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TREMATODES OF BIRDS OF THE FAMILY LARIDAE IN SOUTHERN BOHEMIA

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Received March 19, 1985

Abstract. Examination of 625 specimens of the family Laridae captured in the south-Bohemian pond region revealed the presence of 19 trematode species. Nine species were found for the first time in Czechoslovakia: *Cercarioides aharonii* in *Larus ridibundus; Himasthla secunda, Pachytrema paniceum, Apophallus muehlingi, Cotylurus platycephalus* and *Diplostomum spathaceum* in *Sterna hirundo; Echinostoma revolutum, Pachytrema calculus* and *C. platycephalus* in *Chlidonias nigra*. The extensity of infection with trematodes was highest in *L. ridibundus*.

Members of the family Laridae are common representatives of ornithological fauna of the south-Bohemian pond region. Their high prevalence in some regions, habitat requirements, nesting in colonies and a close proximity to waterfowl farms directed us to study the helminth fauna of these birds. Some species of helminths occurring in the Laridae parasitize in waterfowl and occasionally may be the cause of a widespread enzootic disease.

As summary data on the helminth fauna of the Laridae in the south-Bohemian pond region are still lacking in our literature, some further data are presented in this paper to complete the results of studies on this subject performed in other regions of Czechoslovakia.

MATERIAL AND METHODS

During the years 1968 and 1969 a total of 625 specimens of the family Laridae (515 *L. ridibundus*, 73 *Sterna hirundo* and 37 *Chlidonias nigra*) were dissected and examined for helminths. The birds were captured in 5 localities of southern Bohemia: Frahelž, Klec, Lomnice n/Luž., Lužnice and Ponědraž. The localities are situated in a large pond region and along the main migratory routes of waterbirds, mainly gulls.

Trematodes were fixed in 4 % formol, stained with boraxcarmine, embedded in Canada balsam, examined under a light microscope and measured and drawn using a camera lucida.

RESULTS

Out of the total of 515 *L. ridibundus*, 73 *S. hirundo* and 37 *Ch. nigra* examined 460 (89.3 %), 17 (23.3 %) and 17 (45.9 %) specimens harboured trematodes, respectively. The species found and the extensity and intensity of infection are surveyed in Tab. 1.

Tab. 1. Extensity and intensity of infection with trematodes in the hosts studied

Species	Hosts								
	Larus ridibundus			*Sterna hirundo*			*Chlidonias nigra*		
	No. posit.	% of infes- tation	No. of trematod. per host	No. posit.	% of infes- tation	No. of trematod. per host	No. posit.	% of infes- tation	No. of trematod. per host
Echinostoma revolutum	20	3.8	1— 3	—	—	—	1	2.7	3
Echinoparyphium recurvatum	4	0.7	1— 28	—	—	—	—	—	—
Mesorchis pseudoechinatus	9	1.7	1— 26	—	—	—	—	—	—
Himasthla secunda	2	0.3	1— 2	1	1.3	1	2	—	—
Pachytrema calculus	23	4.4	1— 2	—	—	—	2	5.4	1
Pachytrema paniceum	4	0.7	1— 11	1	1.3	2	—	—	—
Cercarioides aharonii	1	0.1	1	4	5.4	1	—	—	—
Tetracladium sternae	—	—	—	3	4.1	2— 4	—	—	—
Cryptocotyle lingua	3	0.5	1— 4	—	—	—	—	—	—
Apophallus muehlingi	41	7.9	1—257	1	1.3	6	—	—	—
Plagiorchis laricola	280	54.3	1—828	39	53.4	1—360	13	35.1	1—38
Prosthogonimus ovatus	1	0.1	1	—	—	—	—	—	—
Renicola lari	10	1.9	2— 61	7	9.5	2— 72	—	—	—
Tanaisia fedtschenkoi	24	4.6	1— 64	—	—	—	1	2.7	75
Cardiocephalus longicollis	7	1.3	1— 55	—	—	—	—	—	—
Cotylurus pileatus	1	0.1	2	—	—	—	—	—	—
Cotylurus platycephalus	3	0.5	3— 21	1	1.3	3	1	2.7	1
Diplostomum spathaceum	261	50.6	1—252	5	6.8	1— 12	—	—	—
Ornitobilharzia canaliculata	—	—	—	3	4.1	1— 3	—	—	—

Systematic survey of trematodes found

Fam. Echinostomatidae Dietz, 1909

1. *Echinostoma revolutum* (Fröhlich, 1802) **(Figs. 1 A, B)**

Host: *Larus ridibundus* (3.8 %), *Chlidonias nigra* (2.7 %)
Location: small and large intestines, bursa Fabricii
Locality: Klec, Lomnice n/Luž., Ponědraž

A frequent parasite of Anseriformes, Charadriiformes and the family Laridae, less frequent in Ralliformes, Galliformes and other orders of birds.

The species was recorded for the first time in *Ch. nigra* in Czechoslovakia. It was reported also from *L. ridibundus* (Sitko, *1968*; Koubek, *1979*), domestic duck (Kopřiva, 1959), songbirds and Charadriiformes (Macko, *1961—1962*; *1963*), domestic duck and goose (Buša, *1962*), mallard (Zajíček and Páv, 1963) and mallard and domestic goose (Bušta, 1980).

The species was reported from gulls from the USSR (Shigin, 1961; Kosupko, 1962; Sailov, *1970*; Smogorzhevskaya, 1976), *L. ridibundus* from Yugoslavia (Mikeš et al. 1974), gulls from Norway (Bakke, 1972a, b) and England (Jennings and Soulsby, 1957; Threlfall, 1965).

2. *Echinoparyphium recurvatum* (Linstow, 1873)

Host: *Larus ridibundus* (0.7 %)
Location: small and large intestines
Locality: Lomnice n/Luž., Ponědraž

The species is cosmopolitan in distribution and common in Anseriformes, Ralliformes, Charadriiformes etc.

It was recorded in *L. ridibundus* (Kopřiva, 1959; Zajíček and Páv, 1961; Páv and Zajíček, 1963; Sitko, 1968; Koubek, 1979), domestic duck and hen (Rašín, 1933), *Vanellus vanellus* (Macko, 1959), *A. platyrhynchos* (Páv and Zajíček, 1960), hen, turkey, mallard and domestic duck (Buša, 1962) and mallard (Bušta, 1980) in Czechoslovakia.

It was reported from different species of birds from the USSR (Kurochkin and Zablotskiy, 1961; Ryzhikov and Timofeeva, 1961; Sailov, 1970 and Smogorzhevskaya, 1976), *L. ridibundus* from the GDR (Odening, 1964), *Larus canus* from Norway (Bakke, 1972 b) and *L. ridibundus* from Poland (Sulgostowska and Korpaczewska, 1972).

3. *Mesorchis pseudoechinatus* (Olsson, 1876)

Host: *Larus ridibundus* (1.7 %)
Location: small and large intestines
Locality: Klec, Lomnice n/Luž., Ponědraž

A common parasite of Laridae and other fish-eating birds. It was reported from *L. ridibundus* (Macko, 1964a; Sitko, 1968; Koubek, 1979) and fish-eating birds (Macko, 1959; 1964b).

The species was recorded in *L. argentatus* in Bulgaria (Bychvarov, 1960), in birds of the family Laridae and some Charadriiformes in the USSR (Kurochkin and Zablotskiy, 1961; Shigin, 1961; Bykhovskaya-Pavlovskaya, 1962; Sailov, 1970 and Smogorzhevskaya, 1976), *L. ridibundus* in Poland (Sulgostowska, 1958; 1960), *L.*

canus in the GDR (Reimer and Pav, 1973) and Yugoslavia (Mikeš et al., 1974).

4. *Himasthla secunda* (Nicoll, 1906) (Figs. 2A, B)

Host: *Larus ridibundus* (0.3 %), *Sterna hirundo* (1.3 %)
Location: small intestine
Locality: Klec, Lomnice n/Luž.

An infrequent parasite of Laridae occurring more often in Charadriiformes and Anseriformes.. The species has not been recorded in *S. hirundo* and was reported only from *L. ridibundus* in Czechoslovakia (Sitko, 1968; Koubek, 1979).

The trematode was reported from gulls from the USSR (Smogorzhevskaya, 1953; 1956; 1976; Bykhovskaya-Pavlovskaya, 1962) and *L. canus* from the GDR (Reimer and Pav, 1973).

Fam. Pachytrematidae Baer, 1943

5. *Pachytrema calculus* Looss, 1907 (Fig. 3)

Host: *Larus ridibundus* (4.4 %), *Chlidonias nigra* (5.7 %)
Location: bile sac
Locality: Frahelž, Klec, Lomnice n/Luž., Ponědraž

A common parasite of the family Laridae and the orders Charadriiformes and Anseriformes.

The species was recorded only in *L. ridibundus* in Czechoslovakia (Macko, 1964a; Sitko, 1968; Koubek, 1979).

The trematode was found in fish-eating birds in the USSR (Bykhovskaya-Pavlovskaya, 1953; Belopolskaya, 1959; 1966; Shigin, 1961; Kurochkin and Zablotskiy, 1961; Turemuratov, 1962; Sergeeva, 1971). It was recorded also in *L. argentatus* in Bulgaria (Bychvarov, 1960), *L. fuscus* in Scotland (Fraser, 1972—1973) and in Yugoslavia (Mikeš et al., 1974, Šoti et al., 1975).

6. *Pachytrema paniceum* Brinkmann, 1942 (Fig. 4)

Host: *Larus ridibundus* (0.7 %), *Sterna hirundo* (1.3 %)
Location: bile sac
Locality: Klec, Lužnice

An infrequent parasite of birds of the family Laridae.

Until now, the species has not been recorded in *S. hirundo*. It was found only in *L. ridibundus* in Czechoslovakia (Vojtek and Vojtková, 1961; Sitko, 1968).

Brinkmann (1942) described the species from *L. fuscus* from Norway. The trematode was found in 5 species of gulls in the USSR (Shigin, 1954, Kurochkin and Zablotskiy, 1961).

Fam. Galactosomatidae Morosov, 1950

7. *Cercarioides aharonii* Witenberg, 1929 (Fig. 5)

Host: *Larus ridibundus* (0.1 %), *Sterna hirundo* (5.4 %)
Location: cloaca
Locality: Klec

An infrequent parasite of Laridae. It was reported from *S. hirundo* (Sitko, 1968). Until now, it has not been recorded in *L. ridibundus* in Czechoslovakia.

The species was found in fish-eating birds in the USSR (Leonov, 1957; Kurochkin and Zablotskiy, 1961; Krivonogova, 1963).

8. *Tetracladium sternae* Kulackowa, 1952

Host: *Sterna hirundo* (4.1 %)
Location: cloaca
Locality: Lužnice

A sporadic parasite of Laridae. The species was reported only from *S. hirundo* in Czechoslovakia (Sitko, 1968).

The fluke was recorded also in the USSR (Bykhovskaya-Pavlovskaya, 1953; Smogorzhevskaya, 1954; 1956).

Fam. Heterophyidae Odhner, 1914

9. *Cryptocotyle lingua* (Creplin, 1825)

Host: *Larus ridibundus* (0.5 %)
Location: small intestine
Locality: Frahelž, Lomnice n/Luž.

