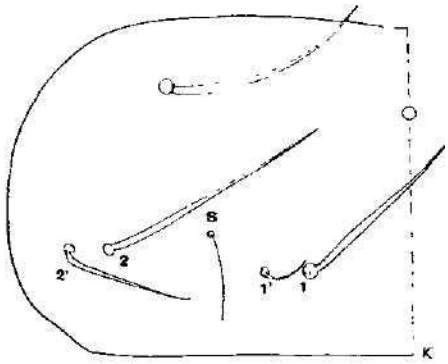


Fig. 5 K *Brasilentulus huetheri* sp. n. (♀ holotype): stern V, the right half with setae and sensilla s.

Thorax. — Foretarsus is characterized with extremely long needle-like sensilla t_3, strong claw and well developed empodial appendage curved at the end. Sensilla t_2 is setiform, sensilla t_1 is slightly claviform and the distal half bent forwards in a rather sharp angle. The ratio of foretarsus (in holotype) in exterior view $a : b : c : d : e : f : g$ as 63 : 51 : 56 : 49 : 44 : 48 : 47; the ratio of sensillae on interior view $a' : b' : c'$ as 50 : 46 : 33. All sensillae are seta-like, b and c closely together (Figs. A, B, C). The sensillae b and c in allotype are of the same length as a. BS = 0.3, TR = 2.8, UE = 0.18.

Abdomen. — Very fine sensilla s is present between setae 1′ and 2 on stern. I—VI (Fig. K). Abdominal legs II—III with one long subapical and one very short apical setae, ratio of setae 1 : 3.3 (Fig. J). The comb of terg. VIII slightly concave with 7 teeth of median length (Fig. M). Small pectinae on terg. VIII present. Complete striate band on segm. VIII, see stern. VIII (Fig. L).

The outer genitalia. Squama genitalis ♀ is prolonged with very long slender and pointed acrostyli (Fig. N). Squama genitalis ♂ see Fig. O.

Survey of chaetotaxy in Tuxen system:

	I	II—III	IV—VI	VII	VIII	IX—X	XI	XII
terg.	6/12	6/12	8/16	8/18	6/17	12	6	9
stern.	3/4	3/5	3/8	3/8	4	4	4	6

Affinity. The new genus *Brasilentulus* is closely related to genus *Delamarentulus* Tuxen, 1963 known from Africa and Central America but

differs from it in the presence of empodial appendage and type of canal of maxillary gland.

Derivatio nominis. Named in honour of the well-known entomologist Dr. W. Hüther, Bochum.

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BIOCENOTICAL RELATIONSHIPS AMONG HELMINTHS OF MICROTUS ARVALIS AND THEIR CHANGES IN THE VARIOUS BIOTOPES AND SEASONS

JAN PROKOPIČ

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Abstract: An analysis has been made of biocenotical relationships among the helminths of the common vole on the basis of the result of helminthological postmortem of 2,467 animals. In the 3 biotopes under consideration, we found in this host a total of 17 helminth species. The dominant species was the nematode *Heligmosomum costellatum*, the subdominant species the cestode *Aprostatandrya macrocephala*. The highest incidence of mixed infection of the host was caused by different species of distant systematic position, or by species infecting different organs.

INTRODUCTION

Data on the helminth fauna of various hosts refer mostly to the number of species parasitizing this or the other host, or to the percentage of incidence of infection. Generally, these data are not based on a detailed ecological analysis of the facts influencing the composition of the helminth fauna of the host in a particular biotope or during a particular season of the year.

In an attempt to disclose the biocenological structure of the helminth fauna of the common vole and its changes in the different biotopes and seasons, we collected these animals in three different biotopes in the vicinity of Nový Bydžov (eastern Bohemia) for a period of 24 months.

MATERIAL AND METHODS

We obtained 2,467 specimens of *Microtus arvalis* trapped during a period of 24 months, i.e., from January 1, 1963 till December 31, 1964. (For trapping methods see: Prokopič, 1968). Postmortem examination of these animals disclosed a total of 17 helminth species.

Both quantitative and qualitative variation was shown in the composition of the helminth fauna of *M. arvalis*. These changes are associated with the various biotopes and that both within the current year and within the individual hosts. Our conclusions are based on a statistical evaluation of the material.

RESULTS

Postmortem inspection of 2,467 specimens of *Microtus arvalis* obtained from vicinity of Nový Bydžov, disclosed a total of 17 helminth species (Table 1, Fig. 1A). As shown in Table 1 and Fig. 1 A, 6 helminth species are permanently present in the common vole from this locality; of these the nematode *Heligmosomum costellatum* and the cestode *Aprostatandrya macrocephala* show a marked dominance. The quantitative and qualitative representation of these six species varies during the different seasons and

Table 1. List of the concomitant incidence of helminth species in *Microtus arvalis*

	Number of findings	*Heligmosomum costellatum*	*Aprostatandrya macrocephala*	*Heligmosomum polygyrum*	*Trichocephalus muris*	*Hydatigera taeniaeformis*	*Syphacia obvelata*	*Taenia tenuicollis*	*Heligmosomum skrjabini*	*Rodentolepis straminea*	*Catenotaenia pusilla*	*Rodentolepis asymetrica*	*Hymenolepis horrida*	*Paranoplocephala denuata*	*Taenia crassiceps*	*Skrjabinotaenia lobata*	*Brachylaemus recurvus*	*Porrocaecum* sp.
Heligmosomum costellatum	687	334	158	93	95	31	43	5	10	5	3	5	—	—	2	—	1	—
Aprostatandrya macrocephala	522	158	299	45	41	19	34	1	1	1	3	—	—	1	1	—	—	—
Heligmosomum polygyrum	183	93	45	46	20	9	10	1	—	1	—	1	—	—	—	—	1	—
Trichocephalus muris	150	95	42	20	32	19	12	—	—	1	—	—	—	—	1	—	1	—
Hydatigera taeniaeformis	142	31	19	9	19	80	—	—	—	1	—	—	—	1	—	—	—	—
Syphacia obvelata	118	43	34	10	12	—	49	—	—	4	—	—	—	—	—	—	—	—
Taenia tenuicollis	21	5	1	1	—	—	—	14	—	—	1	—	—	—	—	—	—	—
Heligmosomum skrjabini	14	10	1	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—
Rodentolepis straminea	11	5	1	1	1	1	4	—	—	1	—	—	—	—	—	—	—	—
Catenotaenia pusilla	9	3	3	—	—	—	—	1	—	—	6	—	—	—	—	—	—	—
Rodentolepis asymetrica	5	3	—	1	—	—	—	—	—	—	—	1	—	—	—	—	—	—
Hymenolepis horrida	3	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	—
Paranoplocephala dentata	2	—	1	—	—	1	—	—	—	—	—	—	—	1	—	—	—	—
Taenia crassiceps	2	2	1	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Skrjabinotaenia lobata	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Brachylaemus recurvus	1	1	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—
Porrocaecum sp.	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1

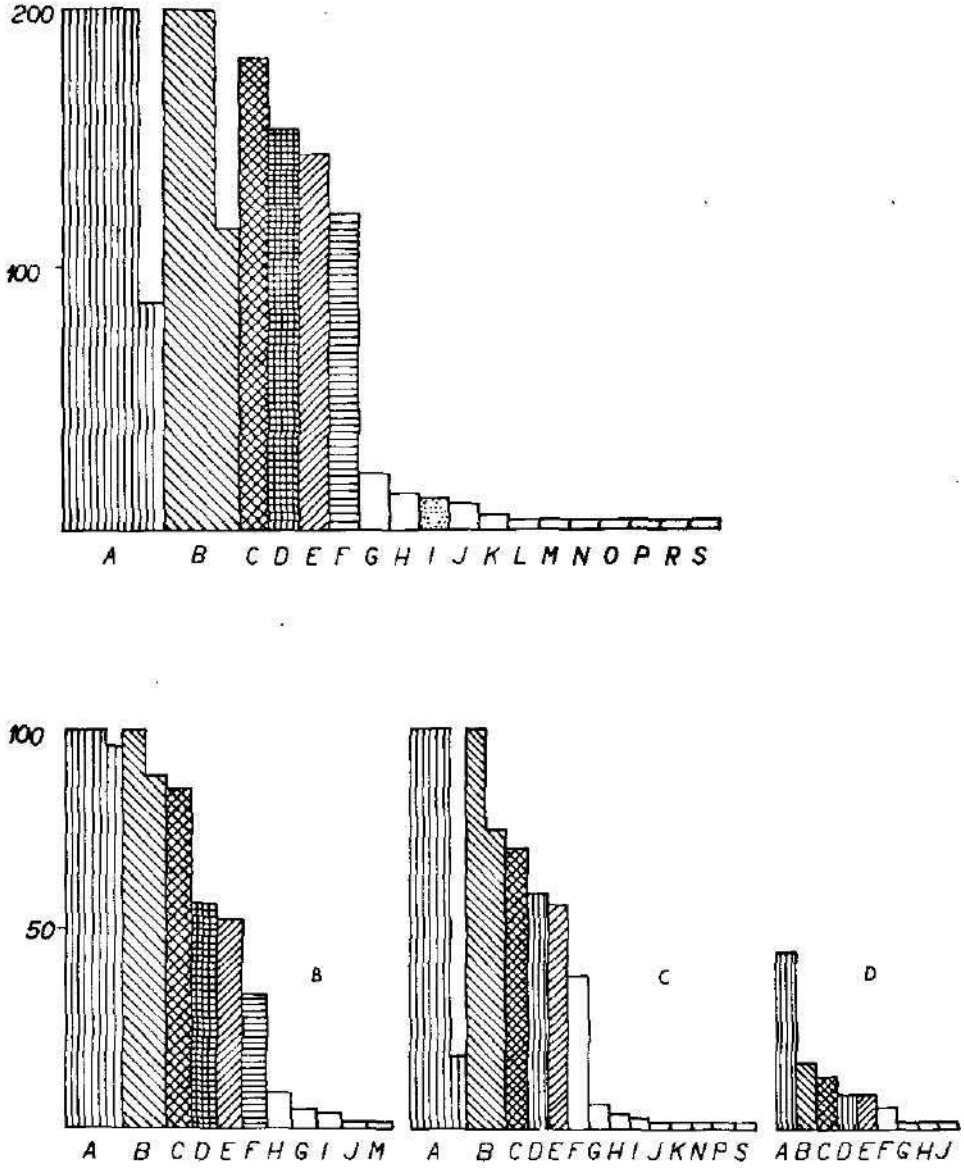

Fig. 1 A: Composition of the helminth fauna of *Microtus arvalis*; A — *Heligmosomum costellatum*, B — *Aprostatandrya macrocephala*, C — *Heligmosomum polygyrum*, D — *Trichocephalus muris*, E — *Hydatigera taeniaeformis*, F — *Syphacia obvelata*, G — *Taenia tenuicollis*, H — *Heligmosomum skrjabini*, I — *Rodentolepis straminea*, J — *Catenotaenia pusilla*, K — *Rodentolepis asymetrica*, L — *Hymenolepis horrida*, M — *Paranoplocephala dentata*, N — *Taenia crassiceps*, O — *Skrjabinotaenia lobata*, P — *Capillaria muris-sylvatici*, R — *Brachylaemus recurvus*, S — *Porrocaecum sp;* — B: Composition of the helminth fauna of *Microtus arvalis* from a ridge in a dry field; — C: Composition of the helminth fauna of *Microtus arvalis* from a cultivated dry meadow; — D: Composition of the helminth fauna of *Microtus arvalis* from a dry oak forest.

Table 2. Double invasions of helminths

	Class of helminths			Organ of host				Biotopes		
	C	N	L	I	C	Bc	G	Fi	M	Fo
Heligmosomum costellatum		+		+				42	43	22
Aprostatandrya macrocephala	+			+						
Heligmosomum costellatum		+		+				29	38	4
Heligmosomum polygyrum		+		+						
Halligmosomum costellatum		+		+				23	19	4
Trichocephalus muris		+					+			
Heligmosomum costellatum		+		+				6	12	2
Hydatigera taeniaeformis	+		+							
Heligmosomum polygyrum		+		+				6	12	
Aprostatandgya macrocephala	+			+						
Heligmosomum costellatum		+		+				6	9	2
Syphacia obvelata		+			+					
Syphacia obvelata		+			+			7	8	1
Aprostatandrya macrocephala	+			+						
Hydatigera taeniaeformis	+		+					4	5	—
Trichocephalus muris		+					+			
Heligmosomum costellatum		+		+				2	4	1
Heligmosomum skrjabini		+		+						
Aprostatandrya macrocephala	+			+				2	5	—
Trichocephalus muris		+					+			
Aprostatandrya macrocephala	+			+				4	1	—
Hydatigera taeniaeformis	+		+							
Heligmosomum polygyrum		+		+				1	3	—
Hydatigera taeniaeformis	+		+							
Heligmosomum polygyrum		+		+				2	—	—
Trichocephalus muris		+								
Syphacia obvelata		+			+			2	—	—
Trichocephalus muris		+					+			
Syphacia obvelata		+			+			2	—	—
Hydatigera taeniaeformis	+		+							
Syphacia obvelata		+			+			2	—	—
Heligmosomum polygyrum		+		+						
Heligmosomum costellatum		+		+				2	—	—
Taenia tenuicollis	+		—							
Heligmosomum costellatum		+		+				—	1	—
Taenia crassiceps	+					+				

in *Microtus arvalis*

Months												Total
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
1	3	—	—	1	6	12	25	30	8	9	2	107
1	7	5	1	2	4	4	2	6	9	11	9	71
5	4	1	1	1	4	1	1	6	8	11	3	46
2	3	3	—	—	—	—	—	2	4	2	4	20
1	1	—	—	—	2	5	1	1	5	2	—	18
1	1	1	1	—	—	—	—	7	2	2	2	17
—	—	1	—	—	1	1	1	6	5	1	—	16
1	4	1	—	—	—	—	—	—	1	2	—	9
1	1	—	—	—	—	—	—	—	1	4	—	7
—	—	—	—	—	—	2	1	2	2	—	—	7
—	—	1	1	—	—	—	—	2	1	—	—	5
1	1	—	—	—	—	—	—	1	—	—	1	4
—	—	—	1	—	—	—	—	1	—	—	—	2
—	—	—	1	—	—	—	—	1	—	—	—	2
1	—	—	1	—	—	—	—	—	—	—	—	2
1	—	1	—	—	—	—	—	—	—	—	—	2
—	1	—	—	—	—	—	—	—	—	1	—	2
—	—	—	—	1	—	—	—	—	—	—	—	1