A common parasite of birds of the family Laridae and Anseriformes, Ciconiiformes, Podicipediformes etc.

It was recorded in *L. ridibundus* in Czechoslovakia (Sitko, 1968; Koubek, 1979). The trematode was reported from gulls and other birds from the USSR (Smogorzhevskaya, 1953; Kurochkin and Zablotskiy, 1961; Bykhovskaya-Pavlovskaya, 1962; Belopolskaya, 1963; Belogurov et al., 1968). The species was found in gulls in England (Jennings and Soulsby, 1957; 1958; Pemberton, 1960; 1963; Harris, 1964; Fraser, 1972—1973), the Netherlands (Broek and Jansen, 1964), Denmark (Guildal, 1964; 1968), Norway (Bakke, 1972a; b) and the GDR (Reimer and Pav, 1973).

10. *Apophallus muehlingi* (Jägerskiöld, 1809) (Fig. 6)

Host: *Larus ridibundus* (7.9 %), *Sterna hirundo* (1.3 %)
Location: small and large intestines
Locality: Frahelž, Klec, Lomnice n/Luž., Ponědraž

A frequent parasite of Laridae and other fish-eating birds. The parasite has hitherto not been recorded in *S. hirundo* in Czechoslovakia. The fluke was found in *L. ridibundus* (Vojtek, 1959; Vojtek and Vojtková, 1961; Zajíček and Páv, 1961; Páv and Zajíček, 1963; Macko 1964a; Sitko, 1968; Koubek, 1979) and *Felis silvestris* f. *catus* (Žitňan, 1964).

The trematode was reported from different species of birds from the USSR (Bykhovskaya-Pavlovskaya, 1953; 1962; Smogorzhevskaya, 1956; Shigin, 1961; Mozgina, 1968; Belogurov et al., 1968). It was recorded in gulls from Poland (Sulgostowska, 1958; 1963; Malczewski, 1964), England (Pemberton, 1963) the GDR (Odening, 1964) and Yugoslavia (Mikeš et al., 1974).

Fam. Plagiorchiidae Lühe, 1901

11. *Plagiorchis laricola* Skrjabin, 1924

Host: *Larus ridibundus* (54.3%), *Sterna hirundo* (53.4%), *Chlidonias nigra* (35,1%)
Location: small and large intestines
Locality: Frahelž, Klec, Lomnice n/Luž., Lužnice, Ponědraž

A common trematode of Laridae parasitizing also in Charadriiformes, Ciconiiformes, Podicipediformes and other orders of birds.

The species was recorded in *L. ridibundus* (Kopřiva, 1959; Ryšavý, 1960; Vojtek and Vojtková, 1961; Zajíček and Páv, 1961; Páv and Zajíček, 1963; Sitko, 1968) and *S. hirundo* (Sitko, 1968) and *Ch. nigra* (Macko, 1964a) in Czechoslovakia.

The parasite was reported from different fish-eating birds from the USSR (Scherbovich, 1946; Smogorzhevskaya, 1956; Golikova, 1959, Shigin, 1961; Parukhin and Truskova, 1963), Poland (Sulgostowska, 1963), Norway (Bakke, 1972a; b) and from *L. canus* from the GDR (Reimer and Pav, 1973).

Fam. Prosthogonimidae Nicoll, 1924

12. *Prosthogonimus ovatus* (Rudolphi, 1803)

Host: *Larus ridibundus* (0.1 %)
Location: bursa Fabricii
Locality: Lomnice n/Luž.

A sporadic parasite of Laridae, more common in Anseriformes, Galliformes and Passeriformes. It was recorded in *L. ridibundus* (Vojtek and Vojtková, 1961; Sitko, 1968), *Fulica atra* and *A. platyrhynchos* (Macko, 1956; 1970; Vojtek and Vojtková, 1961) in Czechoslovakia.

The trematode was reported from Laridae (Smogorzhevskaya, 1956; Kurochkin and Zablotskiy, 1961; Shigin, 1961; Bykhovskaya-Pavlovskaya, 1962), Charadriiformes (Belopolskaya, 1975) and *Cygnus olor* (Rajshite and Paulionis, 1979) from the USSR.

Fam. Renicolidae Dollfus, 1939

13. *Renicola lari* Timon-David, 1933

Host: *Larus ridibundus* (1.9 %), *Sterna hirundo* (9.5 %)
Location: kidneys
Locality: Klec, Lomnice n/Luž., Ponědraž

A characteristic parasite of the Laridae, occurring sporadically in other species of waterbirds.

It has so far been recorded in *L. ridibundus* (Sitko, 1968; Koubek, 1979), *S. hirundo* (Sitko, 1968), *Hydroprogne tschegrava* and *Larus minutus* (Macko, 1964a) in Czechoslovakia.

The fluke was reported from Laridae from the USSR (Smogorzhevskaya, 1956; Shigin, 1961; Sergeeva, 1971), Bulgaria (Zhelyazkova-Paspaleva, 1962), England (Pemberton, 1963), *L. ridibundus* (Odening, 1964) and *L. canus* (Reimer and Pav, 1973) from the GDR and *L. argentatus* from Hungary (Matskási, 1974).

Fam. Eucotylidae Skrjabin, 1924

14. *Tanaisia fedtschenkoi* Skrjabin, 1924

Host: *Larus ridibundus* (4.6 %), *Chlidonias nigra* (2.7 %)
Location: kidneys
Locality: Klec, Lomnice n/Luž., Ponědraž

A common parasite of Laridae and other fish-eating birds.

It was recorded in *L. ridibundus* in Czechoslovakia (Macko, 1964a; Sitko, 1968).

The parasite was reported from the USSR (Shigin, 1961; Kurochkin and Zablotskiy, 1961; Bykhovskaya-Pavlovskaya, 1962).

Fam. Strigeidae Railliet, 1919

15. *Cardiocephalus longicollis* (Rudolphi, 1819)

Host: *Larus ridibundus* (1.3 %)
Location: intestine
Locality: Frahelž, Klec, Lomnice n/Luž.

A common parasite of the Laridae. It was recorded in *L. ridibundus* in Czechoslovakia (Sitko, 1968; Koubek, 1979).

It was reported from different kinds of birds from the USSR (Smogorzhevskaya, 1953; Leonov, 1961; Shigin, 1961; Belopolskaya, 1963; Mashtakov, 1964), Bulgaria (Zhelyazkova-Paspaleva, 1962), *L. ridibundus* from the GDR (Odening, 1964) and *L. fuscus* from Scotland (Fraser, 1972—1973).

16. *Cotylurus pileatus* (Rudolphi, 1802)

Host: *Larus ridibundus* (0.1 %)
Location: intestine
Locality: Lomnice n/Luž.

A sporadic parasite of Laridae which has been recorded only in *L. ridibundu* in Czechoslovakia (Sitko, 1968) until now.

The parasite was reported from fish-eating birds from the USSR (Shigin 1961; Kurochkin and Zablotskiy, 1961; Bykhovskaya-Pavlovskaya, 1962), *S. hirundo* from Poland (Sulgostowska, 1958) an the Netherlands (Broek and Jansen, 1971).

17. *Cotylurus platycephalus* (Creplin, 1825) (Fig. 7)

Host: *Larus ridibundus* (0.5 %), *Sterna hirundo* (1.3 %),
Chlidonias nigra (2,7 %)
Location: bursa Fabricii
Locality: Lomnice n/Luž., Lužnice

An infrequent parasite of Laridae, which was reported from *L. ridibundu* (Sitko, 1968) and has so far not been recorded in *S. hirundo* and *Ch. nigr* in Czechoslovakia.

The parasite was reported from Laridae from the USSR (Smogorzhevskaya, 1956; Shigin, 1961; Bykhovskaya-Pavlovskaya, 196 and Poland (Bezubik, 1956).

Fam. Diplostomatidae Poirier, 1886

18. *Diplostomum spathaceum* (Rudolphi, 1819) (Fig. 8)

Host: *Larus ridibundus* (50.6 %), *Sterna hirundo* (6.8 %)
Location: intestine
Locality: Frahelž, Klec, Lomnice n/Luž., Lužnice, Ponědraž

A common parasite of Laridae and other fish-eating birds. The species was reported from ***L. ridibundus*** **(Ryšavý, 1960; Vojtek** and Vojtková, 1961; Zajíček and Páv, 1961; Páv and Zajíček, 1963; Macko, 1964a; Sitko, 1968; Koubek, 1973; 1979) and until now it has not been recorded in *S. hirundo* in Czechoslovakia.

The trematode was found in fish-eating birds in the USSR (Golikova, 1959; Leonov, 1961; Kurochkin and Zablotskiy, 1961; Kosupko, 1962; Volskis, 1968), Bulgaria (Bychvarov, 1960), Hungary (Edelenyi, 1962; Sey, 1968), England (Pemberton, 1963), Canada (Threlfall, 1965; 1968a; b), in *L. canus* from Norway (Bakke, 1972b) and Poland (Sulgostowska and Korpaczewska, 1972).

Fam. Schistosomatidae Looss, 1899

19. *Ornithobilharzia canaliculata* (Rudolphi, 1819)

Host: *Sterna hirundo* (4.1 %)
Location: blood system
Locality: Klec

A sporadic parasite of Laridae, infrequent also in other birds,

The species was recorded in *S. hirundo* (Sitko, 1968), and *H. tschegrava* (Macko, 1962—1963; 1964a) in Czechoslovakia.

The trematode was reported from 5 species of gulls from western Siberia (Bykhovskaya-Pavlovskaya, 1953) and *H. tschegrava* (Krivonogova, 1963).

DISCUSSION

The first systematic survey of helminths in birds of the family Laridae describing the helminths of 17 Laridae species in Czechoslovakia was published by Macko (1961—1962). The helminth fauna of *L. ridibundus* of southern Moravia was treated by Koubek (1973; 1979). Trematodes of the bird family Laridae were treated by Macko (1964a) and Sitko (1968). Some data are presented also in papers by Kopřiva (1959), Ryšavý (1960), Zajíček and Páv (1961), Vojtek and Vojtková (1961) and Páv and Zajíček (1963).

The helminth fauna of the family Laridae was the subject of many publications (Bykhovskaya-Pavlovskaya, 1953; Smogorzhevskaya, 1953; 1956; Jennings and Soulsby, 1957; 1958; Kurochkin and Zablotskiy, 1961; Edelenyi, 1962; Guildal, 1964; Threlfall, 1968a, b).

In the material examined by us, the highest number of trematode species (17) was recorded in *L. ridibundus*. *Cercarioides aharonii*, Witenberg, 1929 was recorded for the first time in that host in Czechoslovakia. *P. laricola* and *D.*

spathaceum were the most frequent in *L. ridibundus* (54,3 % and 50,6 %, respectively).

The trematode species were found in *S. hirundo*. Of them, *Himasthla secunda* (Nicoll, 1906), *Pachytrema paniceum* Brinkmann, 1942, *Apophallus muehlingi* (Jägerskiöld, 1809), *Cotylurus platycephalus* (Creplin, 1825) and *Diplostomum spathaceum* (Rudolphi, 1819) were recorded for the first time in Czechoslovakia. *P. laricola* was the most frequent trematode parasitizing in that host (53,4 %).

Five trematode species were detected in *Ch. nigra*. Three of them *Echinostoma revolutum* (Fröhlich, 1802), *Pachytrema calculus* Looss, 1907 and *Cotylurus platycephalus* (Creplin, 1925) were recorded for the first time in that host in Czechoslovakia. A predominating species was *P. laricola* (35,1 %).

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

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CZECHOSLOVAK ENCHYTRAEIDS (OLIGOCHAETA, ENCHYTRAEIDAE) I. ENCHYTRAEIDS FROM AN APPLE ORCHARD BY BAVOROV IN SOUTH BOHEMIA

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Abstract. A total of 17 enchytraeid species (Oligochaeta, Enchytraeidae) found in an apple orchard by Bavorov (49° 07′ N, 14° 05′ E) in South Bohemia are reported. Eleven species are new for Czechoslovakia, *Enchytronia annulata* Niels. et Christ., 1959, *Henlea perpusilla* Friend, 1911, *Fridericia connata* Bretscher, 1902, *F. nemoralis* Nurminen, 1970, *F. gracilis* von Bülow, 1957, *F. singula* Niels. et Christ., 1961, *F. bulboides* Niels. et Christ., 1959, *F. paranemoralis* Dózsa-F., 1982, *F. alata* Niels. et Christ., 1959, *F. sylvatica* Healy, 1979 and *F. callosa* (Eisen, 1878).

The knowledge of Czechoslovak enchytraeids (Oligochaeta, Enchytraeidae) has not been quite satisfactory up to now. In the last century Vejdovský (1877, 1879, 1883) gave the first faunistic data about enchytraeids in Bohemia and Moravia. Much later Černosvitov (1930a, b) and Košel (1975) presented enchytraeid finds in Slovakia. Some data about enchytraeids from Czechoslovakia were given also by Lom (1959). A field experiment with herbicide influence on soil organisms and chemical processes in the soil was carried out in 1981 and 1982 by the Laboratory of Soil Biology. The experiment was performed at the fruit growing region near Chelčice in South Bohemia and placed into an apple orchard by Bavorov village. An ecological investigation of soil Enchytraeidae was a part of the study. During two years 17 enchytraeid species were found presented here with some ecological data and taxonomical comments.

LOCALITY AND MATERIAL

Locality: 25 years old apple orchard, not treated with pesticides, by Bavorov (445 m a. s. l., 49° 07′ N, 14° 05′ E) in South Bohemia. Soil type: brown soil, humus form: mull, soil pH 5.62. Understory plant community belongs to *Arrhenatherion*. Precipitation in 1981: 642 mm, in 1982: 463 mm, an average of years 1900—1950: 586 mm.

Material: uppermost layers of the soil were inhabited by enchytraeid populations in abundance varying between 700 — 23,400 ind. m^{-2}. Average abundance in 1981: 5,397 ind. m^{-2}, in 1982: 8,953 ind. m^{-2}. During 1981—82 5,017 enchytraeid individuals were collected, of it 24.5 % mature. All species, their relative abundance, and constancy based on soil cores taken in 1982 are given in Table 1.

METHOD

The soil was sampled by metal tube core. The soil cores taken were 35.68 mm in diameter, i. e. 10 cm^2. Depth of investigated soil layer was 10 cm. A total number of soil cores in 1982: 450. The enchytraeids were extracted by wet funnel method

(O'Connor, 1955). The worms were determined alive in a drop of tap water. Determination up to the species level was done in 1982, thus the results are based on material of this year. Material was fixed in 4 % formaldehyde, later stored in 70 % alcohol. A part of the material stained in Mayer's alcoholic HCl carmine or unstained was mounted whole in canada balsam. All material is kept in the Laboratory of Soil Biology, Czechoslovak Academy of Sciences, České Budějovice. Terminology follows Nielsen and Christensen (1959).

ESTABLISHED SPECIES

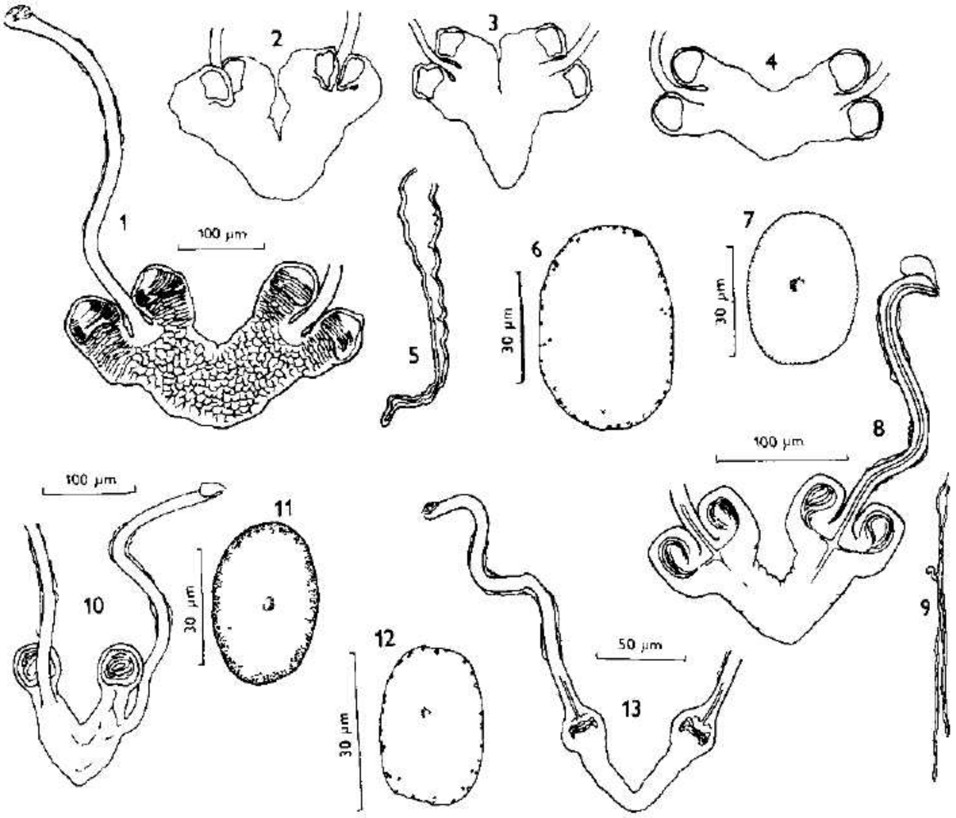
1. *Enchytronia annulata* Nielsen et Christensen, 1959

Four specimens were found. According to typical spermathecae they were true *E. annulata.*

Distribution: Denmark, Netherland and DDR, new for Czechoslovakia

2. *Enchytronia* sp.

It is difficult to tell if the specimens belong to *E. parva* Niels. et Christ., 1959 or to another valid species. They are distinguished from original descript-



Figs. 1–6. *Fridericia connata:* 1 – spermathecae; 2–4 – variability of spermathecae. 5 – peptonephridium; 6 – nucleate coelomocyte. Figs. 7–9. *Fridericia nemoralis* 7 – nucleate coelomocyte; 8 – spermathecae; 9 – peptonephridium. Figs. 10–11 *Fridericia singula:* 10 – spermathecae; 11 – nucleate coelomocyte. Figs. 12–13 *Fridericia bulboides:* 12 – nucleate coelomocyte; 13 – spermathecae.

ion of *E. parva* by a little robust spermatheca. Ental ducts of spermathecae only partly merging. Setae in lateral bundles in VIII–XI were found in two individuals. This feature is unknown in Enchytronia. The whole appearance, structure of oesophageal diverticula and coelomocytes, of course, are of *Enchytronia* beyond any doubt.

3. *Henlea perpusilla* Friend, 1911, augm. Černosvitov, 1937 (Figs. 29–35)

Description: Length 6–7 mm, segments 32–34, setae: 5,4(3) – 5,4,3 : : (7)6,5(4,3) – (6)5,4(3). A pair of ventral and a pair of dorsal oesophageal appendages in VI. Dorsal blood vessel pulsating. Intestine in VII narrow, in VIII abruptly expanded almost through the whole diameter of coelom. Spermathecae jointed entally to each other, ampullae as a spindle shaped broadening of the ducts. Seminal vesicles sparse.

Distribution: Common in Europe, new for Czechoslovakia.

4. *Henlea ventriculosa* (d'Udekem, 1854)

The species was not investigated in detail and fitted well with the description of Nielsen and Christensen (1959).

Distribution: Widely distributed in Europe, without finds in southern countries.

Fridericia Michaelsen, 1888

Taxonomy of the genus *Fridericia* is the most complex in Enchytraeidae. Nevertheless the genus is the most common in many terrestrial biotopes. Over 50 probably valid species are known from Europe. Basic taxonomical criteria are spermathecae, their arrangement, shape and structure. The other useful criteria are combinations of features: peptonephridia, nucleate coelomocytes, seminal vesicles, sperm funnel, penial bulb, chylus cells, originating of dorsal blood vessel, etc.

5. *Fridericia connata* Bretscher, 1902 (Figs. 1–6)

Description: Body anteclitellarly mostly distinctly coloured to yellow and green, length 20–24 mm, segments (54) 62–69, setae: 2(1) – 2,1 : 2 – 2(1). Dorsal blood vessel originates in XX–XXII. Nucleate coelomocytes very flat, 50 μm long, with very fine and dark granula on periphery, cytoplasma pale green. Closely applied to each other in the fore part of the body the coelomocytes give the green shade of the whole worm. Free setae in coelom present. Surface of the ampullae of spermatheca with brown mosaic-like structure. Seminal vesicles large in X and XI. Sperm funnel length : width 3:1.

Discussion: Similarity to *F. bisetosa* (Levinsen, 1884), as given in Nielsen and Christensen (1959), was not found. *F. connata* is very stiff, longer, and coloured yellow to pale green. The setae of *F. connata* are more robust than in *F. bisetosa*. The distinct key characters for a quick separation of this species from the enchytraeid population in the sample are spermathecae and nucleate coelomocytes. *Fridericia* species group with two diverticula and fusing sparmathecae is quite complex. Authors give the illustrations rarely and it can be assumed that in fact there may be more than one species under the name connata which the authors understand in different ways.

Distribution: Common in Europe, new for Czechoslovakia.

Note to ecology: Occurrence rather in compact soil layers.

6. *Fridericia nemoralis* Nurminen, 1970 (Figs. 7–9)

Description: Length 7–9 mm, segments 44–52(54), setae: (1, 2, 3) 4 – 4(3)2 : (1, 2, 3) 4 – 4(3)2. Cuticular glands intensively yellow, in 3–5 incomplete transversal rows per segment anteclitellarly, number of rows decreases caudally, if the glands are not intensively yellow, they are at least conspicuously refractile. Peptonephridia branched usually in three tubes, the first one very short, the second thin and long, and the third thicker and slightly shorter than the second one. Dorsal blood vessel originates in XVIII–XIX. Nucleate coelomocytes with well visible fine granular nucleus, cytoplasma on periphery with exceedingly fine margin of pale minute lobes. Spermatheca with two diverticula, which are often applied to the ectal duct, ampullae merging to each other. One (two?, second minute) gland at the orifice of the ectal duct. Seminal vesicles present. Sperm funnel length: width 3–4:1. In one case three spermathecae were observed. The unpaired one communicated with body surface in V/VI.