Table 2. Double invasions of helminths

	Class of helminths			Organ of host				Biotopes		
	C	N	L	I	C	Bc	G	Fi	M	Fo
Heligmosomum costellatum		+		+				–	1	–
Catenotaenia pusilla	+			+						
Heligmosomum costellatum		+		+				–	1	–
Rodentolepis asymetrica	+			+						
Heligmosomum skrjabini		+		+				1	–	–
Syphacia obvelata		+			+					
Syphacia obvelata		+		+				1	–	–
Taenia tenuicollis	+		+							
Aprostatandrya macrocephala	+			+				–	1	–
Taenia tenuicollis	+		+							
Aprostatandrya macrocephala	+		+					–	1	–
Catenotaenia pusilla	+		+							
Syphacia obvelata		+			+			1	–	–
Rodentolepis straminea	+		+							
Trichocephalus muris		+					+	–	1	–
Rodentolepis straminea	+		+	+						
Hydatigera taeniaeformis	+		+					–	1	–
Rodentolepis straminea	+			+						

the helminth fauna of the common vole is enriched by 11 additional species in the various biotopes and during the individual seasons. The incidence of several of these species occurs through contact of *M. arvalis* with other rodents. For example, contact of *M. arvalis* with *Apodemus flavicollis* or *A. sylvaticus* is responsible for infection with *Heligmosomum skrjabini* and *Skrjabinotaenia lobata*: contact with *Clethrionomys glareolus* for infection with *Catenotaenia pusilla*. Kisielewska (1970) found four permanent species in *C. glareolus*, but this appears to be associated with the lower ecological valence of this host, being more closely bound to a certain biotope than *M. arvalis*.

The quantitative and qualitative differences in the composition of the helminth fauna of the common vole depend on the structure of the biotopes. We found 11 helminth species in 1,180 voles obtained from a ridge in a dry field (Fig. 1 B). The numerical representation of the 6 permanently present helminth species was consistant with the total representation. Five of the incidentally occurring helminth species were missing. In the 1,082 specimens of common voles from a dry cultivated meadow, 14 helminth species were found (Fig. 1 C). This represents the highest number of helminth species of all biotopes. In this group, only 3 of the incidentally occurring helminth species were absent. The numerical sequence of helminths was unchanged. We observed a considerable decrease in the number of the nematode *H.*

in *Microtus arvalis*

Months												Total
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
–	–	–	–	–	–	1	–	–	–	–	–	1
–	–	–	–	–	–	–	–	–	–	–	1	1
–	–	–	–	–	–	–	–	–	–	–	1	1
–	1	–	–	–	–	–	–	–	–	–	–	1
–	1	–	–	–	–	–	–	–	–	–	–	1
–	–	–	–	–	–	–	–	–	1	–	–	1
–	–	–	–	–	–	–	–	1	–	–	–	1
–	–	–	–	–	–	–	–	–	1	–	–	1
–	–	–	–	–	–	–	–	–	–	–	1	1

costellatum, a moderate decrease of *H. polygyrum* and of *A. macrocephala*. The incidence of *Syphacia obvelata* was similar to that observed in the field biotope. In 205 specimens of *M. arvalis* obtained from a dry oak forest, we found 9 helminth species (Fig. 1 D); this is 50% only of the total number of helminth species disclosed in the area under consideration. Responsible for this poor species representation is the fact that the forest is not a typical biotope of *M. arvalis*. Moreover, the animals were trapped mainly during the winter when the incidence of infection is lowest. Although the numerical sequence of the helminths remained unchanged, the quantitative representation of *H. costellatum* was 5 times lower than that in the field biotope, and 7 times lower than that in the meadow biotope. The incidence of the remaining helminth species was either the same or slightly lower than that in the field biotope.

It is evident from this survey, that the cultivated meadow and the field represent typical biotopes (environment of the second order) of the helminths of *M. arvalis*, to which these had become adapted during the historical process.

Our results indicate that the species composition is largest in hosts living in biotopes offering optimal conditions, in which biocenotical parasite-host-relationships are perfectly balanced. Under these conditions, the host can survive an infection without serious damage, because the incidence of

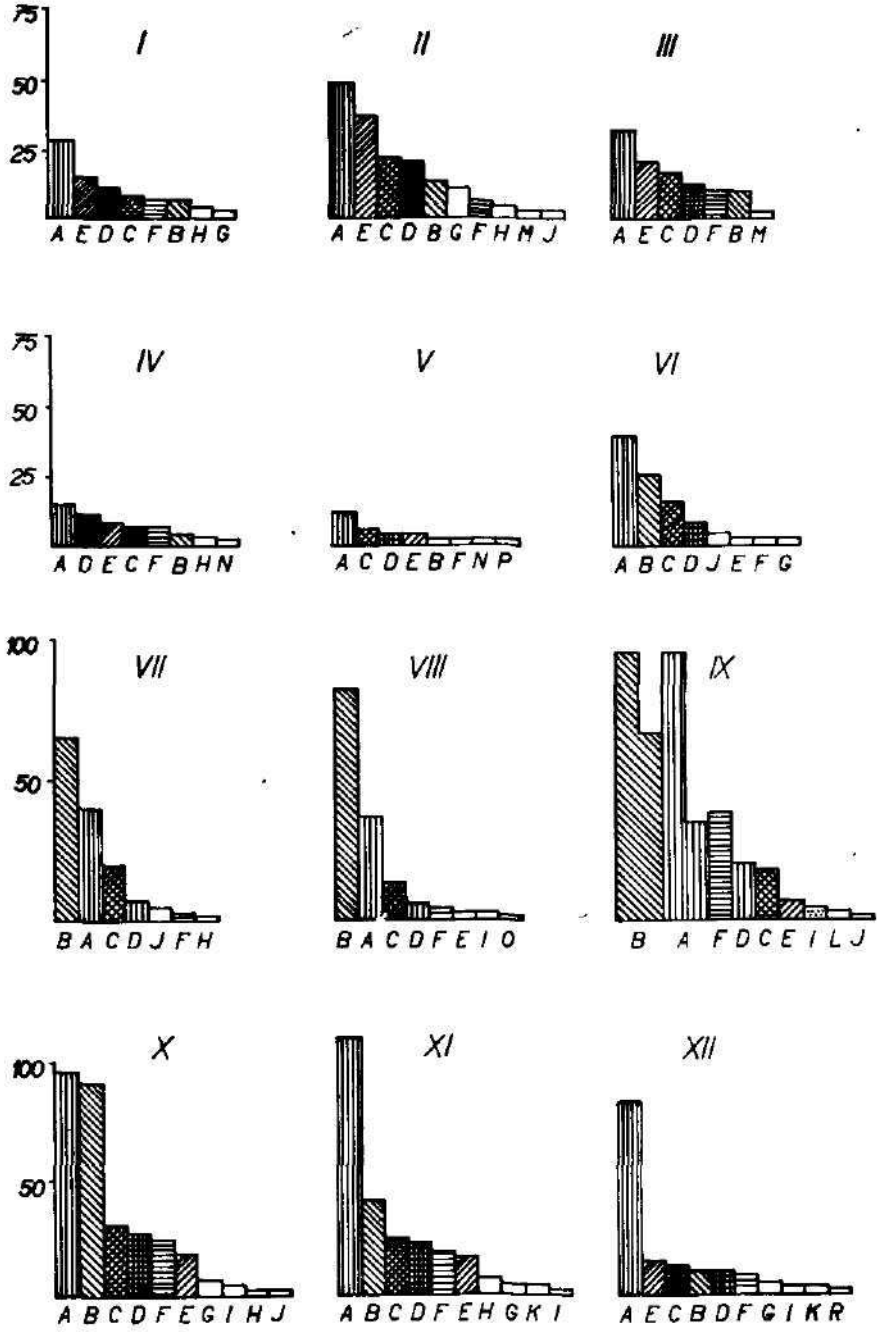

Fig. 2 — Composition of the helminth fauna of *Microtus arvalis* during the various months of the year.

parasites is regulated by these optimal conditions. Under less favourable conditions occurring mainly in biotopes interfered with by the activity of man, the number of helminth species is low, but their incidence is very high and, hence, infection causes serious pathological damage.

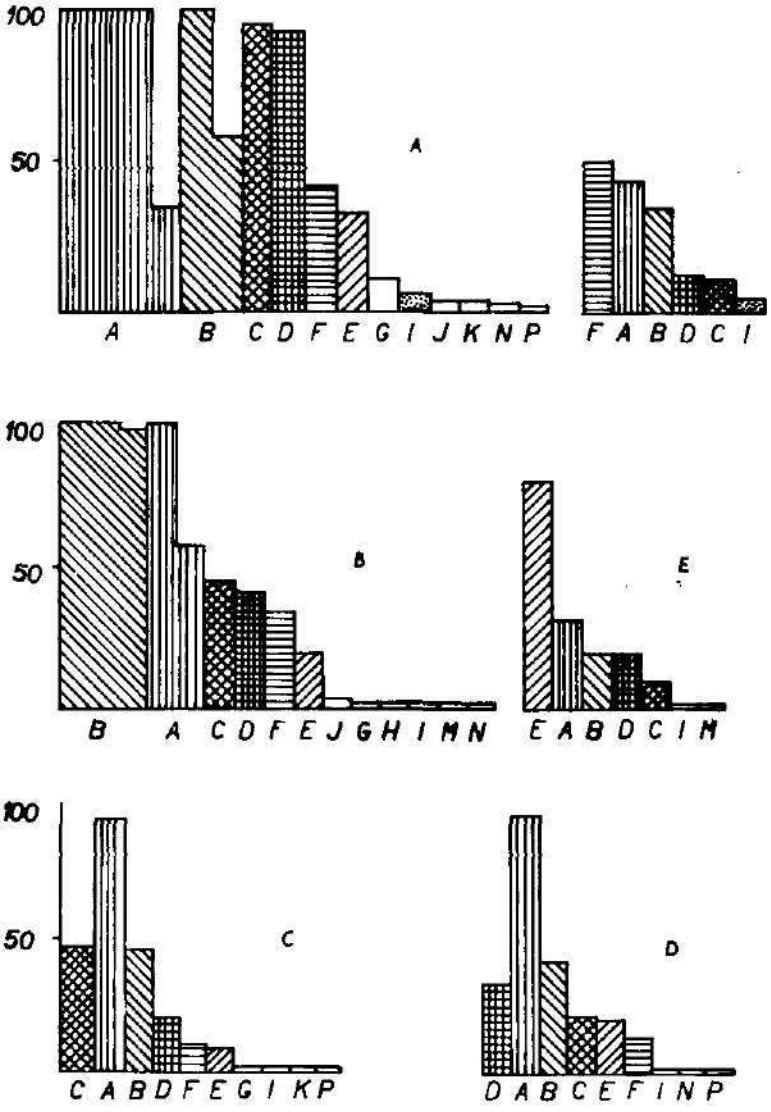

Fig. 3 A: Concomitant incidence of *Heligmosomum costellatum* with other helminth species; — B: Concomitant incidence of *Aprostatandrya macrocephala* with other helminth species; — C: Concomitant incidence of *Heligmosomum polygyrum* with other helminth species; — D: Concomitant incidence of *Trichocephalus muris* with other helminth species; — E: Concomitant incidence of *Hydatigera taeniaeformis* with other helminth species;— F: Concomitant incidence of *Syphacia obvelata* with other helminth species.

Table 3. Triple invasions of helminth.