Discussion: The key characters of this species are yellow cuticular glands and arrangement of spermathecae. Diverticula are not ear-shaped as given by Nurminen (1970). They are rather oval and bent forward to ectal duct. They can rarely resemble small ears, but they suggest more the shape shown by Dózsa-Farkas (1982).

Distribution: Sweden, Finland, Hungary, new for Czechoslovakia.

7. *Fridericia gracilis* von Bülow, 1957 (Figs. 14–17)

Description: Length 13–15 mm, segments (47)–53–(60), setae: 4 – (4)2 : 4 – (4)2, length of inner pair of setae in bundle about a half of outer one. Peptonephridia in III–IV much coiled in cluster, a simple branch can go out from the cluster towards the head, turn back and reach the third pair of septal glands. Nucleate coelomocytes with irregularly scattered dark granula, cytoplasma may be also filled with pale bigger granula which increase the whole impression of granulation of coelomocytes. Ampullae pouch-like, jointed separately with oesophagus, 5–8(9) diverticula per ampulla, diverticula oval to rather cylindrical shape. Seminal vesicles in X and XI, very large.

Discussion: Notwithstanding the small differences as compared with the description given in Nielsen and Christensen (1959) (up to six setae in bundles, lower number of segments) my material fits well with that.

Distributiton: Sparse in Europe, it occurs rather in northern countries, new for Czechoslovakia.

8. *Fridericia singula* Nielsen et Christensen, 1961 (Figs. 10, 11)

Description: Colour rather intensive white to pale yellow, length 9–11 mm, segments (47)–50(51), setae: (1)2 – 2 : 2(3) – 2. Chylus cells in XIII–XV. Nucleate coelomocytes with many small granula towards the periphery, shaded to brown. Sperm funnel length:width 3.5:1.

Discussion: My specimens are slightly different from the original description of Nielsen and Christensen (1961). According to these authors the body length is 15 mm, number of segments 44, four setae in bundles anteclitellarly, the ectal duct of spermatheca is devoid of glands at the orifice, sperm funnel length:width 1.5:1. Based merely on the description it is difficult to decide about the right species status of my species. Species group of the genus *Fridericia* with one diverticulum per ampulla consists of: *F. monopera* Cognetti, 1903, *F. singula* Niels. et Christ., 1961, *F. deformis* Möller, 1971, *F. asymmetrica* Kasprzak, 1972, and *F. anomala* Košel, 1975.

Note to ethology: Specimens usually tightly coiled in Petri dish.

Distribution: Denmark, Poland, Roumania, new for Czechoslovakia.

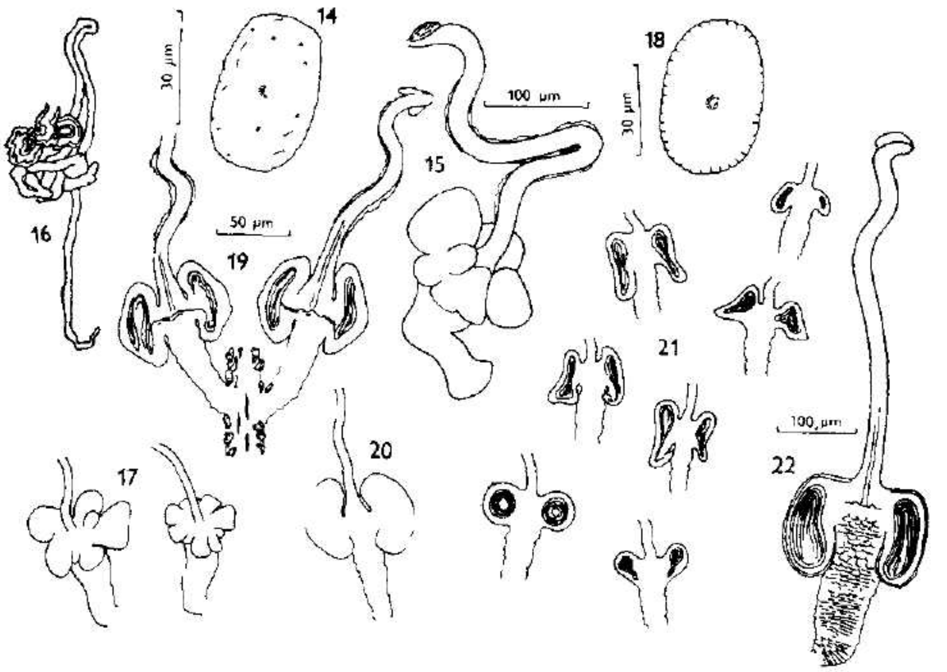
9. *Fridericia ratzeli* (Eisen, 1872)

Description: Length 25 mm, segments (46, 48)54–59, setae: (4)5,6 –6,5,4 (3,2) : (5)6,7(8) – (6)5,4(3,2). Spermatheca with cone-like to pouchy ampulla. Seminal vesicles large, rather disturbed into smaller parts and corpuscles.

Discussion: Based on the cytological studies and rather incompatible descriptions of the species, Nielsen and Christensen (1959) consider *F. ratzeli* as a group of species which we are not able to separate by morphological characters. I also found two closely related forms in the locality. Only further study can lead to right conclusions about the taxonomic status of these forms.

Note to ecology: In spring and autumn frequently in the litter layer.

Distribution: Very common in Europe.



Figs. 14–17. *Fridericia gracilis:* 14 – nucleate coelomocyte; 15 – spermathecae; 16 – peptonephridium; 17 – variability of spermatheca. Figs. 18–20. *Fridericia paranemoralis:* 18 – nucleate coelomocyte; 19 – spermathecae; 20 – variability of spermatheca. Figs. 21–22. *Fridericia alata:* 21 – variability of spermatheca; 22 – spermatheca.

10. *Fridericia bulboides* Nielsen et Christensen, 1959 (Figs. 12, 13)

Description: Length 6—8 mm, segments 33—37, setae (3)4 — 4(3)2 : 4 — 4(3)2. Peptonephridia unbranched, long, often only coiled in IV. Chylus cells in XII—XIII. Dorsal blood vessel originates in XVI. Nucleate coelomocytes 25—30 µm long, with fine dark granula on periphery.

Discussion: Studied population of the worms is in close correspondence with the description of Nielsen and Christensen (1959).

Distribution: Common in Europe in many habitats. New for Czechoslovakia.

11. *Fridericia paranemoralis* Dózsa-Farkas, 1982 (Figs. 18—20)

Description: Length 12—14 mm, segments (43, 49) 55—59 (60), setae (2)3 — (1)2(3,4) : (3)4(5) — (5)4,3,2. Peptonephridia branched in the upper third in several short branches. Dorsal blood vessel arises in XVIII—XIX. Nucleate coelomocytes 40—43 µm long, on periphery very fine lobed margin, nucleus with refractile granula. Spermathecae jointed separately with oesophagus, ampullae with two ears resembling diverticula. The ectal duct has two conspicuous glands at the ectal orifice. Seminal vesicles present. Sperm funnel with wider collar, length:width 2—3:1.

Discussion: Specimens found correspond with the range of variability in original description. However, the spermatheca suggests more *F. aurita* Issel, 1905. The only essential difference given by Dózsa-Farkas (1982) for *F. paranemoralis* and *F. aurita* is the number of glands at the ectal orifice The ectal duct with one small gland or none at the orifice in *F. aurita*, two large ones in *F. paranemoralis*. On the other hand *F. paranemoralis* in my material does not resemble *F. nemoralis* Nurminen, 1970 as described by Dózsa-Farkas (1982).

Distribution: Hungary, new for Czechoslovakia.

12. *Fridericia bisetosa* (Levinsen, 1884) (Figs. 23, 24)

Description: Length 15—17 mm, segments (45, 48) 56—63 (66), setae 2 — 2(1) : 2 — 2(1). Nucleate coelomocytes 43—50 µm long, pale or glassy nucleus with 1—3 refractile granule. Spermathecae: ampullae jointed separately to oesophagus, with two lens-like to globular diverticula on a short neck

Discussion: Some specimens of *F. bisetosa* can be confused with *F. paroniana* Issel, 1904 (Nielsen and Christensen, 1959). I found *F. paroniana* on another locality in South Bohemia, it is smaller, with small spermathecae and with nucleate coelomocytes having dark granula on periphery, just like in *F. bulboides*.

Distribution: Widely distributed in Europe.

13. *Fridericia alata* Nielsen et Christensen, 1959 (Figs. 21, 22)

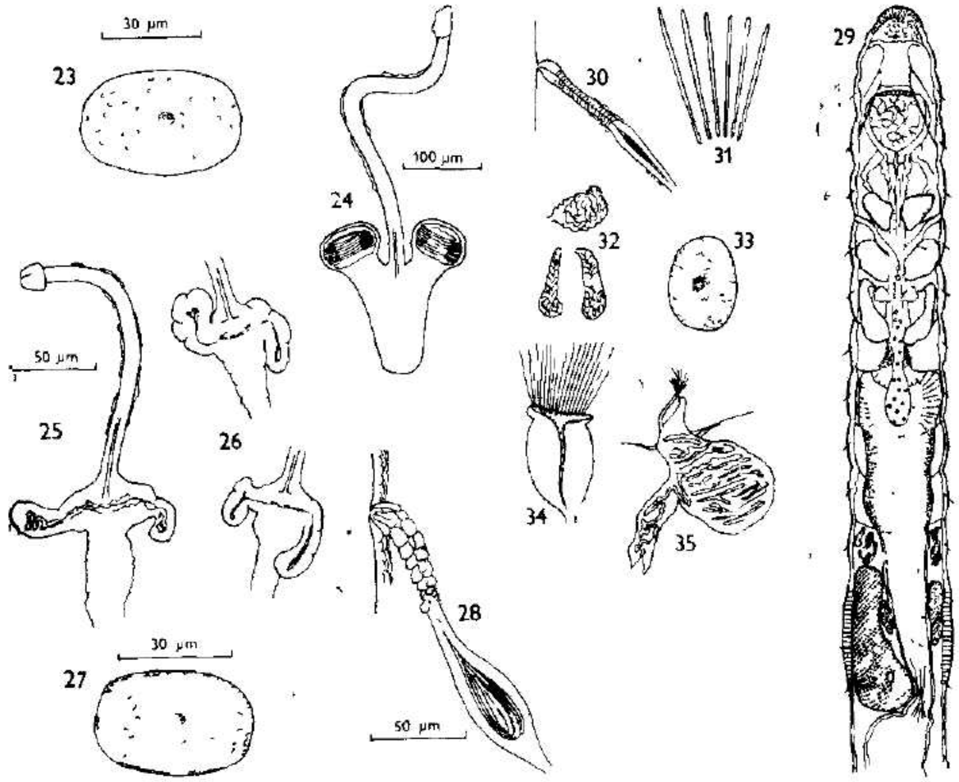
Description: Length 17 mm, segments (54)—57—(67), setae: (1, 2, 3)4 — —4, 3, 2 : (2, 3) 4 (5,6) — (6,5) 4, 3, 2, dorsolateral bundles in XII always present. Dorsal blood vessel originates in XIX, blood may be light reddish. Nucleate coelomocytes 40—43 µm long, outer margins with different structure Spermathecae: ampullae with brown surface structure, two diverticula per ampulla vary much in shape, from very small underdeveloped to globular and rather cylindrical long ones, bent along the ampulla. One specimen with three spermathecae. Two spermathecae on the right side were attached to the oesophagus closely to each other and both had an own orifice in IV/V with shared single large gland. Seminal vesicles middle in size. Sperm funnel length: :width 2.5–3:1.

Discussion: The specimens correspond almost in all characters with the original description, except the light reddish blood and lateral setae in XII. Shape of diverticula varies and is not reliable for determination. Occurrence of species with quite reduced diverticula is not rare and those with regular globular diverticula can be distinguished only after a thorough investigation of a total population in the locality.

Distribution: Denmark, DDR, Poland, new for Czechoslovakia.

14. *Fridericia sylvatica* Healy, 1979 (Figs. 25–27)

Description: Length 8–10 mm, segments (40) 41–42, setae: (2, 3) 4 – 4 (2) : (2, 3) 4 – (4, 3) 2. Peptonephridia rather short, wide, unbranched,



Figs. 23–24. ***Fridericia bisetosa:*** 23 – nucleate coelomocyte; 24 – spermatheca. Figs. 25–27. ***Fridericia sylvatica:*** 25 – spermatheca; 26 – variability of spermatheca; 27 – nucleate coelomocyte. Fig. 28. ***Enchytraeus buchholzi:*** spermatheca.
Figs. 29–35. ***Henlea perpusilla:*** 29 – internal anatomy; 30 – spermatheca; 31 – setal bundle; 32 – dorsal oesophageal lobe and ventral one in VI; 33 – coelomocyte; 34 – sperm funnel; 35 – nephridium from VI/VII.

Tab. 1. Enchytraeid species in Bavorov 1982.
Numbers of individuals in 450 cores, relative abundnce D %, constancy C %

species	sampling dates										
	18. 3.	19. 4.	19. 5.	21. 6.	26. 7.	18. 8.	22. 9.	25. 10.	26. 11.	D	C
Enchytronia annulata	4	—	—	—	—	—	—	—	—	0.10	0.4
Enchytronia sp.	4	8	—	3	4	8	—	1	—	0.69	4.4
Henlea perpusilla	2	2	1	—	—	3	5	4	9	0.65	3.3
Henlea ventriculosa	—	2	—	2	2	7	3	1	—	0.42	2.0
Fridericia connata	3	33	25	62	28	38	14	44	11	6.40	33.3
Fridericia nemoralis	23	15	4	12	3	12	3	26	32	3.23	14.2
Fridericia gracilis	9	7	11	8	3	9	16	19	7	2.21	8.9
Fridericia singula	7	50	3	10	3	4	1	5	1	2.08	11.3
Fridericia ratzeli	4	3	2	5	—	2	3	30	18	1.66	9.8
Fridericia bulboides	2	4	1	5	5	9	16	17	6	1.61	10.4
Fridericia paranemoralis	18	18	1	6	—	4	5	—	3	1.37	8.0
Fridericia bisetosa	3	13	2	4	2	8	2	3	—	0.92	6.9
Fridericia alata	6	10	—	2	1	3	—	5	—	0.67	5.1
Fridericia sylvatica	—	—	—	3	2	2	—	7	1	0.37	2.2
Fridericia callosa	1	—	—	—	—	—	3	—	—	0.10	0.4
Enchytraeus sp.	12	18	1	3	6	4	—	1	—	1.12	7.3
Enchytraeus buchholzi	15	10	—	4	3	3	—	3	—	0.94	5.8
Enchytraeidae spp. juv.	176	514	235	455	278	403	275	386	316	75.46	88.7

The dorsal blood vessel arises in XVI, pulsates anteclitellarly, in the cavity of the vessel radial cells strained between the vessel walls. Chylus cells in XIII (XIV). Nucleate coelomocytes 30—40 μm long, with inexpressive and irregular granulation. Spermathecae: ampullae irregularly onion-like, with two diverticula variable in shape. Diverticula long, cylindrical deformed or shortly lobed. The ectal duct has one compact gland at the ectal orifice. Seminal vesicles missing. Sperm funnel length:width 3:1.

Discussion: The species corresponds well with the original description. Shape of diverticula much more variable in my material.

Distribution: Ireland, new for Czechoslovakia.

15. *Fridericia callosa* (Eisen, 1878)

Four specimens were not taxonamically investigated in detail.

Distribution: Not rare in Europe, new for Czechoslovakia.

16. *Enchytraeus* sp.

Description: The species is in the extent of characters of *E. buchholzi* Vejdovský, 1877. But it differs from that species in three points: a) body length about 3 mm, segments 25—26, b) chloragogen cells without regular oil globules, cells shaded to brown, intestine sparsely covered caudally, c) coelomocytes with pale granula, without dark grains. Spermathecae: ectal ducts rather short, almost completely covered with single layer of small glands, ampullae of rather spindle shape, ental ducts of the same length as the ectal ones.

Discussion: The species is probably either a form of *E. buchholzi* or a form of *E. minutus* Niels. et Christ., 1961.

17. *Enchytraeus buchholzi* Vejdovský, 1877 (Fig. 28)

Description: Length 5–8 mm, coloured white, segments (29) –33–(36), setae: 2, 3 – (3)2 : 3 – 3(2), usually present in lateral bundles in XII. Coelomocytes oval to pear shaped, carry different amount of dark grains.

Distribution: Very common in Europe.

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ECOLOGICAL STUDIES ON BAT-FLY BRACHYTARSINA SINHAI (Diptera, Streblidae) AT JODHPUR, INDIA

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Received February 18, 1985

Abstract. Ecological studies on the streblid fly, *Brachytarsina sinhai* Vazirani and Advani, ectoparasitic on bat, *Rhinopoma microphyllum kinneari* (Wroughton) are reported in the paper. The studies include observations on the distribution of flies on bats, seasonal prevalence in population density, percentage of infestation and sex ratio. The flies were found unrandomly distributed on bats, infesting a range of 20 – 100 % of bats. The lowest mean number of flies per bat was 0.20 in April while the highest in February and August months. A need for improved methods for population studies is stressed.

INTRODUCTION

Streblid flies belonging to Diptera-pupipara group of insects are exclusively parasitic on bats. Although some protozoans have been isolated from bat-flies (Chatton, 1909: Anciaux, 1965), their public health importance is not known. Being host-specific to bats the public health importance of bat-flies is further limited. However, contemplating the reservoir potentiality of bats for several pathogens of medical importance to man (Constantine, 1970) the bio-ecology of these haematophagous flies deserves attention. Considerable ecological work has been done on the New world genera of streblids, viz *Trichobius, Strebla, Megistopoda* and *Speiseria* (Ross, 1961; Overal, 1980 and Fritz, 1983), but little attention has been paid to Old World genus *Brachytarsina* (= *Nycteribosca*). Recently, Dhiman (1982, unpublished work) and Dhiman and Rama-Rao (1983) studied the bio-ecology of *Brachytarsina sinhai* of which ecological studies are being reported here.

MATERIAL AND METHODS

The study was carried out at Johpur, the gateway of Indian desert, loocated between 26.18°N and 73.8°E. Regular monthly observations were made at the roosting place of bats at Mandore tunnel located 8 km in north of Jodhpur. *Rhinopoma microphyllum kinneari* (Wroughton) (RMK), the principal host of *B. sinhai* were collected from a particular chamber of the roost individually with hand net from their day roosting quarters. Each bat was transferred to polythene bag containing pyrethrum and its mouth tied with rubber band. The patagium of the bats was unfolded to record the number of flies per bat. 302 host specimens have been examined on which 297 flies were found. The sex of the flies was identified with the aid of hand lens. After record, the bats were restored back to their habitat. The

observations on the behaviour of flies were made in field as well as laboratory. The temperature and relative humidity of the roosting place were recorded around 10 a. m. after placing Dry and Wet bulb thermometer in the roost for half an hour.

OBSERVATIONS AND RESULTS

For better understanding of the ecology of *B. sinhai* some important observations recorded on the biology of fly and bat, RMK (Dhiman, 1982) are summarised here:

i. The bat species is highly gregarious. Majority of the bats leave the roost in extreme summer and winter season. In the latter season bats remain lethargic (Sinha, 1977). The bats rest on the walls of the roost, remaining in close contact with fellow bats.

ii. The rate of development of *B. sinhai* is fastest in summer and lowest in winter season. However, at more than 30 °C temperature, though the rate of intra-uterine development is fast, the majority of pupae get dessicated resulting into slow rate of eclosion.

Distribution on the host

The flies were found mostly on the body of bats except at the time of deposition of offsprings, mating or due to disturbances inflicted by the bats. They prefer to remain on dorsal side, particularly uropatagium and tail of bats which are without fur. In winter the flies were found hidden in the folds

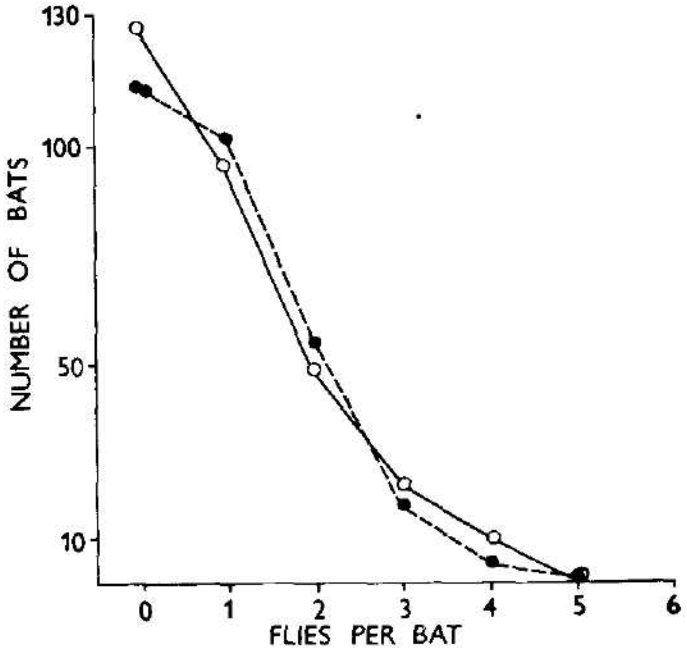

Fig. 1. Distribution of *Brachytarsina sinhai* on *Rhinopoma microphyllum kinnear* (.— — — —. Poisson distribution).