	Class of helminths			Organ of host			Biotopes		
	C	N	L	I	C	G	Fi	M	Fo
Heligmosomum costellatum		+		+					
Heligmosomum polygyrum		+		+			18	7	4
Aprostatandrya macrocephala	+			+					
Heligmosomum costellatum	+			+					
Trichocephalus muris	+			+		+	9	8	2
Aprostatandrya macrocephala	+			+					
Heligmosomum costellatum		+		+					
Heligmosomum polygyrum		+		+			2	3	3
Trichocephalus muris		+				+			
Heligmosomum costellatum		+		+					
Trichocephalus muris		+				+	2	3	1
Hydatigera taeniaeformis	+		+						
Heligmosomum costellatum		+		+					
Syphacia obvelata		+			+		2	2	1
Rodentolepis straminea	+			+					
Heligmosomum costellatum		+		+					
Syphacia obvelata		+			+		2	—	1
Trichocephalus muris		+				+			
Heligmosomum polygyrum		+		+					
Heligmosomum costellatum		+		+			—	3	—
Hydatigera taeniaeformis	+		+						
Heligmosomum costellatum		+		+					
Heligmosomum skrjabini		+		+			2	1	—
Trichocephalus muris		+				+			
Heligmosomum polygyrum		+			+				
Aprostatandrya macrocephala	+				+		—	2	1
Hydatigera taeniaeformis	+		+						
Trichocephalus muris		+				+			
Aprostatandrya macrocephala	+			+				—	2
Hydatigera taeniaeformis	+		+						
Heligmosomum polygyrum		+		+					
Syphacia obvelata		+			+		—	2	—
Hydatigera taeniaeformis	+		+						
Heligmosomum costellatum		+		+					
Aprostatandrya macrocephala	+			+			1	—	1
Hydatigera taeniaeformis	+		+						
Heligmosomum polygyrum		+		+					
Syphacia obvelata		+			+		1	—	1
Trichocephalus muris		+				+			
Syphacia obvelata		+			+				
Aprostatyndrya macrocephala	+			+			1	—	1
Hydatigera taeniaeformis	+		+						

in *Microtus arvalis*

Months												Total
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
—	1	1	—	—	1	1	5	10	7	2	1	29
—	1	—	—	—	1	1	1	9	5	—	1	19
—	1	2	1	—	1	—	—	—	1	1	1	8
1	1	2	1	—	—	—	—	—	—	—	1	6
—	—	—	—	—	—	—	1	2	1	1	—	5
—	—	—	—	—	—	1	—	—	2	—	—	3
—	1	—	—	—	—	—	—	—	—	2	—	3
2	—	—	1	—	—	—	—	—	—	—	—	3
—	—	—	—	—	—	—	—	—	1	2	—	3
—	—	—	2	—	—	—	—	—	—	—	—	2
—	—	2	—	—	—	—	—	—	—	—	—	2
—	—	1	—	—	—	—	—	—	1	—	—	2
—	1	1	—	—	—	—	—	—	—	—	—	2
1	—	—	—	—	—	—	—	—	—	—	1	2

Table 3. Triple invasions of helminth

	Class of helminths			Organ of host			Biotopes		
	C	N	L	I	C	G	Fi	M	
Heligmosomum polygyrum		+		+					
Syphacia obvelata		+			+		2	—	-
Trichocephalus muris		+				+			
Heligmosomum costellatum		+		+					
Aprostatydrya macrocephala	+			+			2	—	-
Catenotaenia pusilla	+			+					
Catenotaenia pusilla	+			+					
Hydatigera taeniaeformis	+		+				1	—	-
Trichocephalus muris		+				+			
Syphacia obvelata		+			+				
Trichocephalus muris		+				+	1	—	-
Hydatigera taeniaeformis	+		+						
Heligmosomum costellatum		+		+					
Heligmosomum polygyrum		+		+			—	—	
Syphacia obvelata		+			=				
Heligmosomum polygyrum		+		+					
Rodentolepis straminea	+			+			1	—	-
Aprostatyndrya macricephala	+			+					
Syphacia obvelata		+			+				
Trichocephalus muris		+				+	1	—	-
Aprostatandrya macrocephala	+			+					
Heligmosomum polygyrum		+		+					
Heligmosomum costellatum		+		+			1	—	-
Rodentolepis straminea	+			+					
Heligmosomum costellatum		+		+					
Syphacia obvelata		+			+		2	2	
Aprostatandrya macrocephala	+			+					

The seasonal changes in the composition of the helminth fauna within th course of the year are shown in Fig. 2. In each month, we found 7—1 helminth species in *M. arvalis* (never all 17 species). The 6 basic helmint of *M. arvalis* species were present in varying numbers throughout the yea and supplemented by incidentally occurring species. The lowest numbe of helminth species was found in March (Fig. 2/III), i.e., *H. costellatu* 33 times, *Hydatigera taeniaeformis* 22 times. In February, October, Novembe and December we found 10 species each with variation in quantity an quality. The lowest number of cases (1—10) was observed in May (Fig. 2/V i.e., *H. costellatum* in 10 cases, *H. polygyrum* in 2 cases; the remaining specie occurred only once. In June (Fig. 2/VI), no increase occurred in the numbe of helminth species, but it did so in the frequency of infection of the host e.g., the incidence of infection with *H. costellatum* was 3.5 times higher; w found 25 cases of infection with *A. macrocephala*, 13 cases of infection wit

in *Microtus arvalis*

Months												Total
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
–	–	–	–	–	–	1	1	–	–	–	–	2
–	–	–	–	–	1	–	–	1	–	–	–	1
–	1	–	–	–	–	–	–	–	–	–	–	1
–	–	–	1	–	–	–	–	–	–	–	–	1
–	–	–	–	–	–	–	–	1	–	–	–	1
–	–	–	–	–	–	–	1	–	–	–	–	1
–	–	–	–	–	–	–	–	1	–	–	–	1
–	–	–	–	–	–	–	–	–	–	1	–	1
–	1	–	–	–	–	–	–	4	–	1	–	6

H. polygyrum, etc. In July, changes were observed in the numerical sequence (Fig. 2/VII). The dominant place was taken by *A. macrocephala* (68 cases), followed by *H. costellatum* (63), *H. polygyrum* (20), *T. muris*, etc. In August (Fig. 2/VIII), the sequence of the basic species remained unchanged, but their frequency increased. The fifth place was occupied by *Syphacia obvelata*, which, in September, occupied the 3rd place. In September (Fig. 2/IX), all basic species attained their maximum incidence; the dominant species was the cestode *A. macrocephala* (178 cases). In this month we observed also a change in the numerical sequence of the individual helminth species. The composition of the helminth fauna appeared to be best balanced in September and October. By contrast, Kisielewska (1970) observed in *Clethrionomys glareolus* that this stage occurred from November till January, this being the period during which the dominance of the dominant species over the remaining species was particularly marked. *S. obvelata* moved up

Table 4 Quadruple and quintuple invasions

	Class of helminths			Organ of host				Biotopes			
	T	C	N	L	Bc	I	C	G	Fi	M	Fo
Heligmosomum costellatum			+			+					
Heligmosomum polygyrum			+			+					
Trichocephalus muris			+					+	2	1	–
Hydatigera taeniaeformis		+		+							
Heligmosomum costellatum			+			+					
Heligmosomum polygyrum			+			+					
Trichocephalus muris			+					+	1	1	1
Aprostatandrya macrocephala		+				+					
Heligmosomum costellatum			+			+					
Syphacia obvelata			+				+				
Hydatigera taeniaeformis		+		+					2	–	–
Aprostatandrya macrocephala		+				+					
Heligmosomum costellatum			+			+					
Heligmosomum polygyrum			+			+					
Hydatigera taeniaeformis		+		+					1	–	–
Aprostatandrya macrocephala		+				+					
Heligmosomum costellatum			+			+					
Trichocephalus muris			+								
Hydatigera taeniaeformis		+		+				+	1	–	–
Aprostatandrya macrocephala		+				+					
Heligmosomum costellatum			+			+					
Syphacia obvelata			+				+				
Trichocephalus muris			+					+	–	1	–
Hydatigera taeniaeformis		+		+							
Heligmosomum costellatum			+			+					
Trichocephalus muris			+					+			
Aprostatandrya macrocephala		+				+			–	1	–
Taenia crassiceps		+			+						
Heligmosomum costellatum			+			+					
Heligmosomum polygyrum			+			+					
Trichocephalus muris			+					+	–	1	–
Syphacia obvelata			+				+				
Brachylaemus recurvus	+					+					

to the third place; the larval stages of *H taeniaeformis* took the sixth, *Rodentolepis straminea* the seventh place

A change in the sequence of the dominant species occurred in October (Fig. 2/X) The first place was taken by the nematode *H. costellatum*; the cestode *A macrocephala* occupied the second place While the numbers of the adults of *A macrocephala* decreased in November, December and in the subsequent months, those of the larval stages of *H. taeniaeformis* increased to such an extent in December (Fig. 2/XII), that they took the second place and held it until March next year (i e., for 4 months). The change in the structure of host populations (Kratochvíl et al., 1959) marks a turning

Months												Total
I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
–	1	1	–	1	–	–	–	–	–	–	–	3
–	–	–	1	–	–	–	–	–	1	1	–	3
1	–	–	–	–	–	–	–	–	–	–	1	2
–	–	–	1	–	–	–	–	–	–	–	–	1
–	–	–	–	–	–	–	1	–	–	–	–	1
–	–	–	1	–	–	–	–	–	–	–	–	1
–	–	–	1	–	–	–	–	–	–	–	–	1
–	–	–	–	1	–	–	–	–	–	–	–	1

point as maintained also by Kisielewska (1970). The old generation dies and the young generation born in the late summer and during autumn has generally not yet acquired infection with a large number of species. The winter months show no changes in the composition or order of helminth species infecting *M. arvalis* These changes occur in the spring with a marked increase of helminth infection.

Kisielewska concluded that the composition of the intestinal helminth fauna may be used as an indication of the age of the common vole. The youngest hosts are first infected with pseudogeohelminths (*Syphacia obvelata*), then with geohelminths (*Heligmosomum* sp), biohelminths (*Aprostatandrya*

macrocephala) are to be found in the oldest age groups only. Thus the relationship between the incidence of infection with geo- and biohelminths indicates the age of the population under consideration.

INTERSPECIFIC RELATIONSHIPS OF HELMINTHS

In the foregoing text we discussed the composition of the helminth fauna of *Microtus arvalis* in the different biotopes and during the various seasons. The host represents the true external environment of its parasites and establishes their contact with other, either systematically close or distant species. All important factors influencing the host (struggle for food, living space, etc.) are reflected in its helminth fauna. In this chapter, attention will be given to the incidence of the individual helminth species in the individual host specimens.

A list of helminth species arranged in frequency order, is given in Table 1. We recovered the nematode *H. costellatum* from a total of 687 common voles; of these, 334 times (Fig. 3A) in cases of nonconcomitant infection, 158 times in a mixed infection together with *Aprostatandrya macrocephala*, 93 times together with *H. polygyrum*, 95 times with *T. muris*, 43 times with *S. obvelata*, 31 times with *H. taeniaeformis*, etc. The cestode *A. macrocephala* was encountered 522 times, of these 299 times alone (Fig. 3 C), 158 times together with *H. costellatum*, 45 times with *H. polygyrum*, 41 times with *T. muris*, 34 times with *S. obvelata*, etc. The nematode *H. polygyrum* (Fig. 3 B) was recovered from 183 *M. arvalis*, of these in 46 cases of a nonconcomitant infection, 93 times together with *H. costellatum*, 45 times with *A. macrocephala*, 20 times with *T. muris*, etc. *Trichocephalus muris* was found 151 times in *M. arvalis*, of these 32 times (Fig. 3 D) in a nonconcomitant infection, 95 times together with *H. costellatum*, 41 times with *A. macrocephala*, 20 times with *H. polygyrum*, 12 times with *S. obvelata*, etc. *Hydatigera taeniaeformis* (larvae) was recovered 142 times, of these 80 times in a nonconcomitant infection (Fig. 3 E), 31 times together with *H. costellatum*, 19 times with *A. macrocephala*, 19 times with *T. muris* and 9 times with *H. polygyrum*. *Syphacia obvelata* was found 118 times in the common vole, of these 49 times in a nonconcomitant infection (Fig. 3 F), 43 times together with *H. costellatum*, 34 times with *A. macrocephala*, 12 times with *T. muris* and 4 times with *R. straminea*.

The results indicate that the higher the incidence of infection with a certain helminth species, the more frequent the infection with this species only or together with a larger number of other species.

In a mixed infection (Table 2) caused by two parasite species, we found a total of 27 combination. Of these the most frequent were these: *Heligmosomum costellatum* and *Aprostatandrya macrocephala* (107 times).

These helminths belong to different classes (Cestoidea, Nematoda) and live in the small intestine of *M. arvalis*. The frequent incidence of two helminth species inhabiting the same organ indicates that their relationship is not antagonistic. The dominant position of these species, however, changes with the seasons: *Aprostratandrya macrocephala* dominates from July to October, *H. costellatum* from the autumn till the next summer. The next most frequent combination is that of *H. costellatum* and *H. polygyrum* (71 cases, i.e., almost 1/3 less than the foregoing combination). The third place is taken by nematodes of different orders (Strongylata) — *H. costellatum*

in the small intestine — and (Trichurida) — *T. muris* in the large intestine of *M. arvalis*. There is no competition among these parasites belonging to distant systematic groups as regards the food and space. This combination was present throughout the year; its incidence of infection was higher during the autumn and winter, i.e., from September till February. The highest frequency of a mixed infection with two helminth species was found to occur either with species of distant systematic position, or with species attacking different organs of the host. An exception were *H. costellatum* and *H. polygyrum*, both parasitizing the small intestine of the common vole.

In a mixed infection with 3 helminth species (Table 3), we found 23 combinations. Of these, the most frequent was that of *A. macrocephala*. *H. costellatum* and *H. polygyrum* (29 times). The combination of *A. macrocephala*, *H. costellatum* and *T. muris* was found 19 times, etc. The situation was similar to that observed in a mixed infection with two helminth species, i.e., most frequent was an infection with three systematically distant species or with parasites attacking different organs of the host.

We found 7 combinations of mixed infection with 4 different species and, in one case, a mixed infection with 5 species. Also in these instances, the situation was analogous to that described afore. Multiple helminth infection occurred during the period of a minimum incidence of hosts and parasites (from March till June). It appears that the low populations of hosts and parasites enable a concentration of several helminth species in a single host. During the growth period marking an increase in population numbers of hosts and parasites, hosts are more plentiful and, hence, multiple infections of a single host are less frequent.

The incidence of concomitant infection of *M. arvalis* in the various biotopes is shown in the following text. Out of the 27 combinations of mixed infection with 2 helminth species, 20 occurred in the field biotope. Most frequent was the combination *H. costellatum* and *A. macrocephala* (42 times); the next in succession was that of *H. costellatum* and *H. polygyrum* (29 times); *H. costellatum* and *T. muris* (23 times), etc.