Table 1. Seasonal fluctuations in *Brachytarsina sinhai* at Mandore tunnel, Jodhpur, India

Date of observation	No. of bats	No. of bats infested No. of flies 0	1	2	3	4	% of infes- tation	Total No. of flies	% of female flies
1978									
June 30	16	10	6	0	0	0	37.5	6	100.0
July 8	20	10	6	4	0	0	50.0	14	78.6
Aug. 1	18	4	3	4	4	3	77.7	35	85.7
Sept. 14	20	5	8	6	1	0	75.0	23	91.3
Oct. 7	14	3	11	0	0	0	78.5	11	90.9
Nov. 23	16	12	2	2	0	0	25.0	6	100.0
Dec. 25	18	12	0	4	2	0	33.3	14	92.8
1979									
Jan. 10	20	15	4	1	0	0	25.0	6	100.0
Feb. 17	18	3	0	8	6	1	83.3	38	89.4
Mar. 21	6	0	6	0	0	0	100.	6	100.0
Apr. 13	5	4	1	0	0	0	20.0	1	100.0
May 12	10	8	2	0	0	0	20.0	2	100.0
May 29	16	10	6	0	0	0	37.5	6	100.0
June 13	15	9	4	2	0	0	40.0	8	100.0
July 1	9	3	3	3	0	0	66.6	9	77.7
Aug. 23	20	0	11	2	3	4	100.0	40	87.5
Sept. 26	28	2	12	8	4	2	92.8	48	87.5
Nov. 15	18	9	7	2	0	0	50.0	11	90.9
Dec. 8	15	8	3	2	2	0	46.6	13	84.6

formed by the patagium and fore-arm, and endopatagial region. The off-host flies were found resting on the wall surface below the bat's roosting quarters, up to a distance of 150 cm, exhibiting negative geotropism. The flies go on sweeping the body of bats excepting winter season and move from one bat to another. Of the 302 bats observed during the course of present study 42.05 % were negative for the flies while 31.45 % were harbouring single fly individually. Only 3.31 % bats were found with four flies. Thus the distribution of flies seem to be unrandom. The observed and expected values (Fig. 1) are in good agreement following Poisson distribution ($P<0.05$).

Seasonal prevalence

i. *Population density:* The data pooled in Table 1 and Fig. 2 show that the population of flies is maintained in nature throughout the year. The highest mean number of flies per infested bat was 2.5 whereas it was lowest in summer months. The maximum parasite burden was recorded as 4 in August 1978 1979 and September 1979. In February 1979 also a single bat was found infested with 4 flies. The lowest mean number of flies per bat was 0.20 in the month of April and May while it was highest (2.1) in Fabruary and August months.

ii. Percentage of infestation: Normally over 50 % bats were found infested The percentage of infestation ranged from 20—100, the lowest being in summer and winter while it was highest in rainy season (Table 1).

iii. Sex ratio. There is remarkable difference in the availability of either sex of the fly. The female flies comprised of more than 70 % of the population and sometimes it was even 100 %. The percentage of male flies was only 22.3 % in the month of July 1979.

DISCUSSION

The distribution of *B. sinhai* was unrandom following Poisson distribution. It is true that the collection of foraging bats is an important reason for unrandom distribution as discussed by Fritz (1983) in case of *Trichobius* and *Speiseria* sp. on *Carollia*. In spite of the collection from day roost during the present study, the flies were not randomly distributed as observed by Overal (1980) in *Megistopoda aranea* on *Artibeus jamaicensis*. The reason of it may be attributed to the behaviour of flies, gregariousness of the bat species and the method of collection. When the bats are approached for collection, the

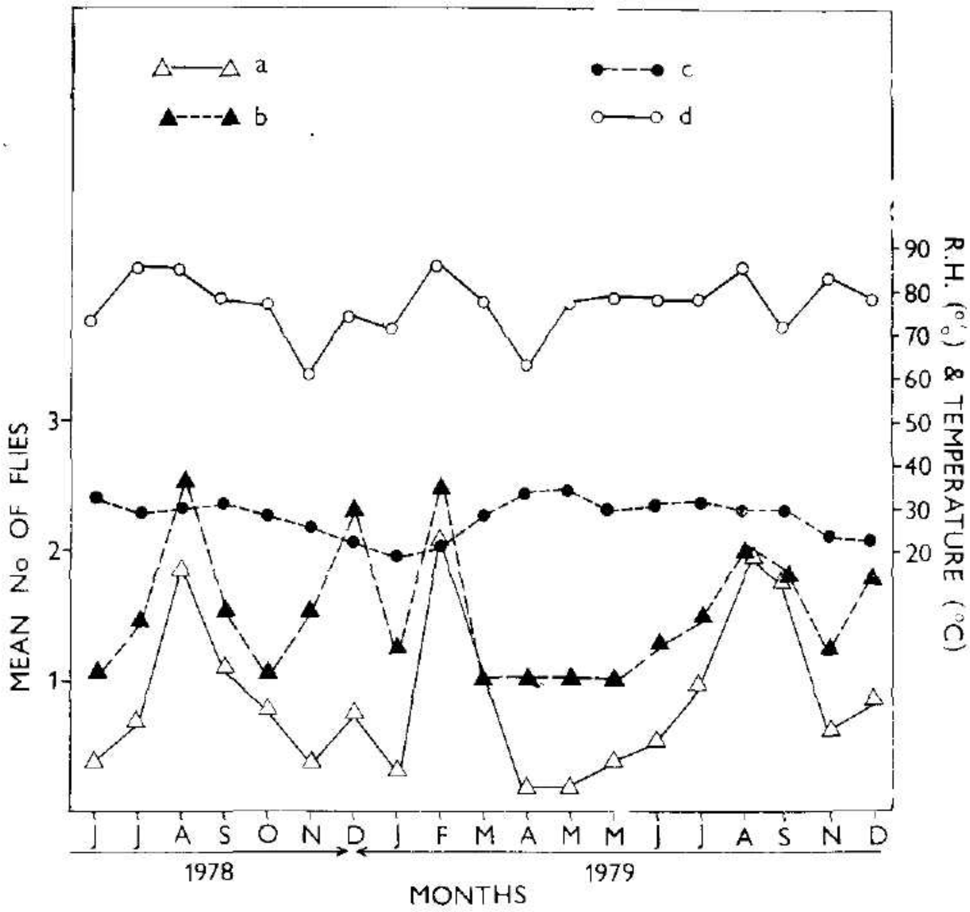

Fig. 2. Seasonal fluctuation in *Brachytarsina sinhai* in relation to temperature and relative humidity.
a — mean number of flies per bat, b — mean number of flies per infested bat, c — temperature, d — relative humidity.

flies might get disturbed and leave or congregate on the fellow bats. Therefore, the bat captured in net may not reveal the true estimate of infestation. Therefore, improved methods for population studies of bat-flies are desired.

Like in the present study, the low population of bat-flies has been reported by Marshall (1971), and Funakoshi (1977) and Fritz (1983). The highest mean number of flies per bat was recorded in the month of August and February while the lowest in April and May. It may be explained that around 30 °C temperature in rainy season favours smooth development, increased longevity of flies and the availability of bats in the roosting place. With the onset of winter season the rate of development of flies is prolonged but due to winter migration of bats, few hosts are available to the flies subsequently increasing the number of flies per bat. In summer at more than 30 °C temperature, reaching up to 34 °C, the population of flies is very low owing to dessication of pupae and availability of few bats due to summer migration. The decrease in the longevity is also remarkable in summer (Dhiman, 1982). The same reason holds true for the fluctuation in mean number of flies per infested bat.

In spite of the highest mean number of flies per infested bats in winter season, the reason of lowest percentage of infestation may be attributed to the lethargic activities of bats and subsequently of flies, leaving less scope for dissemination of the latter.

The reason of the low number of male flies as compared to females in wild population may be attributed to the difference in the microclimate of either sex. As the males are poor bloodsuckers and they mate with females during the act of pupiposition, it is likely that the majority of males rest on the wall surface of the roosting place. Amongst the male flies caught on the bats, there may be some which reached the bats in copulo-condition with females. However, large sample size of the population on and off the bats may explicate the intriguity.

Acknowledgement

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DIE DRITTE PALÄARKTISCHE AULONIA-ART: AULONIA KRATOCHVILI SP. N. (ARANEIDA, LYCOSIDAE)

Peter M. DUNIN, Jan BUCHAR, Karel ABSOLON

Eingegangen am 30. April 1985

Abstract. A third palearctic species of *Aulonia: Aulonia kratochvili* sp. n. (Araneida, Lycosidae). 26 specimens of *Aulonia kratochvili* from Azerbaidzhan (USSR) are examined. The new species is described, its genitalia (epigynes, vulva, palps, embolus) and leg I illustrated. Variability and affinities of this new species are discussed.

Die vorgelegte Beschreibung der neuen Art ist das Ergebnis einer langfristigen Zusammenarbeit zwischen dem Lehrstuhl für Systematische Zoologie der Karls-Universität in Prag und der Staatlichen M. S. Kirov Universität in Baku. Die neue Art wird zu Ehren des 75. Geburtstages des bedeutenden tschechoslowakischen Zoologen, Akademiker Josef Kratochvíl, bennant, der zur Erforschung der paläarktischen Arachnofauna bedeutsam beigetragen hat.

Aulonia kratochvili sp. n.

(Abb. 1—7)

Fundorte und Material: Aserbaidschan (UdSSR).

Holotypus ♀ (Zool. Inst. AN SSSR, Leningrad, Katalog-Nr.: 29), Gobustan (Denkmalschutzgebiet), etwa 60 km südlich von Baku, in der Umgebung einer Quelle und eines aus dieser Quelle ausfliessenden kleinen Baches (der Umkreis dieses Baches durchnässt, mit Kräutervegetation, unweit der Untergrund dürr mit einer sporadischen Vegetation von Holzarten der Gattungen Prunus, Ficus u. ä), Lokalität südlich exporniert, 20 m ü. d. M., 20. 6. 1982, leg. K. Absolon.
Paratypen: 6 ♀ gleiche Daten wie Holotypus. — Mingečaur, 20 m ü. .d. M., 2 ♂, 3 ♀, 15. 5. 1946, leg. Bogačev; nordl. Seeufer, 2 ♀, 20. 6. 1978 und 1 ♀, 26. 6. — 27. 1982 (Formolfang), leg. Absolon. Jevlach, Chaldan, 20 m, 2 ♂, 21. 5. 1950 leg. Bogačev. Kjurdamir, 0 m ü. M., 1 ♂, 1 ♀, 6 juv., 8. 4. 1978 leg. Dunin. Uždary, 0 m, 2 ♀, 27. 5. 1979 leg. Dunin. Šeki, Ochud, 300 m, 2 ♂, 28. 5. 1979 leg. Dunin. Saatly, Džafarchan, 1 ♂, 26. 5. 1983 leg. Dunin. — Süd.-Aserbaidschan (Lenkoran), Gaftoni, 2 ♀, 0 m ü. d. M., 8. 5. 1984, leg. Alijev. Material bei den Autoren und im Zool. Inst. AN SSSR, Leningrad, aufbewahrt.

Das gesamte Material, mit Ausnahme von 2 Weibchen aus Lenkoran, stammt aus Fundorten mit Halbwüsten-Klima sowie Vegetation (Jahresniederschläge niedriger als 400—450 mm). In Lenkoran sind die Niederscshläge bedeutend reicher (Jahresmittel 1200 mm), sie treten jedoch in der kühlen Jahreshälfte auf.