Of the 23 combinations of infection with three helminth species, 19 combinations occurred in the field biotope: *H. costellatum*, *H. polygyrum* and *A. macrocephala* (18 times), *H. costellatum*, *A. macrocephala* and *T. muris* (9 times).

Of the 7 combinations of infection with 4 helminth species, 5 combinations occurred in the field biotope.

In the meadow biotope, we found 19 times a mixed infection with 2 species, 11 times with 3 species, 5 times with 4 species and once with 5 species.

In the forest biotope, the common vole was infected 7 times with two helminth species, 12 times with 3 and once with 4 helminth species.

As regards the changes in the concomitant incidence of helminths within the course of the year, we observe that, e.g., *H. costellatum* occurred together with *A. macrocephala* 158 times; of this twice in January, 3 times in February, twice in March, twice in April, once in May, 12 times in June, 41 times in July, 49 times in August, 56 times in September, 20 times in October, 12 times in November and 5 times in December. Evidently, these changes are associated with the seasonal incidence of both helminth species as shown in Fig. 2. Similar changes in the concomitant incidence have been observed with all other helminth species. The concomitant incidence of the various helminth

species in one host is in accord with the total incidence of infection of the host population in the biotope under consideration.

CONCLUSIONS

An ecological and biocenological evaluation of our helminth material obtained from 2,467 specimens of *Microtus arvalis* from three different biotopes (collected during the course of 24 months) resulted in these conclusions:

1) We found a total of 17 helminth species with a marked dominance of *Heligmosomum costellatum* (Nematoda) and *Aprostatandrya macrocephala* (Cestoidea).
2) Six helminth species are typical of *M. arvalis* from this locality. The remaining species are acquired by contact with other rodents during a certain season and in the different biotopes.
3) In the field biotope, we found 11 helminth species, in the meadow biotope 14 and in the forest biotope 9 species. The frequency of their incidence in the host indicates that the helminths of the common vole have become adapted to the biotopes of their host.
4) We observed 7—10 helminth species of varying numbers in the individual months.
5) The most frequent incidence of different species in one host was observed either among species of distant systematic position or species parasitic in different organs.
6) The higher the numbers of a certain parasite, the higher the incidence of this species either alone or in combination with other helminth species in the host.
7) Infection of the host with numerous helminth species are more frequent during the period of low helminth populations (from March till June). This appears to be due to the fact that host populations are low during this period, and, for survival reasons, different helminth species concentrate in the few hosts available. Since the numbers of parasites are also low during this period, even low numbers of hosts ensure the survival of the different helminth species.
8) Changes in the frequency of the concomitant occurrence of different helminths in the individual hosts are consistent with the frequency of these parasites in the entire host population.

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HELMINTHS AS INDICATORS OF THE AGE STRUCTURE OF MICROTUS ARVALIS PALLAS, 1778 POPULATION

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Abstract: Theriological and helminthological examinations of 1542 specimens of *Microtus arvalis* from the vicinity of Nový Bydžov were carried out in 1964 and the relationship between the structure of helminth fauna and the age of the host was observed. It was found that with the age of the host the number of helminth species and the incidence of helminth infection increased and the ratio of biohelminths to geohelminths changed. In specific biocenoses the dominant species of helminths may indicate the age structure of the population of common vole.

The common vole, which causes large economical damages and is an important carrier of some infectious agents of human and animal diseases, has been the subject of intensive investigations, due to Kratochvíl and his co-workers, and a state norm dealing with the control of this pest has been elaborated. An important part of this research, the ecology of helminths of the common vole, has been carried out in our country by several authors: Erhardová (1955, 1956, 1957, 1958, 1960), Holišová and Kočiš (1955), Tenora (1957, 1958, 1967), Tenora and Baruš (1955), Prokopič (1968, 1969, 1971). The research of ecology of helminths, which was made during last years (Prokopič, 1968, 1970 a, b, Prokopič, 1972) can be applied for many-sided evaluation of not only biology and ecology of parasites but also of their hosts. Kisielewska (1962) mentions the application of helminthological data in the study of the biology of small mammals. In a recent paper (1971) she describes the intestinal helminths as indicators of age structure of common vole population.

In our experiments we have investigated the material of common vole, both from theriological and helminthological point of view.

MATERIAL AND METHODS

In the present paper a survey of helminth parasites of *Microtus arvalis* Pallas 1778 is given. The common voles were captured on three ecotones as smaller ecological units of a biotope in the vicinity of Nový Bydžov are called. The methods used have already been described in an earlier paper (Prokopič, 1968) and we are therefore giving a concise description only. On a 3 km long area between Nový Bydžov and Prasek (1 km dry field boundary, 1 km edge of a meadow, 1 km oak forest) 300 glass jars of 5 l each, 45 cm high, were placed into holes dug in the ground. The jars were dug in a line at a distance of 10 m from one another. The bait in these traps was changed once a week (a mixture containing celery, parsley, carrot, wheat, oats, maize). The traps were covered with a roof to protect them against the rain so that the animals could enter them only from two sides. The trapped animals were collected every 48 hours. After killing, theorio-

logical and helminthological examinations of the animals were carried out and the helminths recovered were prepared and preserved. The cestodes and termatodes were stained with borax carmine, the nematodes were cleared by lactophenol. In this way we examined in the year 1964 1542 specimens of common vole (Tab. 1), of which 686 specimens, i.e. 44.5%, harboured 15 species of helminths.

RESULTS

The examined specimens of *Microtus arvalis* were divided into three groups: juveniles, subadults and adults. In the first group we placed the specimens which had not reached the physical and sexual maturity and whose body length did not exceed 70 mm. The group of subadults contained speci mens which had not reached sexual maturity, length of body being 71—80 mm. The adult specimens measured more than 80 mm and according to their sexual glands they reached the sexual maturity. It is very difficult to distinguish exactly the subadult and adult specimens, because there is no reliable set of characters available on the basis of which the age of the examined specimens could be exactly determined. The weight and length of body, the length of tail and hind paw, as well as the measurement of the skull are very variable (Šebek in Kratochvíl et al., 1959). From this point of view a certain tolerance can be admitted which, with regard to the quantity and constancy of preparation of the material, is quite negligible. In correlation with the age groups of the common vole the hel-

Table 1. Total incidence of infection with the helminths in *M. arvalis* of different age

Month	Total number of examined specimens	Total number of positive specimens	%	Juveniles			Subadults			Adults		
				Examined	Positive	%	Examined	Positive	%	Examined	Positive	%
January	20	8	40.0	—	—	—	8	—	—	12	8	66.6
February	120	47	39.2	—	—	—	44	—	—	76	47	61.9
March	41	25	62.5	—	—	—	7	—	—	34	25	73.6
April	27	13	48.1	—	—	—	—	—	—	27	13	48.1
May	11	6	54.5	—	—	—	—	—	—	11	6	54.5
June	61	42	68.8	1	—	—	4	3	75.0	56	39	69.6
July	126	66	52.4	8	1	12.5	21	7	33.3	97	58	59.8
August	158	85	53.9	6	2	33.3	39	5	12.8	78	78	69.0
September	389	176	45.2	33	7	20 8	72	24	33.3	284	145	51.0
October	347	117	33.6	24	3	12.5	85	23	27.1	238	91	38.0
November	140	63	45.0	—	—	—	64	8	12.5	76	55	72.5
December	102	38	37.3	—	—	—	31	4	12.9	71	34	47.9
Total	1542	686	44.5	72	13	18.0	375	74	19.8	1095	599	54.5

Table 2. The incidence of infection with different helmith species in *M. arvalis* of different age

	Total			Juvenles			Subadults			Adults		
	Examined	Positive	%	Examined	Positive	%	Examined	Positive	%	Examined	Positive	%
Brachylaemus recurvus	1542	1	0.06	72	—	—	375	—	—	1095	1	0.09
Paranocephala dentata	1542	2	0.13	72	—	—	375	—	—	1095	2	0.18
Aprostatandrya macrocephala	1542	290	19.0	72	2	2.8	375	17	4.5	1095	271	24.6
Catenotaenia pusilla	1542	6	0.4	72	—	—	375	—	—	1095	6	0.5
Rodentolepis asymetrica	1542	1	0.06	72	—	—	375	—	—	1095	1	0.09
Rodentolepis straminea	1522	3	0.26	72	—	—	375	1	0.27	1095	2	0.18
Hydatigera taeniaeformis	1542	103	6.7	72	—	—	375	16	4.26	1095	87	7.9
Taenia crassiceps	1542	2	0.13	72	—	—	376	—	—	1095	2	0.18
Taenia tenuicollis	1542	1	0.06	72	—	—	376	—	—	1095	1	0.09
Syphacia obvelata	1542	65	4.2	72	2	2.8	376	4	1.1	1095	59	6.4
Heligmosomum costellatum	1542	458	28.5	72	4	5.6	375	73	19.4	1095	381	34.8
Heligmosomum polygyrum	1542	145	9.4	72	1	1.4	375	26	6.9	1095	118	10.8
Heligmosomum skrjabini	1542	9	0.6	72	1	1.4	375	1	0.27	1095	7	0.6
Capillaria murisylvatici	1542	1	0.06	72	—	—	375	1	0.27	1095	—	—
Trichocephalus muris	1542	123	8.0	72	1	1.4	375	34	9.0	1095	88	8.0

minth infestation is further evaluated.

Juveniles. As can be seen in Table 1, the population of common vole in the given locality started to multiply as late as in May. In this month we captured the first gravid female. The first juvenile specimens were captured only in June. We examined 72 juvenile specimens captured from January till December and we found 13 specimens (18%) to be infested with 6 helminth species, namely 1 species of cestodes and 5 species of nematodes. The ratio of biohelminths to geohelminths was 1 : 5. Most juveniles were captured in September (33 specimens) and in October (24 specimens). Helminth infestation reached 20.8% in September and 12.5% in October. Most numerous parasites recovered from juveniles were the nematodes of the species *Heligmosomum costellatum* (Dujardin, 1845). (In our earlier papers we mentioned this species as *H. kalli* (Schulz, 1926) — 5.6%.) Less numerous were the species *Syphacia obvelata* — 2.8% and *Aprostatandrya macrocephala* — 2.8%. The other three species were found only rarely. Kisielewska (1971) found that the juvenile specimens of the common vole are parasitized mostly by pseudogeohelminths. In her material (Kisielewska, 1971) the dominant species recovered from juveniles was the nematode *Syphacia obvelata*. Our results are not consistent with this finding, because in our

material of this age group *Syphacia obvelata* is the subdominant species (Tab. 2). This will be dealt with in detail in Discussion.

Subadults. Subadult specimens were captured during the whole year, with the exception of April and May. The specimens captured in spring originated from the litters of late autumn, since the reproduction period lasts till November. The animals placed in this group of subadults could be therefore at least 2 months old in January and 6 months in April. The development and sexual maturity of these specimens is retarded due to the unfavourable winter conditions. The helminth infestation of subadult specimens should therefore have a similar course as in adults, if helminth infestations occurred in winter season. Therefore there should not be any essential differences in subadult and adult specimens captured from January till May. All the same, the differences between these two groups were considerable (Tab. 2). While the subadult specimens did not harbour any helminth parasites from January till March, in adult specimens we found in the same months helminth infestation of 66.6—73.6%.

Of 375 subadults, 74 specimens, i.e. 19.8%, were infested with 9 species of helminths, namely 3 species of cestodes and 6 species of nematodes. The ratio of biohelminths to geohelminths was 1 : 2. The most numerous was the nematode *Heligmosomum costellatum* (19.4%), then *Trichocephalus muris* (9.0%) and *H. polygyrum* (6.9%). The cestode *Aprostatandrya macrocephala* was found in 4.5% and *Hydatigera taeniaeformis* in 4.3% of subadult mice. In winter months no further infestations with helminths occurred. This was proved by the fact that the infestation of subadult specimens was 12.5% in November and 12.9% in December, that is half as in the autumn months (September 33.3%, October 27.1%). From January till March the subadult specimens were free of parasites. This finding also supports the assumption that the helminth infestations occur only rarely or do not occur at all in winter months.

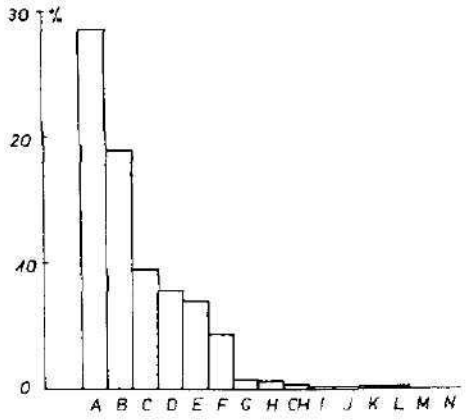

Fig. 1. Incidence of helminth infection in *Microtus arvalis*.

Adults. We examined 1095 adult specimens of which 599, i.e. 54.5%, were found to be infested with 14 species of helminths, namely 1 species of trematodes, 8 species of cestodes and 5 species of nematodes. The ratio of biohelminths to geohelminths was 9 : 5. Most numerous were again *H. costellatum* — 34.8% and *A. macrocephala* — 24.7%. According to the season, the lowest infestation of adults was found in October (38.0%), the highest in March (73.6%) (Tab. 1).

There were marked differences in helminth infestation of subadult and adult specimens, especially in autumn and winter months.

Month	Adults	Subadults
November	72.5%	12.5%
December	47.9%	12.9%
January	66.6%	—
February	61.9%	—
March	73.6%	—

There were also differences in the dominant and subdominant helminth species in different groups. Most numerous species in the whole population of the common vole was the nematode *H. costellatum* (28.5%) (Fig. 1). The incidence of infection with this parasite in the different age groups of the host was the following: juveniles 5.6%, subadults 19.4%, adults 34.8% (Fig. 2). Subdominant parasite in the whole population of the common vole was the cestode *A. macrocephala* — 19.9%. The incidence of infection was 24.7% in adults, 4.5% in subadults and only 2.8% in juveniles. It follows from these data that the older the population of host, the higher the incidence of infection with dominant and subdominant species of helminths.

Although it was not the aim of our work, we observed also the differences between infestation of males and females of the common vole. Of the 715 males examined, 341 specimens, i.e. 47.7%, harboured eleven species of helminths (incidence of infection 0.14—35.4%), namely 6 species of biohelminths and 5 species of geohelminths. The dominant species was the nematode *H. costellatum* — 35.4%, subdominant the cestode *A. macrocephala* — 21.7%. Of the 827 females examined, 362 specimens, i.e. 43.8%,

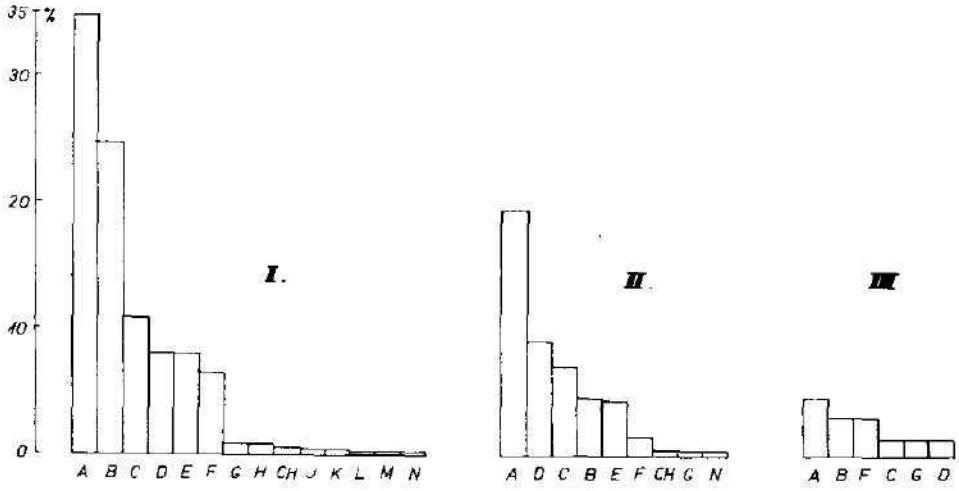

Fig. 2. Parasite infestation of *M. arvalis* in relation to the age. I — adults, II — subadults, III — juveniles. A — *Heligmosomum costellatum*, B — *Aprostatandrya macrocephala*, C — *Heligmosomum polygyrum*, D — *Trichocephalus muris*, E — *Hydatigera taeniaeformis*, F — *Syphacia obvelata*, G — *Heligmosomum skrjabini*, H — *Cutenotaenia pusilla*, CH — *Rodentolepis straminea*, I — *Taenia crassiceps*, J — *Paranoplocephala dentata*, K — *Brachylaemus revurvus*, L — *Rodentolepis asymetrica*, M — *Taenia tenuicollis*, N — *Capillaria muris-sylvatici*.

harboured 13 species of helminths (incidence of infection 0.1 – 24.8%), namely 7 species of geohelminths. The dominant species was *H. costellatum* — 24.8%, subdominant *A. macrocephala* — 16.3%. The above survey shows that the males were infested with a smaller number of helminth species, but the incidence of infection was higher.

DISCUSSION

In our experiments we tried to find the laws of parasitation of the common vole with helminths in relation to the age of the host. Our results show that there exists a correlation between the qualitative and quantitative composition of helminth parasites and the age of *Microtus sarvalis* population:

1. The number of helminth species increases with the age of the host (juveniles — 6 species, subadults — 9 species, adults — 14 species).
2. The extensity of infection also increases with the age of the host (juveniles 18.0%, subadults 19.8%, adults 54.5%).
3. The ratio of biohelminths to geohelminths differs in the individual age groups (juveniles — 1 : 5, subadults — 1 : 2, adults — 9 : 5).

According to Kiršenblat (1938) the intensity of geohelminth infection is higher in adult specimens than in juveniles.

We have come to the following conclusion:

a) Low number of helminth species reveals that the younger specimens prevail in the host population.

b) Low percentage of extensity of helminth infection also gives evidence that hosts of younger age groups prevail in the common vole population.

c) The higher the ratio of biohelminths to geohelminths, the more numerous are adult specimens of host.

Our results do not agree with the finding of Kisielewska (1971) that the dominant helminth species in juveniles is *Syphacia obvelata*. This statement seems to be true only under certain ecological conditions depending on the character of biocenosis, as it follows from many literary data. For example, Erhardová (1958) found in common vole 23 species of helminths, among which the most numerous was *H. costellatum*. The ratio of biohelminths to geohelminths was 15 : 8, which in our opinion gives evidence that the specimens of older age groups prevailed in the material of this author. Mituch (1970) recovered from *M. arvalis* 27 helminth species, with dominating *H. costellatum* (7.1%). Subdominant were *H. polygyrum* — 6.6% and *S. obvelata* — 5.6%. The ratio of biohelminths to geohelminths was 18 : 9 (2 : 1). According to this ratio and to the high number of species recovered, it can be assumed that the author examined mostly adult specimens, whereas the low incidence of infection (46%) gives evidence that younger specimens prevailed. The author did not mention the age composition of the examined population, but the discrepancy may be explained only by a specification of the biotopes of High Tatras where the experiments were carried out.

Genov (1967) found 17 species of helminths in the common vole. Dominant species was *H. polygyrum* (34.95%), subdominant *S. obvelata* (15.4%). The ratio of biohelminths to geohelminths was 13 : 4. This ratio was influenced by the moist character of the biotope and among others it also gives evidence that mostly specimens of older age groups were examined.

Tenora and Baruš (1955) found 9 helminth species in *M. arvalis*, extensity of infection was 56.5%. The ratio of biohelminths to geohelminths

(7 : 2) and the high percentage of incidence give evidence that mostly specimens of older age groups were examined.

Tenora (1967) found 4 helminth species; most numerous was *H. costellatum* — 16%. According to the low number of helminth species and the low incidence of infection we can suppose that the author examined mostly young animals.

Holišová and Kočiš (1955) examined *Microtus arvalis* in summer and autumn months. In 64.4% of hosts they found 8 species of helminths. Dominant species was *H. halli* (35.5% and 37.8%), subdominant *S. obvelata* (23.7% and 34.8%). The high percentage of infection and the ratio of biohelminths to geohelminths (5 : 3) give evidence that the authors examined mostly adult animals.

Andrejko (1963) found 16 helminth species in *M. arvalis*, dominant species was *S. obvelata* — 42.42%, subdominant *H. polygyrum* — 11.36%. According to the ratio between biohelminths and geohelminths (8 : 8) it can be assumed that the younger host specimens prevailed in the material examined. This assumption is also supported by the fact that *S. obvelata* prevailed, which according to Kisielewska (1971) is a dominant species in juvenile hosts.

Merkuševa (1963) found in *M. arvalis* 15 helminth species, the dominant one was *S. obvelata* (17%). The ratio of biohelminths to geohelminths was 8 : 7 and it can be supposed therefore that the author examined equal number of adult and young animals.

Dimitrova et al. (1961) found in *M. arvalis* 4 helminth species, dominant one was *S. obvelata* (13.63%). Dimitrova et al. (1962) recorded also 4 helminth species with dominating *S. obvelata* (74.4%) and subdominating *H. costellatum* (25.6%). According to Kisielewska (1971) this absolute dominance of *S. obveleta*, as well as the low number of helminth parasites and the ratio of biohelminths to geohelminths (0 : 3) give evidence that younger host specimens prevailed in the examined material.

Stammer (1955) recovered 15 helminth species from *M. arvalis*. Dominant species was *Rhabditis strongyloides* — 73.4%, subdominant *H. polygyrum* — 70.0% and *H. halli* — 65.4%. The ratio of biohelminths to geohelminths (6 : 9) shows that mostly young animals were examined.

Žarnowski (1955) found in the same host species 5 species of cestodes with dominating *Paranoplocephala dentata* (60.8%). Prokopič (1972) found in *M. arvalis* 13 species of cestodes where the most numerous was *A. macrocephala* (21%). The author points out that the composition of helminth fauna in this host is dependent on the character of biogeocenosis.

Under specific ecological conditions of the environment the helminths may serve as one of the indicators of the age composition of common vole population. In our opinion this concerns in particular the dominant and subdominant species in the given biotope. The higher the percentage of extensity of infection with dominant species, the higher the number of adult specimens in the population.

Jančev (1965) found 11 species of helminths in the common vole; dominant species was *S. obvelata* — 38.02%, subdominant *H. polygyrum* — 21.12%. The author recorded the incidence of infection to be 66.66% in adult specimens, but only 30% in younger animals, which fully supports our conclusions. The ratio of biohelminths to geohelminths was 4 : 6.

Chiriac and Hamar (1966) found in *M. arvalis* 7 helminth species; dominant species was *S. obvelata* — 28.5%, subdominant *H. polygyrum* — 18.3%. Extensity of infection (49.4%), low number of parasitizing species and the ratio of biohelminths to geohelminths (3 : 4) show the prevalence of young host specimens in the examined material, although the authors did not mention this fact.

CONCLUSION

On the basis of theoriological and helminthological examinations of 1542 specimens of *Microtus arvalis* in the vicinity of Nový Bydžov in 1964 we came to the conclusion that there exists a correlation between the age composition of the common vole population and the quantitative and qualitative composition of helminth parasites.

1. With the age of the host increases the number of helminth species.
2. With the age of the host increases the incidence of infection with helminths.
3. With the age of the host increases the ratio of biohelminths to geohelminths.
4. In specific biogeocenoses the dominating and subdominating species serve as indicators of the age composition and structure of the host population.
5. The higher the percentage of incidence of infection with dominant and subdominant species, the higher the number of adult specimens in the common vole population.

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LEPIONYSIUS ASHLOCKI SP.N. FROM N.S. WALES — A SECOND SPECIES OF LEPIONYSIINI (HETEROPTERA: LYGAEIDAE: ORSILLINAE)

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Abstract: *Lepionysius ashlocki* sp.n. (Australia, N.S. Wales) is described and compared with the only other known species of the tribe Lepionysiini, *L. grossi* Ashlock, 1967. The structure of phallus of the new species supports the hypothesis on the cladistic affinity between Orsillinae and Blissinae, and on the relict nature of the tribe Lepionysiini.

Ashlock (1967) revised the generic and tribal classification of Orsillinae, and described a new tribe Lepionysiini characterized mainly by a scale-like vestiture and ventral position of the spiracles on the 7th urite; both these characters are unique among Orsillinae and suggest a possible relationship of this subfamily to Blissinae (and Slaterellinae). The monotypic genus *Lepionysius* Ashlock, 1967 (type species *L. grossi* Ashlock, 1967) is the only known member of the tribe. The species was described according to two brachypterous specimens (♂ holotype, ♀ paratype) from the Kangaroo Island (S. Australia); a third specimen congeneric with *L. grossi* was available from the Northern Territory of Australia, but it was impossible to place it in *L. grossi*, because it was a macropter. No more specimen have been known, and no information on the ecology of this obviously rare group is available.

In this paper a new species of *Lepionysius* is described from N. S. Wales. Except for the characters mentioned in the following description, particularly the strangely different structure of phallus, the new species completely agrees with Ashlock's (1967) tribal, generic and specific diagnoses, and illustrations. Since Ashlock did not use in his revision the characters concerning the shape of pygophore, metapleural orifices, parameres and hind tarsi, also these characters which are of possible taxonomical importance are described here. All measurements are given in millimeters.

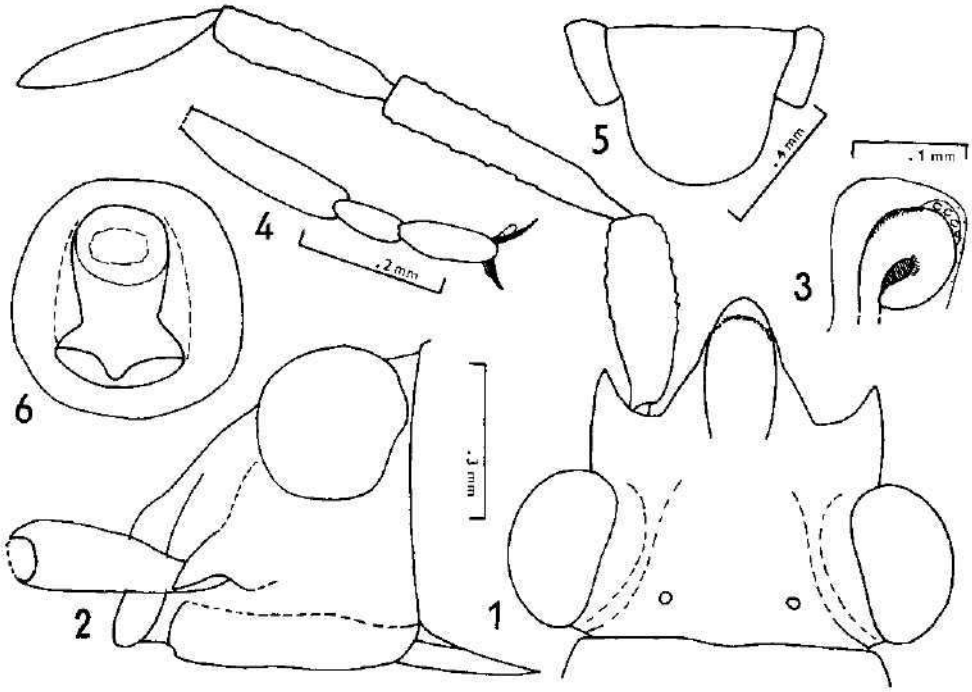
Lepionysius ashlocki sp.n.