Diagnose: Ein typischer Vertreter der Gattung *Aulonia*, ausgezeichnet durch die Form der Epigyne, das Vulvenbild, sowie durch die Form des Bulbus und die Behaarung der männlichen Ti-Ta I.

♀-Beschreibung (Holotypus): Gesamtlänge 5; Länge (Breite) des Ceph. Th. 2,55 (1,7) mm. — Carapax braun, Radialstreifen fast undeutlich. Weißliche Haare bilden eine undeutliche mediane Längsbinde und einen Saum herum den Ceph. Th. Kopfregion über das Cephalothorax-Niveau ein wenig erhöht und vorn geneigt. — Augen: Länge der Augenreihen: I 0,47 (procurv); II 0,61; III 0,84 mm. HMA-Durchmesser 0,23 mm. HMA:HSA:VMA:VSA wie 1:0, 92:0, 32:0,30. HMA (HSA) voneinander um 0,76 (2,55) Augen-Durchmesser getrennt. Abstand VS/VM ein wenig größer wie VM/VM (0,069:0,063). — Cheliceren (sowie Clypeus) braun. Hinterer Falzrand mit drei gleich größen Zähnen. Grundglied 0,95 (0,42) mm lang (breit); die Klaue 0,39 mm lang. — Sternum und Gnathocoxen hellbraun; Labium ein wenig dunkler gefärbt, doch sein Vorderrand weißlich umsäumt. Cx I dunkelgrau, Cx II-IV gelb, apical mit einem dunklen Flecken. — Palpus dunkelbraun, nur Pt und Apicalteil des Fe gelb. Pedipalpus-Länge 2,65 (0,85 + 0,40 + 0,55 + 0,85) mm.

Beine: IV/I/III/II. Grundfarbe gelb, nur Fe I dunkelbraun. Fe II-IV mit je eine helle graubräunliche Ventralbinde: auf dem Fe II retrolateral, auf den Fe III-IV prolateral lokalisiert. Übrige Glieder noch weniger gefleckt; am meistem Bein IV, am wenigsten Bein II. — Bestachelung: Fe I-IV mit 2 DS (der basalere gerade, der apicalere bogenförmig) und drei AS.*) Fe II, III prolateral, Fe II-IV retrolateral mit je einem kleinen Stachel. Pt III, IV mit einem apicalen DS (auf den Pt I, II derselbe nur haarförmig entwickelt). Ti I mit 3 Paare von VS. Ti II mit 2 retrolateralen VS, aber prolateral nur mit einem distalen VS; daneben prolateral mit 2 LS, retrolateral nur mit einem distalen LS. Ti III, IV mit 2 Paare VS (doch auf der Ti III fehlen beide RVS), 2 AS, 2 PLS, 2 RLS, 2 DS.

Absolute Längenmaße der Beinglieder (in mm):

	Fe	Pt	Ti	Mt	Ta	Ges.—L.
I	1,90	0,85	1,55	1,50	1,00	6,80
II	1,65	0,75	1,20	1,25	0,80	5,65
III	1,60	0,70	1,20	1,50	0,85	5,85
IV	2,35	0,85	2,15	2,35	1,10	8,80

Abdomen ovalförmig, von oben dunkelgraubraun, in der Mitte mit einem länglichen, schmalen, weißen, nicht bis zum Abdomenende reichenden Streifen weißlicher Haare. Im hinteren Dritten des Abdomens schmale, weißliche Streifen angedeutet. Die Unterseite graugelb. Die vorderen Spinnwarzen graugelb, die hinteren von oben etwas dunkler, das Apicalglied schwarzbraun.

Die Epigyne (Abb. 1) bräunlich gefärbt, zweimal breiter als lang. Das in der vorderen Hälfte sehr schmale Septum erweitert sich in der hinteren Hälfte in ein niedriges Dreieck, dessen Grundseite fast der Gesamtbreite der Epigyne entspricht. Beiderseits des Septums befinden sich zwei Paare dunkler pigmentierter Höcker. Das vordere, wenig auffallende und pigmentierte Paar durch ein tiefes Grübchen von dem Septum getrennt. Der Boden dieses Grübchens

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*) AS, DS, VS = Apical-, Dorsal-, Ventral-Stachel; PLS, RLS = Pro-, Retro-lateralstachel.

sowie die gesamte Epigyne unscheinbar behaart. Auf der dicht an das Grübchen angrenzenden Seite erreichen die vorderen Höcker die größte Höhe. Das hintere Paar der Höcker schließt unmittelbar an das Septum an und bildet eine auffallende, quere Struktur, besonders am vorderen Rand. In den Höckern scheinen die Rezeptakula in Form eines spiralfödrmig gedrehten großen Buchstaben C durch.

Die Vulva (Abb. 3) wird durch ein Paar von Rezeptakula gebildet, die sich in einem sehr geräumigen Hohlraum befinden, dessen Umfang dem hinteren Höckerpaar entspricht. Das Rezeptakulum selbst findet sich am Hohlraumboden. Sein Ausführkanal ist fast gleichmässig breit und bildet eine locker gewundene Spirale, deren Endteil an den dreieckförmigen Teil des Septums anschliesst.

Variabilität: Die Färbung der Beine kommt bei manchen Exemplaren kontrastreicher vor: Fe I dunkelschwarzbraun, Fe II – IV ohne Flecke. Beträchtlich variiert das Aussehen der vorderen Höcker an der Epigyne.

♂-Beschreibung: Gesamtlänge 4,25; Länge (Breite) des Ceph. Th. 2,1 (1,5) mm. – Färbung und Form des Cephalothorax wie beim Weibchen. Beine gelb, nur Cx und Fe I braun, zum Unterschied vom Weibchen die Fe-Distalhälfte auffallend heller. Auch Cx II-IV, besonders auf der Rückenseiten gewissermassen bräunlich. – Augen: Länge der Augenreihen: I 0,45 (procurv); II 0,65; III 0,80 mm. HMA-Durchmesser 0,21 mm. HMA:HSA:VMA:VSA wie 1:0,190:0,33:0,30. HMA (HSA) voneinander um 0,87 (2,44) Augen-Durchmesser getrennt. Abstand VS/VM 0,57, VM/VM 0,50 mm. Clypeus 0,11 mm hoch. – Grundglied der Cheliceren 0,85 (0,35) mm lang (breit); die Klaue 0,34 mm lang.

Pedipalpus-Länge: 2,51 (0,78 + 0,40 + 0,35 + 0,98) mm. Cx, Fe braun, Pt hellbraun mit klarweißer Behaarung, Ti + Cymbium schwarzbraun. Die Form der ungewöhnlich großen Tegular-Apophyse erinnert an den großen Buchstaben F (Abb. 5,6). Der obere Querstrich fast entsprechend der Cymbiums-Breite lang und ungefähr so lang wie der längliche Teil der Apophyse. In Seitenansicht ist die breit bandförmige Gestaltung der Apophyse sichtbar. An dem freien Ende ist der obere Querstrich in drei Lappen gegliedert. Der mittlere Lappen setzt sich in Verlängerung des Querstrichs fort, der proximaler liegende Lappen säumt den Querstrich auf der äußeren (vom Bulbus abgewandten) Seite ein, und der apicaler befindliche Lappen wächst an der zum Bulbus gerichteten Seite aus und ist senkrecht auf die untere Seite der bandförmig gestalteten Apophyse orientiert; ähnlich wie der gesamte kürzere mittlere Querstrich, wenn wir die Gesamtgestaltung der Apophyse in der Form des F-Buchstaben in Betracht ziehen.

Der Embolus ist in Ventralansicht (Abb. 5) nur undeutlich, als ein winziges, dunktel sklerotisiertes, hinter dem retrolateralen Teil des Tegulums hervortretendes Zäpfchen erkennbar. Er ist flach und bogenförmig, mit einem kurzen spitzigen Endteil. Von der Basis des gestreckten tritt in senkrechter Richtung ein unpigmentiertes, stäbchenförmiges Gebilde hervor, dessen Länge den pigmentierten Endteil auffallend überragt (Abb. 7).

Beine: IV/I/II/III. Wie beim Weibchen bestachelt. Besondere Behaarung der *Beine des ersten Paares: Ta ventroprolateral mit* langen (dreimal längeren als die Gliedbreite), markant gebogenen Haaren. Mt und zum Teil auch der Apicalteil von Ti an den gleichen Stellen mit gleich langen, jedoch senkrecht abstehenden Haaren (Abb. 4).

Absolute **Längenmaße** der Bein**glieder** (in mm):

	Fe	Pt	Ti	Mt	Ta	Ges.-L.
I	1,90	0,65	1,80	1,75	1,13	7,23
II	1,43	0,60	1,13	1,30	0,78	5,24
III	1,48	0,53	1,05	1,38	0,65	5,09
IV	2,03	0,53	1,95	2,35	1,05	7,91

Abdomen: Gleicher Gestaltung und Färbung wie beim Weibchen.
Weibchen.

Verwandschaft: Nach der Konzeption des von Roewer (1959: 950) aufgestellten Systems der Unterfamilie Hippasinae gehört die beschriebene neue Art in die Gattung *Aulonia*. Es ist jedoch notwendig, auf die Frage der Toleranz aufmerksam zu machen, was den zulässigen Wert für den Abstand der hinteren Mittelaugen (HMA) im Verhältnis zum Durchmesser dieser Augen betrifft. Wenn die beiden Werte identisch sind, determinieren sie die Gattung *Aulonia*, wenn jedoch der Abstand kleiner als der Durchmesser ist, handelt es sich um die Gattung *Anomalomma*. Roewer führt in der erwähnten Arbeit auch die Art *Aulonia albimana* an und rechnet damit, daß der ermittelte Abstand zwischen den Augen auch ihrem Durchmesser entspricht. Dieser Abstand beträgt aber bei der mitteleuropäischen Population nur 81 % des Augendurchmessers. Wenn wir diesen Wert mit der Roewers Angabe für *Anomaloma rhodesianum* vergleichen, wo er 60 % beträgt, ergibt sich daraus, daß die Abweichung bei *Aulonia albimana* klein ist und zeigt, welche Toleranz bei diesem Merkmal eingerechnet werden kann. Die Abweichung ist bei der neuen Art Aulonia kratochvili, wo der Abstand 85 % beträgt, etwas geringer.

Auffallend ist auch die Übereinstimmung in der Färbung der neuen Art mit *A. albimana*, wie auch mit der ägyptischen Art *Aulonia werneri* Roewer, 1959 — besonders was die Extremitäten, insbesondere dann die Taster betrifft.

Dementgegen bestehen große Differenzen in der Gestaltung der Kopulationsorgane. Die Tegular-Apophyse bei *A. albimana* ist in der Form und Größe ganz unterschiedlich. Bei *A. werneri* ist das Männchen unbekannt. In diesem Zusammenhang ist jedoch darauf aufmerksam zu machen, daß die sehr charakteristische Gestaltung der Tegular-Apophyse bei *A. kratochvili* sp. n. gewissem Maße auch bei Roewers Arten angedeutet ist: bei *Anomalomma rhodesianum* in Form einer umgekehrten „Drei", sowie bei *Auloniella maculisternum*, wo die „Drei" noch mit einer zweilappigen Beendigung des oberen kleinen Bogens versehen ist (bei *A. kratochvili* sp. n. ist dies dreilappig!). Die beiden genannten Arten gehören in Gattungen, welche sich nach Roewer von der Gattung *Aulonia* lediglich durch das Verhältnis der Größe und Anordnung der Augen unterscheiden!