(Figs. 1—10)

Holotype: brachypterous ♂, Australia, N. S. Wales, Mt. Victoria, lgt. Biró, 10.—16. 11. 1900; deposited in the collection of the Department of Zoology, Hungarian National Museum, Budapest. Genitalia mounted separately. I have not found Mt. Victoria in N. S. Wales in any map or gazetteer, but it might be near the Victoria Pass (33.30 S., 150.15 N.).

Description.

Head (Figs. 1, 2) with markedly produced, narrow and pointed apex, exceeding the produced spinose parts of antenniferous tubercles by more than their length, and reaching to about 2/3 of the length of first antennal segment. Anterodorsal part of head slightly sinuate and gently sloping



Leptomysius ashlocki sp n 1 — Head and antenna, dorsal view. 2 — Head, lateral view. 3 — Left metapleural peritreme and evaporatorium. 4 — Hind tarsus, dorsal view. 5 — Male 7th tergum. 6 — Pygophore. Figs. 1, 2 and 6 to the same scale.

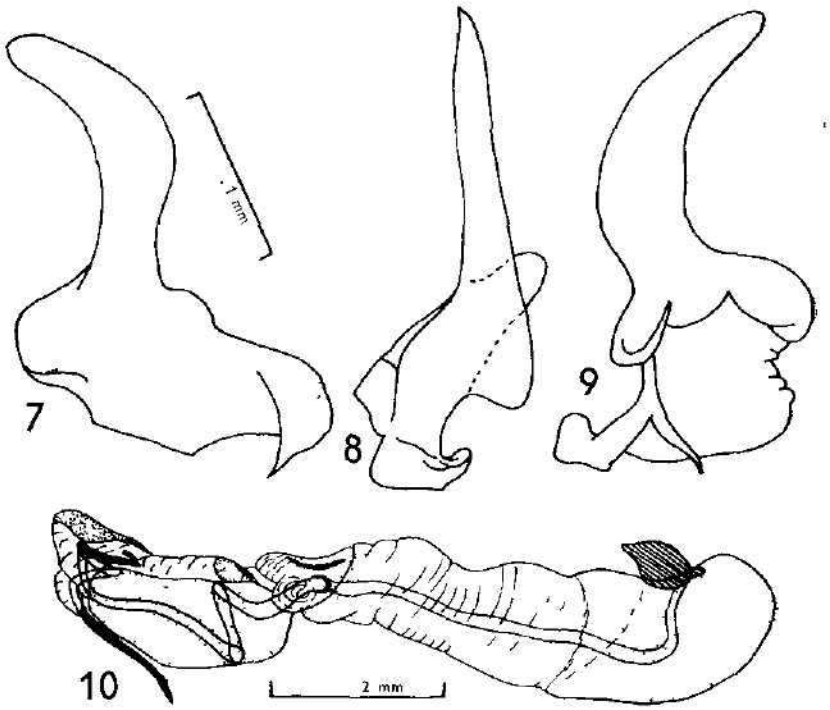
ventrally (in lateral view), apical part of anteclypeus concave, suddenly almost vertically deflecting ventrad. Eyes small, globular in the lateral view, not produced behind the fore margin of prothorax (in contrast to Ashlock's (1972: 23) generic diagnosis). Bucculae almost fully covered with scales, their distal apices markedly remote from the apex of head. Length of head 0.60, anteocular length 0 33, length of eye 0 27, max. width across eyes 0.83, min. width of vertex 0.45.

First antennal segment (Figs. 1, 2) only moderately thickened, about three times as long as wide, widest in the middle, as long as 3rd segment, slightly shorter than 4th. Second and 3rd segments terete, rather thin, 4th fusiform. Segment lengths from base to apex: 0.345, 0.465, 0.345, 0.36.

Labium reaching the base of mesoxyphus, the apex of first segment distant from the base of head, the apex of second segment reaching the proximal third of prosternum; segment lengths from base to apex 0.30, 0.30, 0.27, 0.24.

Pronotum. length 0.63, max. width 0.80. Scutellum. length 0.39, width 0.80. The outline of the dorsum of scutellum straight and horizontal in the lateral view, the apex is not "somewhat raised" (Ashlock, 1972 : 23, generic diagnosis).

The deep pro— and mesosternal labial groove shallowly continuing onto the proximal half of swollen metasternum.



Leptonysius ashlocki sp n. 7, 8, 9 — Left paramere from different aspects; hairs omitted. 10 — Phallus, lateral view; vesica incompletely inflated.

Metapleural peritreme (Fig. 3) situated in a subrectangular depressed evaporatorium; its conspicuous whitish auriculum with a free, curved, posteroventrally and somewhat laterally directed apex.

Hind tibia: length 1.02. Hind tarsus (Fig. 4): length 0.42; segment lengths from base to apex 0.22, 0.09, 0.12; first segment moderately thin.

Fore wings slightly surpassing the apex of 3rd tergum; their length 0.90.

Lateral margin of abdomen evenly convex, none of the laterotergites with a separate curvature. Seventh mediotergite twice as long as its laterotergites, its produced part uniformly rounded (Fig. 5).

Pygophore small, globular, without hypandrium; its posterior foramen as in Fig. 6, the dorsolateral processes obtusangular, slightly depressed. Parameres as in Figs. 7—9.

Phallus (Fig. 10). Phallotheca elongate, simple, without processes. Conjunctiva long, with a distal lobe (lobes ?) and a distal pigmented area. The strongly asymmetrical vesica has not been fully inflated, and its construction is not fully understood, but at least two of its lobes are pigmented,

the pigmentation showing at least two distinctly delimited sclerites. Helicoid process absent, gonoporal process short.

Vertex of head and posterolateral angles of pronotum almost blackish. Antennal segments light brown, concolorous. Scutellum dark castaneous to blackish, only the apical half of lateral margins pale. Fore wings proximally yellowish, laterally and distally brownish. Abdomen pale brown, with extensive blackish spots on laterotergites occuppying approximately their proximal and lateral two thirds; mediotergites 1—3 darkened, mediotergite 7 with a blackish median longitudinal vitta.

Length 3.2 mm, maximum width 1.2 mm.

Differential diagnosis.

The main characters separating the species of *Lepionysius* are tabulated below.

	Lepionysius ashlocki sp. n.	*Lepionysius grossi* Ashlock
Apex of head	more produced; exceeding the spinose projections of antenniferous tubercles by more than their length; reaching to about two thirds of first antennal segment;	less produced; exceeding the spinose projections of antenniferous tubercles by less than their length; reaching to about the middle of first antennal segment.
Apex of anteclypeus	suddenly almost vertically reflected ventrad, concave in lateral view; the extreme apex rather distant from bucculae;	evenly convex in lateral view; the extreme apex close to bucculae.
First antennal segment	thinner, about three times as long as wide, thickest in the middle;	thicker, about twice as long as wide, thickest apically.
Second and third antennal segments	thinner, definitely terete;	thicker, subfusiform (?)*.
Antennal formula (segments numbered from base to apex, the shortest first)	1 = 3, 4, 2;	3, 1 = 4, 2.
Curvature of abdominal margins	simple, evenly convex;	each laterotergite slightly separately convex.
Produced part of ♂ mediotergite 7	rounded;	subtrapezoidal.
Medial carina on scutellum	dark;	pale.
Pigmented area on conjunctiva	present;	absent.
Pigmentation of vesica	on two lobes at least; showing sclerites;	on one lobe only; no sclerites.

* The thickening of these segments is probably exaggerated by Ashlock (1972 : Fig. 11c) due to the artist's licence.

Discussion.

The somatic differences between *Lepionysius ashlocki* sp.n. and *L. grossi* Ashlock are of the usual kind and degree as among the other congeneric species in Lygaeidae, and the discrepancies between the characters of the new species and Ashlock's (1972) generic diagnosis mentioned in the above description are not important. However, important differences do exist in the structure of phallus.

Ashlock (1967) characterized the orsilline phallus by the presence of a distal pigmented area on the conjunctiva, a single basal pigmented lobe on the vesica, the lack of phallothecal processes, a completely asymmetrical vesica, and the lack of a helicoid process. The phallus of *Lepionysius grossi* is exceptional among Orsillinae through the lack of the pigmented area on the conjunctiva. Ashlock (1967) stressed the similarity between the phalli of Blissinae and Orsillinae, and noted that "If one of the blissine aedeagi that lacks phallothecal and helicoid processes and has pigmented lobes at the base of the vesica (rather than sclerite-bearing loges — P. Š.) were to lose one of its basal pigmented lobes, the resulting aedeagus would be quite like that of *Lepionysius (grossi* — P.Š.)".

The distal pigmented area on the conjunctiva is well developed in *Lepionysius ashlocki*, and in this respect the second species of the genus is not exceptional among Orsillinae. On the other hand, at least two of the lobes of the vesica of *L. ashlocki* are pigmented, and the pigmentation seems to form sclerites which rather resemble a reduced form of the ring sclerite. This makes the vesica of *L. ashlocki* not only sharply different from that of *L. grossi* and all other Orsillinae, but also, of all the orsilline species, the most similar to the vesica of Blissinae.

Table 1. Occurrence of blissine characters in Lepionysiini (Orsillinae). Black circle indicates an apomorphic presence of a character

	Spiracle of the 7th urite dorsal	Scale-like vestiture	Conjuctiva with a distal pigmented area	Vesica with one pigmented basal lobe only
Blissinae	○	○ → ●	○	○
Lepionysius grossi	○	●	○	●
Lepionysius ashlocki	○	●	●	○
rest of Orsillinae	●	○	●	●

These facts are most interesting when considered from the viewpoint of a possible cladistic affinity of Lepionysiini to Blissinae. The Lepionysiini share with Blissinae and Slaterellinae (which should, perhaps, constitute a mere tribe of Blissinae) the ventral position of the spiracle on the 7th urite — it is a plesiomorphic character, the apomorphic dorsal position of this spiracle characteristic of all the other Orsillinae has not yet been evolved in this tribe. The scale-like vestiture of Lepionysiini is an apomorphic character, shared with Slaterellinae and some genera of Blissinae — it could be looked upon as a parallel development. The conjunctiva of *Lepionysius grossi*, lacking the distal pigmented area, is alike to Blissinae (symplesiomorphy), while its vesica is of a typically orsilline type (probably synapo-

morphy). On the other hand, the conjunctiva of *Lepionysius ashlocki* is like that of the other Orsillinae (synapomorphy), while its vesica is transitional between the two subfamilies considered (probably symplesiomorphic with that of Blissinae). The summary of the characters discussed is given in Table 1.

It seems quite probable that Lepionysiini represent a relict tribe of Orsillinae with a close cladistic affinity to the blissine ancestor of the subfamily. Lepionysiini had diverged from the common orsilline stock at a time when they still possessed some plesiomorphic blissine characters, and the apomorphic orsilline characters started to appear in a mosaic-like pattern. This hypothesis would explain the presence of both blissine and orsilline characters in the species of Lepionysiini, and the surprising variation in the distribution of these characters in the species of its single genus.

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RESERVOIR PARASITISM IN CESTODES OF THE FAMILY HYMENOLEPIDIDAE (ARIOLA, 1899) PARASITIC IN DOMESTIC AND WILD DUCKS

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Abstract: We examined a total of 10,212 water snails belonging to 11 species. Cysticercoids recovered from three species: *Lymnaea auricularia (Microsomacanthus compressa, M. paracompressa, M. paramicrosoma); L. peregra ovata (Dicranotaenia coronula, M. compressa, M. paracompressa, M. paramicrosoma); L. peregra peregra (Dicranotaenia coronula, Microsomacanthus paracompressa, M. paramicrosoma).* Our experiments and field findings suggest that the snails are not utilized as intermediate hosts, but act as reservoir hosts of these cestode species; the cysticercoids concentrate in the body of the snails without undergoing any further development; the cysts stain with liver dyes from a yellowish brown to a dark brownish violet colour; the fine parenchymatous tail is either partly or completely torn off. The snails harbour cysticercoids with solid and elastic walls only. Under laboratory conditions the cysticercoids retained their capability of infection in the snails for a period of two years. Factor important for reservoir parasitism is the length of the time for which cysticercoids can survive in dead intermediate hosts (crustaceans). At 4° C, they survive by 20—24 hrs in tap water, by 14 hrs in fishpond water; at 18—20° C, by 10—12 hrs in tap water, by 6—7 hrs in fishpond water.

INTRODUCTION

The findings of cysticercoids in snails were recorded by Villot (1883)*, Leuckart (1885)*, Joyeux (1929), Oparin, Ošmarin, Rummel (1958), Petročenko and Kotelnikov (1959), Supperer (1959), Ryšavý (1961, 1962a,b), Zajíček (1961), Pike (1968). Several of these autors merely recorded the finding of these cysticercoids or considered the snails to be intermediate hosts of the cestodes (Leuckart, Supperer); others (Joyeux, Oparin, Ošmarin, Rummel, Petročenko and Kotelnikov, Ryšavý, Zajíček) listed the snails among the reservoir hosts. Pike discussed both eventualities without taking sides. Ryšavý (1962b) dealth with this problem into all details and added the microsomacanthoid type to the list of types of reservoir parasitism suggested by Šumakovič and Ryžikov (1954). The present study has been undertaken with the intention of adding new knowledge to the problem of reservoir parasitism in snails supported by evidence from findings in the field and from laboratory experiments.

MATERIAL

a) Material from the field: During the years 1964—1968, we examined a total of 10,212 water snails, collected in 42 fishponds in the environments of Chlumec nad Cidlinou, Louny, Prague,

Table 1. List of snails examined

Snail species	No. examined	Cysticercoids species recovered							
		Dicranotaenia coronula		*Microsomacanthus compressa*		*M. paracompressa*		*M. paramicrosoma*	
		E	I	E	I	E	I	E	I
Anisus vortex (L.)	60	–	–	–	–	–	–	–	–
Gyraulus sp.	26	–	–	–	–	–	–	–	–
Lymnaea auricularia (L.)	1,038	–	–	50	1–15	101	1–15	5	2–7
L. palustris (Müll.)	697	–	–	–	–	–	–	–	–
L. peregra ovata (Drap.)	4,728	10	1–10	166	1–32	210	1–40	12	1–5
L. peregra peregra (Müll.)	886	2	1	–	–	10	1–5	1	1
L. stagnalis (L.)	1,780	–	–	–	–	–	–	–	–
Physa fontinalis (L.)	83	–	–	–	–	–	–	–	–
Planorbis corneus (L.)	536	–	–	–	–	–	–	–	–
Planorbis planorbis (L.)	160	–	–	–	–	–	–	–	–
Viviparus viviparus (L.)	218	–	–	–	–	–	–	–	–

E = Incidence of infection, I = Intensity of infection

Vlašim, Písek, Blatná, Lomnice nad Lužnicí, Třeboň (Bohemia), Valtice and Lednice (Moravia). Tab. 1.

b) Laboratory work: In our experiments we employed these snail species: *Lymnaea auricularia, L. palustris, L. peregra ovata, L. peregra peregra* and *L. stagnalis*. The snails were collected in fishpond areas not occupied by nesting wild ducks to avoid the possibility of natural infection (no cysticercoids were recovered from the snails upon control inspection. Part of the snails was bred from eggs.

RESULTS

a) Findings of cysticercoids in snails under natural conditions: We recovered from *Lymnaea auricularia, L. peregra ovata* and *L. peregra peregra* fully developed cysticercoids of the cestode species *Dicranotaenia coronula* (Dujardin, 1845), *Microsomacanthus compressa* (Linton, 1892), *M. paracompressa* (Czapliński, 1956) and *M. paramicrosoma* (Gasowska, 1932) (Table 1). Cysticercoids are ingested by the snails together with the bodies of dead crustaceans and are deposited with indigestible food particles (grains of sand, shells of diatoms) in the ultimate tubules of the hepatico-pancreas. The colour of the cysts ranges from a light yellowish brown to a dark brownish violet; the fine parenchymatous tail is partly or completely torn off. The coloration of the cysts is due to the influence of the hosts liver dyes, its intensity increases with the duration of survival of the cysticercoid in the snails.

b) Laboratory work: The results of laboratory experiments confirmed and exactified several field observations.

1. Experimental infection of snails with cestode eggs: We set up a total of 11 experiments with eggs of the cestode *Dicranotaenia coronula* (one experiment); *Diorchis nyrocae* Yamaguti, 1935 (2); *Fimbriaria fasciolaris* (Pallas, 1781) (2); *Microsomacanthus compressa* (2); *M. paracompressa* (2); *Sobolevicanthus gracilis* (Zeder, 1803) (2). The eggs were placed in vessels occupied by the snail species *Lymnaea auricularia, L. palustris, L. peregra ovata, L. peregra peregra* and *L. stagnalis*. We employed 20 snails in each experiment. and 50–70 eggs per snail. Simultaneously we set up control experiments with crustaceans. All experiments were conducted at 18–20°C, pH water 6,8–7.

Table 2. Period of survival of the cysticercoids in dead crustaceans

Model of infection	No. of experiment	Intermediate hosts	No. of intermediate hosts	Cysticercoids	Intensity of infection	Duration of survival (in hrs) 4° C tap water	4° C fish-pond water	18–20° C tap water	18–20° C fish-pond water
Experimental	1	*Acanthocyclops viridis*	15+15	*Microsomacanthus paracompressa*	1–3	24	14	—	—
	2	*Macrocyclops albidus*	15+15	*M. paracompressa*	1–2	22–24	14	—	—
	3	*A. viridis*	15+15	*M. paracompressa*	1–3	—	—	10–12	7
	4	*M. albidus*	15+15	*M. paracompressa*	1–2	—	—	12	6–7
	5	*M. albidus*	15+15	*M. paracompressa*	1–2	—	—	12	7
Natural	6	*Cyclops strenuus*	15+15	*M. compressa*	1	20–24	14	—	—
	7	*C. strenuus*	15+15	*M. compressa*	1–2	—	—	11–12	7
	8	*C. strenuus*	15+15	*M. compressa*	1	—	—	12	7

As late as on day 30 of the experiment, we did not find cysticercoids or other larval stages in the snails. In the crustaceans, cysticercoids were recovered between day 14–18.

2. Duration of survival of the cysticercoids in dead crustaceans: Experiments were performed with naturally and experimentally infected crustaceans at 4°C and 18–20°C. At 4°C, the cysticercoids survived in the dead crustaceans 20–24 hrs in tap water, 14 hrs in fishpond water; at 18–20°C, 10–12 hrs in tap water, 6–7 hrs in fishpond water (Table 2). After this period dead crustaceans with the cysticercoids (from all 8 experiments) were fed to a total of 48 snails of the species *Lymnaea auricularia* and *L. peregra ovata* and, 14 days later, these snails were fed to 10 four week-old ducklings of the species *Anas platyrhynchos dom.* Linné. Post-mortem inspection of the ducklings revealed the presence of the corresponding cestode species.

3. Cysticercoid species surviving in the snails: In our experiments we employed the species *Fimbriaria fasciolaris* (fine and thin cysts), *Diorchis nyrocae* (fine cysts recorded from snails by Zajíček, 1961), *Microsomacanthus paracompressa* and *M. paramicrosoma* (thick and strong cysts) (Table 3). As regards the cysticercoids of *F. fasciolaris*, *M. paracompressa* and *M. paramicrosoma*, the results are consentient, in the case of *D. nyrocae* it may be possible that Zajíček found the cysticercoids shortly after the infected crustaceans had been ingested by the snails (from day 1–9).

4. Duration of survival of the cysticercoids in the snails: The longest period of survival of cysticercoids in snails, assessed experimentally, was two years. The experiment was performed with 10 snails of the species *L. peregra ovata* infected with cysticercoids of the species *M. paracompressa* (intensity of infection 3–5 cysticercoids). After twoo years, the snails were fed to two 4 week-old ducklings (*Anas platyrhynchos dom.*); after 6 weeks, post-mortem disclosed the presence of the adult cestodes *M. paracompressa*.

Table 3. Period of survival of the cysticercoids in the snail *Lymnaea peregra ovata*

Cysticercoids of the cestode species	No. of snails in the experiment	No. of cysticercoids per snail	Time of snails inspection	No. of snails examined	Findings	Repetition of the experiment
Microsomacanthus paracompressa	20	3–5 (i.e. 1–3 crustaceans)	2 hrs	2	cysticercoids	twice
			4 hrs	2	cysticercoids	
			day 2	2	cysticercoids	
			day 4	2	cysticercoids	
			day 6	2	cysticercoids	
			day 8	2	cysticercoids	
			day 10	2	cysticercoids	
			day 12	2	cysticercoids	
			day 14	2	cysticercoids	
			day 16	2	cysticercoids	
M. paramicrosoma	The same procedure and course of experiment as that with *M. paracompressa*					three times
Diorchis nyrocae	30	3–5	2 hrs	2	cysticercoids	five times
			4 hrs	2	cysticercoids	
			day 2	2	cysticercoids	
			day 3	2	cysticercoids	
			day 4	2	cysticercoids	
			day 5	2	cysticercoids	
			day 6	2	cysticercoids	
			day 7	2	cysticercoids	
			day 8	2	negative snails in two experiments	
			day 9	2	negative snails in three experiments	
			day 10	2	negative	
			day 12	2	negative	
			day 14	2	negative	
			day 16	2	negative	
			day 18	2	negative	
Fimbriaria fasciolaris	20	3–5	2 hrs	2	negative	three times
			4 hrs	2	negative	
			day 2	2	negative	
			day 4	2	negative	
			day 6	2	negative	
			day 8	2	negative	
			day 10	2	negative	
			day 12	2	negative	
			day 14	2	negative	
			day 16	2	negative	

5. The infective capability of cysticercoids from snails: No decrease in the degree of the infectivity of the cysticercoids occurs during their stay in the snails. Feeding experiments with ducklings (*Anas platyrhynchos dom.* infected with cysticercoids from snails disclosed twice the number of cestodes than those found in feeding experiments with cysticercoids from intermediate hosts. We established these facts by comparing 50 feeding experiments on each group.

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MORPHOLOGICAL CHANGES DURING THE LIFE CYCLES OF THE VICIACEAE-INHABITING SPECIES OF THE GENUS ACYRTHOSIPHON MORDV., 1914 (HOMOPTERA: APHIDINEA). (PRELIMINARY NOTE)

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Abstract: The principal results, as well as their theoretical aspects, of the biometrical analysis of the polymorphism phenomenon in *Acyrthosiphon pisum* (Harris), *A. spartii* (Koch), *A. caraganae* Chol., *A. parvus* C. B. and *A. loti* Theob. are presented in the form of a preliminary note.

INTRODUCTION

The evolutionary interpretation of the discovery of different types of life cycles in aphids has often been the result of experience and instinct of taxonomists (Mordvilko, 1934, Hille Ris Lambers, 1950 a. 1966, Börner in Müller, 1956 a. 1966, Kennedy a. Stroyan, 1959, Šaposnikov, 1959). The aphid life cycles were described and estimated mostly from the bionomical point of view. The occurrence of separate morphological forms, i.e. morphs, was carefully recorded. However, the interrelations of morphological changes during the life cycle have not yet been studied in detail. Therefore, the necessity of a study has appeared that would sift out and compare the manifestations of polymorphism through an objective method using biometrical analysis, with consistent regard to individual phases of the life cycle.

The polymorphism was investigated in this way in the following species: *Acyrthosiphon pisum* (Harris, 1776) collected from *Medicago sativa*, *A. spartii* (Koch, 1855) from *Sarothamnus scoparius*, *A. caraganae* Chol., 1907 from *Caragana* sp. and *Colutea* sp., *A. parvus* C. B., 1950 from *Cytisus capitatus* and *A. loti* Theob., 1912 from *Lotus corniculatus*. The life cycles of all these species are of a formally identical monoecious type.

The aphid material was collected in the vicinity of Prague, Czechoslovakia, in 1967—1969 by random sample collecting. Samples of 30—40 specimens were taken from populations of the species mentioned above. The sites of collecting were frequented at intervals of about 14—20 days. In this way adults and nymphs of all the morphs occurring during the life cycle were registered. Supplementary information was obtained through the rearing of *A. pisum* under laboratory conditions. Some phenomena unnoticed till now, have been thus discovered enabling us to draw certain well-based conclusions and supporting many theoretical suppositions concerning some questions of the evolution of the aphid life cycles. Moreover, it was possible to work out a descriptive scheme for an easy and detailed orientation in all morphological manifestations and interrelations of the polymorphism in all species studied. The information on the changes of meristic and quantitative characters and their occurrence in the partial phases on the life cycle in adults and nymphs could be used in experiments aimed at the study on the immediate mechanism of the aphid polymorphism on various levels, especially in *A. pisum* that is used frequently in experiments.

MORPHS OBSERVED, PHYLOGENETIC EVALUATION OF MORPHOLOGICAL CHARACTERS

The biometrical analysis was preceded by a detailed study of the external morphology of adults and nymphs. The following morphs occurred during the life cycle: apterous fundatrix, alate or apterous virginoparous female, apterous oviparous female, and alate or apterous male.

The results of the phylogenetic evaluation of the morphological characters yielded valuable information extending the interpretation of the complete assessment of polymorphism in the evolutionary aspect. Criteria were taken over from the experienced authors Šapošnikov (1956) and Szelegiewicz (1965) and applied to the following characters of the investigated aphid material: shape of forehead, antennae, number of secondary rhinariae, ultimate rostral segment, legs of oviparous females, siphunculi, cauda, arrangement of dorsal body hairs, cuticle, its sculpture and sclerotization, spinal, pleural and marginal tubercles and spiracles, their shape and insertion.

The results of the evaluation have shown that — in accordance with contemporary criteria and opinions of various authors on the phylogenetic significance of the morphological characters in aphids — the characters examined are mostly apomorphic. It is in complete accordance with the classification of the species mentioned in the phylogenetically youngest family Aphididae and in its the most derived tribus Macrosiphini.

However, there is one exception presented by several simultaneously occurring plesiomorphic characters, found only in the first three instars of the *A. pisum* fundatrix. (Nymphs of the other species have not yet been studied in this respect.) In this case it is a flat and heavily sclerotized forehead with a conspicuous epicranial suture, the marginal and spinal tubercles and peritremal sclerites of spiracles are well-developed. The arrangement of dorsal body hairs is probably plesiomorphic, too.

From the viewpoint of the phylogenetic evaluation these results point to a possible evolutionary inequality of the various morphs and show the importance of the study of morphology of nymphal instars.

THE RESULTS OF THE BIOMETRICAL ANALYSIS

The graphic presentation of the variability of quantitative and meristic characters by means of the so called "Dice-gramms" method indicates that the characters studied undergo a certain change during the life cycle in accordance with a characteristic scheme which is common for all these species. However, there exist some specific deviations. (See below.)

The universally occurring morphological changes are as follows:

In the fundatrix, compared with the virginoparous female, there is a conspicuous tendency to the reduction of the length of extremities and of sense organs. Many of these changes are of diagnostic value for this morph.

Morphological changes in oviparous females have a trend analogous to that in the fundatrices. But these differences, in comparison with the fundatrices, are not so striking as to be diagnostically valuable. Therefore it is necessary to use also qualitative characters in the identification of the oviparous females, e.g. the occurrence of pseudorhinariae on hind tibiae and chaetotaxy of the genital plate and of cauda.

Virginoparous females are a more or less morphologically homogeneous group. The morphological differences recorded among separate generations

of this morph are mostly the manifestations of modifiability, e.g. dwarfish specimens in mid-summer populations or sometimes the first generation of virginoparous females, fundatrigeniae. Only in *A. pisum* and *A. spartii* sexuparous females bearing some alatiformous characters occur regularly. (More detailed information is given below.)

It is impossible to distinguish the alate and apterous virginoparous females with the exception of the characters indicating the adaptation for flying.

Only qualitative characters are suitable for the identification of males, e.g. reproductive organs, etc.

The variation of the caudal bristle index introduced by Meier (1964) is linked with the regularly occurring changes of chaetotaxy in various morphs.

On the whole we can say that the majority of morphological characters varies so much during the life cycle that the polymorphism of the species is sufficiently demonstrated by them. However, the morphological change of a certain character in a certain morph need not be of diagnostic value.

An identical phenomenon of morphological changes also appears in the nymphs of various morphs and frequently in the first instar as well. For instance, fundatrices of the first instar are easily distinguished by their quantitative and qualitative characters. The same trend of morphological changes as in adult oviparous females can be observed in the nymphs of this morph. The alate virginoparous females are safely distinguished by their wing lobes from the beginning of the third instar. The diagnostic differentiation of male nymphs is still problematical.

THE MORPHOLOGICAL DIFFERENTIATION OF APTEROUS AND SEXUPAROUS FEMALES

It has been said that virginoparous females form a morphologically homogeneous group. However, there are certain deviations with various causes. The obvious manifestation of modifiability of virginoparous females is the occurrence of dwarfish forms in mid-summer populations and predominantly in species living on trees and shrubs, i.e. *A. caraganae* and *A. parvus*, but not in *A. spartii*. The rearing of *A. pisum* under unfavourable conditions, i.e. high temperature and withering host plant, also resulted in the production of morphs that occur in field populations in a smaller proportion.

In the first generation of virginoparous females, sometimes called fundatrigeniae, the quantitatively varying displacement of the state of the characters was observed. It is the gradual transition from the situation obtaining in the fundatrices to that in their progeny — the fundatrigeniae. It was most striking in the chaetotaxy and sometimes also in the extremities. Again it is obviously a manifestation of the modifiability. Maybe that it is most likely caused by environmental conditions that are similar to those prevailing during the season when the fundatrices are developing. Therefore in this case there is apperently no reason to consider the fundatrigeniae equal to the morphs mentioned above.

In autumnal populations of the related species *A. pisum* and *A. spartii* the two forms of sexuparous females regularly occur. They are partly normal apterous and alate androgynoparous females which from the viewpoint of morphological evaluation are identical with the virginoparous females still occurring in the population at this time, and partly apterous andro-

gynoparous] females often bearing very striking alatiformous characters, i.e. a high number of secondary rhinariae on the third antennal segment, and sometimes ocelli persist as well. On the other hand, these special alatiformous characters are always missing in normal apterous virginoparous females occurring at any time during the life cycle.

In comparison with the other types of life cycles in aphids there is only one explanation. It seems that these sexuparous females bearing the alatiformous characters mentioned above are originally functional immigrants regularly occurring in a certain phase of the primeval heteroecious type of the life cycle. At the present time these forms probably represent the one persisting morphological (and doubtless also physiological) relic.

This phenomenon certainly supports the hypothesis on the secondary monoecy that should be derived from the primary heteroecy (Hille Ris Lambers, 1950 a. 1966). In the other species with the monoecious life cycle, that have been studied, no analogous vestiges of changes of their life cycles were found. The origin of their monoecy remains open to theoretical consideration.

SPECIFICALLY DIFFERENT MANIFESTATIONS OF POLYMORPHISM

In species living on trees and shrubs, *A. caraganae* and *A. parvus* (not in *A. spartii*!), the manifestations of polymorphism are more striking than in *A. pisum*, *A. spartii* and partially also *A. loti* feeding on herbs. The situation in the latter species is, however, more complicated, since the characters involved in the manifestation of polymorphism change differently during its life cycle, and the most striking morphological changes often concern different characters than in the other species.

It is possible to accept an explanation based on the theory taking in account the period of time in which the modern type of the life cycle has been in existence, and the degree of bionomical and morphological specializations of the various morphs (Kennedy a. Stroyan, 1959 and Hille Ris Lambers, 1950, 1966). And the results of the study of the originally most probably heteroecious life cycles in *A. pisum* and *A. spartii* correspond with this explanation.

NOTE ON THE TAXONOMY OF THE STUDIED SPECIES

Biometrical data on the morphology of all the five species have enabled their detailed comparison. With regard to the bionomical data it seems that the investigated group of leguminous species of the genus *Acyrthosiphon* is the result of the union of two groups — *A. pisum*, *A. spartii* — *A. caraganae*, *A. parvus* and maybe *A. loti* as well. The inter-group morphological differences are indisputable and often too striking, e.g. the shape and chaetotaxy of the first antennal segment, length and shape of siphunculi and cauda, etc. Finally, their life cycles formally identical in the bionomical respect, are also different from the morphological point of view, as it has been mentioned above.

According to this information it is very unlikely that *A. pisum* would be the ancestral species (Müller, 1959) of all the ones mentioned.

Note

The complete paper with elementary biometrical data on all the five species will be published in Acta Universitatis Carolinae-Biologica, 1974.

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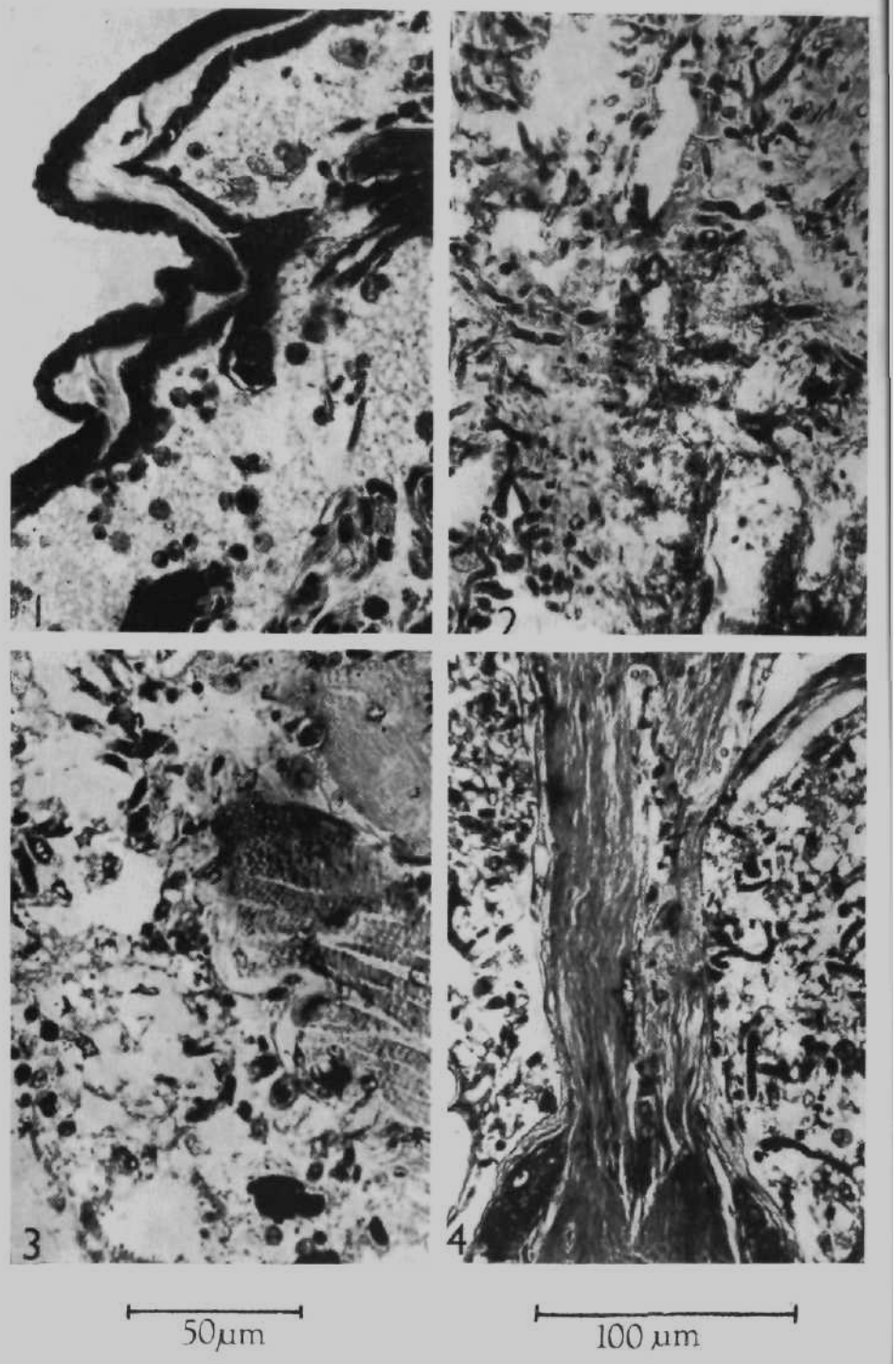

Fig. 1. At the beginning of the infection only the adipose tissue is infested with the fungus.
Fig. 2. The adipose tissue is strongly infested with the hyphal bodies.

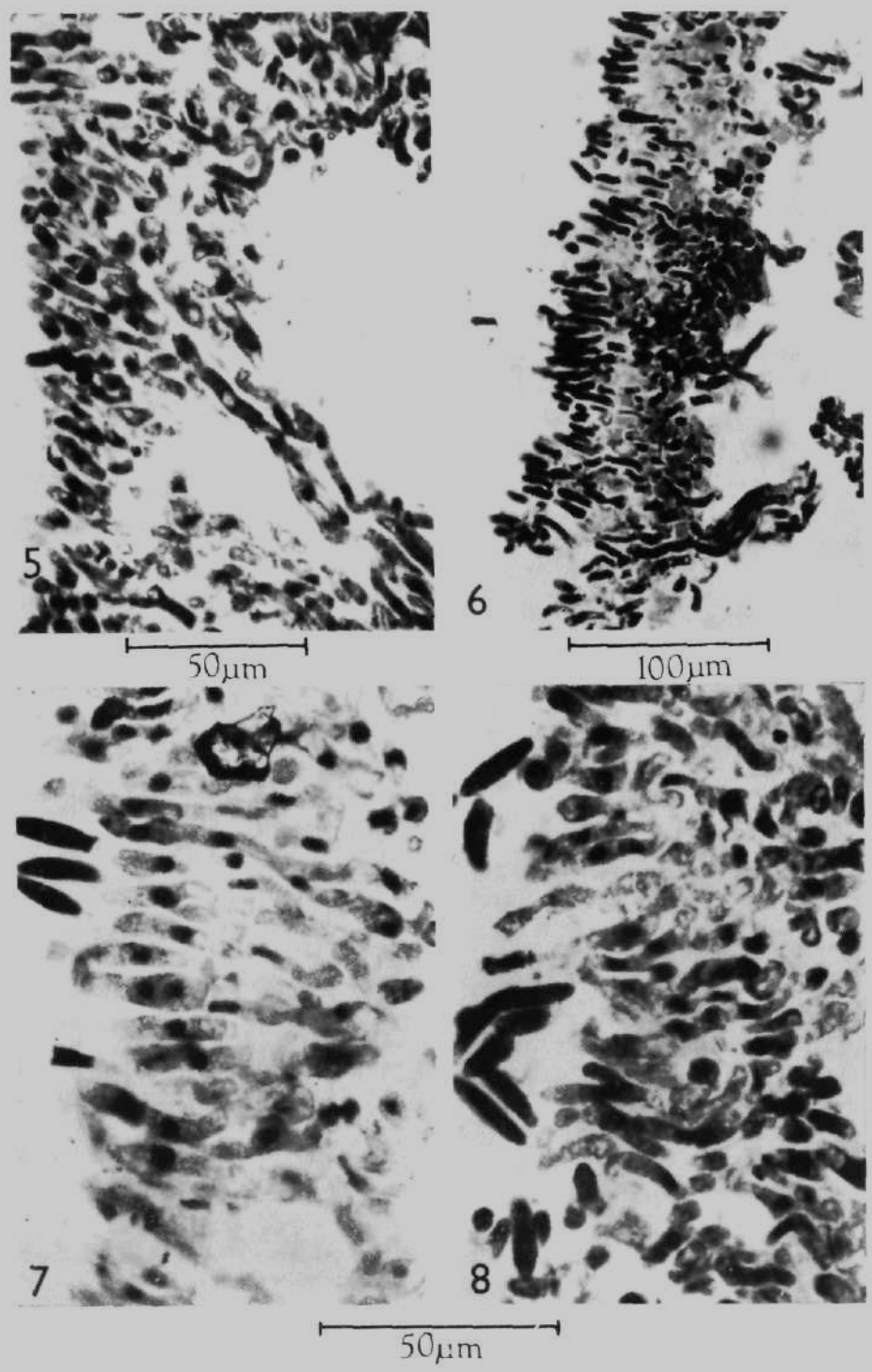

Fig. 5. After death the whole body-cavity is filled with hyphal bodies.
[illegible] through the integument and form the ellipsoid conidia

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