Was den Embolus betrifft, erinnert seine Form und Lage bei *A. kratochvili* sp. n. an die Situation bei *A. albimana*. In beiden Fällen ist der Embolus bogenförmig und an der Innenseite des Bogens mit einem unsklerotisierten häutigen Gebilde ausgefüllt; Embolus ist bei Ansicht von unten vom größeren Teil hinter dem Tegulum verdeckt.

Aulonia kratochvili sp. n. unterscheidet sich sehr markant von allen angeführten Arten durch die Gestaltung der Epigyne. Keine Art wird von Roewer mit einem Septum abgebildet, des in der vorderen Hälfte so auffallend schmal ist, während seine hintere Hälfte die ganze Epigynebreite einnimmt. Ebenfalls die Rezeptakula sind vollkommen abweichend in Form und Lage.

Seit 1960 wurde keine neue Art von den drei erwähnten Gattungen — *Anomalomma, Aulonia, Auloniella* — beschrieben. Von Brignoli (1983) und auch von Bonnet (1955) wurde keine ältere Art aus dem zoogeographischen Gebiet des Vorkommens von Exemplaren der neuen Art *Aulonia kratochvili* angeführt.

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Die Abbildungen sind am Ende des Heftes zu suchen.

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COMPARISON OF SEASONAL RHYTHMS OF ACTIVITY OF GREY SQUIRRELS (SCIURUS CAROLINENSIS, RODENTIA) IN CAPTIVITY AND IN THE WILD

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Abstract. Seasonal changes in the activity rhythm in captive grey squirrels (*Sciurus carolinensis*) were recorded by a photocell system at the Cedar Creek Natural History Area, Minnesota. Photocell recordings from grey squirrels near the Arctic Circle at Kuusamo, Finland and at Andechs, West Germany were analyzed and compared with those from Cedar Creek. Activity rhythms of wild squirrels, and also of the captives, were monitored by radio telemetry at Cedar Creek.

The duration of activity time (α) in both captive and wild squirrels did not follow the duration of the photoperiod throughout the year. The very short α in late winter might be under the control of exogenous factors other than light, especially in wild squirrels. The marked increase in length of activity in September in wild squirrels was probably related to mast harvesting behavior. Seasonal differences in phase angle and duration of activity indicate larger variations in wild than in captive squirrels. Secondly, our data on grey squirrels suggest that day-active mammals exhibit larger variations in phase angle differences and duration of activity than day-active birds.

INTRODUCTION

Entrainment of circadian systems of vertebrates to a Zeitgeber has been studied primarily in birds and mammals in captivity, usually indoors, but sometimes under natural photoperiod and weather conditions. Aschoff (1969) and Daan and Aschoff (1975) summarized data on birds and mammals to explain this mechanism in different latitudes and seasons. Their interpretations are based on data from numerous day-active birds and a few night-active mammals. Only one day-active mammal, *Tupaia belangeri*, was studied.

Differences in the circadian clock in birds and mammals have been observed and reported by many authors (Aschoff 1965, Hoffmann 1969, Pittendrigh 1972, Gwinner 1973, Eskin 1971, Menaker 1971 and others). The entrainment of the circadian system to light cycles in some species of diurnal mammals shows much variability (Kenagy 1978, Halberg et al. 1982). Pohl (1982) investigated variability in entrainment of circadian rhythms and concluded: "... organisms show a high degree of variability probably related to special ecological requirements ... It remains a matter of further study to analyze the specific adjustments of entrainment mechanisms in closely related species experiencing different light condition in their natural habitats."

Information on locomotor activity of wild or wild animals compared to captive animals of the same species is needed to understand entrainment phenomena. Telemetry or radio-tracking with automatic recording of movement and activity, as reported by Mech et al. 1966, Rongstad and Tester 1977, Tester 1978 and Figala et al. 1984, provides an excellent opportunity to obtain such data on wild animals. Grey squirrels were chosen for this study because radio transmitters did not appear to influence their behavior or psychology (Bland 1977) and they were easy to maintain in captivity for long periods.

Simultaneous collection of data on wild and captive squirrels by use of telemetry and photocell-activated strip chart recorders made it possible to determine effects of captivity. Thus, behavior in response to natural day-night rhythms and weather conditions could be evaluated under both wild and captive conditions.

This paper reports on seasonal changes of activity rhythms and attempts to explain deviations from predicted patterns of entrainment in terms of behavioral and ecological factors influencing the squirrels. In addition, effects of captivity on activity rhythms are evaluated.

METHODS

Data on captive and wild squirrels were collected at the Cedar Creek Natural History Area in east-central Minnesota (45°24'N, 93°12'W) from 1 January 1976 to 31 December 1976. Four animals (1 adult male, 1 adult female, 1 juvenile male and 1 juvenile female) were held in 1 × 1 × 1 m wire cages positioned 1.1 m above the ground in mature deciduous forest. Nest boxes (40 × 40 × 40 cm) with bedding of dry oak leaves were attached outside each cage. Corn, sunflower seeds and acorns (in season) were provided ad libitum in food boxes attached outside each cage. Two other adults, a male and female, were kept in a large pen (2 × 4 × 1.5 m) with one nest box and one feeding box.

All squirrels were captured within 1.0 km of the pen in November 1975. They were placed in the experimental pens and allowed to acclimate to captivity until the experiment began.

In winter the roofs of the cages were covered with canvas to protect the animals against the snow. On 22 April the plywood bottoms on the nest boxes were replaced with wire to provide for air circulation. On 21 September the plywood bottoms were replaced on the nest boxes.

All animals were weighed 7 times during the year as a means of monitoring physical condition. Individual weights ranged from 550 to 800 grams, and all squirrels appeared to be in good physical condition. One juvenile male increased in weight from 450 g in December 1975 to 860 g in November 1976.

Locomotor and feeding activity were measured by photocells on the boxes and recorded on an Esterline strip-chart recorder. Kodak filter paper (Types 87 and 89B) was used to keep the intensity of the photocell bulbs as low as possible.

All caged squirrels were fitted with a radio transmitter in the 53 mHz range. The transmitters were designed as collars with the broadcasting antenna forming the collar loop. Weight of the transmitter was 35 gr, life was 180 days and range was about 1.7 km. Every 2 or 3 months the squirrels were trapped and the batterys in the transmitters were replaced.

Signals from all caged squirrels were monitored with a stationary antenna and continually recorded on microfilm. When the squirrel was motionless the signal appeared as a continuous black line on the microfilm records, whereas when the squirrel moved, the signal appeared as a broken interrupted line. These breaks were caused by modulation of the radio signal due to a change in circuit capacitance as the collar changed position on the neck of the squirrel.

The combination of photocells and telemetry produced 3 unique measures of activity. Transmitter activity (TA) is defined as any movement in the nest box detected by the radio transmitter. Nest activity (NA) is defined as the time the squirrel first left the nest box in the morning or last entered the box in the evening as measured by the photocell. Feeding activity (FA) is defined as those periods when the photocell beam on the food box was interrupted.

The time an individual first left the nest box and the time of first feeding in the morning or vice versa in the evening were determined from the Esterline records. Since all movements of these squirrels were also recorded on microfilm, we transcribed movement data for 1 hour preceding the time the animal left the nest box and for one hour after the animal left the cage and entered the nest box to determine when "true" activity began and ended. The speed of the microfilm recorder made it possible to "read" movement shorter than one second, which made it difficult to establish the real time of awakening in the nest box or the time of last movement before beginning "real" sleep. Therefore, continuous movement of longer than 1 minute has been considered as "activity".

We could not use data from the Esterline record to determine which squirrel left the nest box first in the morning (or entered last in the evening) in the large pen containing 2 animals. Therefore, film records were analyzed for 60 min preceding and 30 min following the morning and evening initiation and cessation of activity as indicated by the nest box photocell.

During the research period we utilized the Cedar Creek automatic radio tracking system (Cochran et al. 1965) to determine activity (WA) of 9 wild squirrels. Individual squirrels were monitored for periods ranging from 1 to 8 months, with the average being 3.7 months (Figure 1). Signals from each animal were recorded on microfilm every 45 seconds.

Cessation or end of activity in wild squirrels was determined as that time when more than 4 minutes of uninterrupted bars were recorded on the microfilm. This 4 minute period was chosen based on information on the beginning and ending of activity in captive squirrels, as described above. If there was no exact evidence of the time of beginning or ending of activity, we did not calculate values for that day.

The times of sunrises and sunsets were determined from U. S. Naval Observatory Chart No. 1155 for Minneapolis. Weather data were recorded at the U. S. Weather Bureau Station at the Cedar Creek Natural History Area.

Comparable data on nest activity of captive grey squirrels in Andechs, West Germany and in Kuusamo, Finland were kindly provided by J. Aschoff, Max Planck Institute für Verhaltensphysiologie. At Andechs (47°58′N, 11°30′E) nest activity measured by a photo cell was recorded nearly continuously for a single captive grey squirrel from January 1967 to December 1970. At Kuusamo (66°27′N, 29°21′E), near the Arctic Circle, a single captive grey squirrel was similarly monitored from September 1967 through December 1968.

The combined data from the 3 locations resulted in 17,000 records of onsets and ends of activity. Measurements from Cedar Creek were grouped into 24 ½-month averages and measurements from Andechs and Kuusamo were grouped into 36 ⅓-month averages.

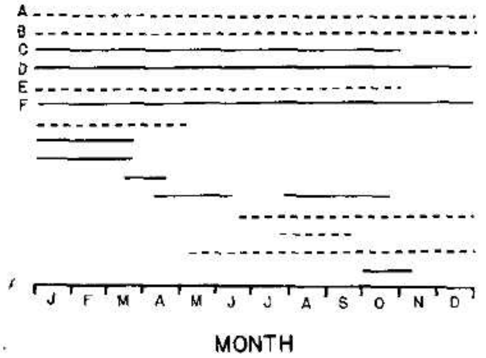

Fig. 1. Dates when radio-marked male (solid line) and female (dashed line) grey squirrels were monitored at Cedar Creek in east-central Minnesota. Letters indicate squirrels held in outdoor pens.

RESULTS

During 1976 six squirrels were monitored in captivity and nine in the wild. The time period that each squirrel carried an effective radio transmitter varied (Figure 1).

Onset and cessation of activity

Onset and cessation of daily activity are usually related to sunrise and sunset or to a specified level of light intensity. The time difference, measured in hours, between sunrise and the onset of activity is referred to as Ψ onset. Similarly, Ψ end is the time between cessation of activity and sunset for day-active animals. Positive values indicate that activity began or ended earlier than the time of the Zeitgeber. This results in a positive phase-angle difference. Negative values indicate that activity onset or end occured later than the Zeitgeber, resulting in negative phase-angle differences. Daan and Aschoff (1975) unified both values and, categorizing them as "large" or "small", found the following pattern of Ψ: at high latitudes day-active animals have their largest Ψ onset and smallest Ψ end in mid-winter and the smallest Ψ onset

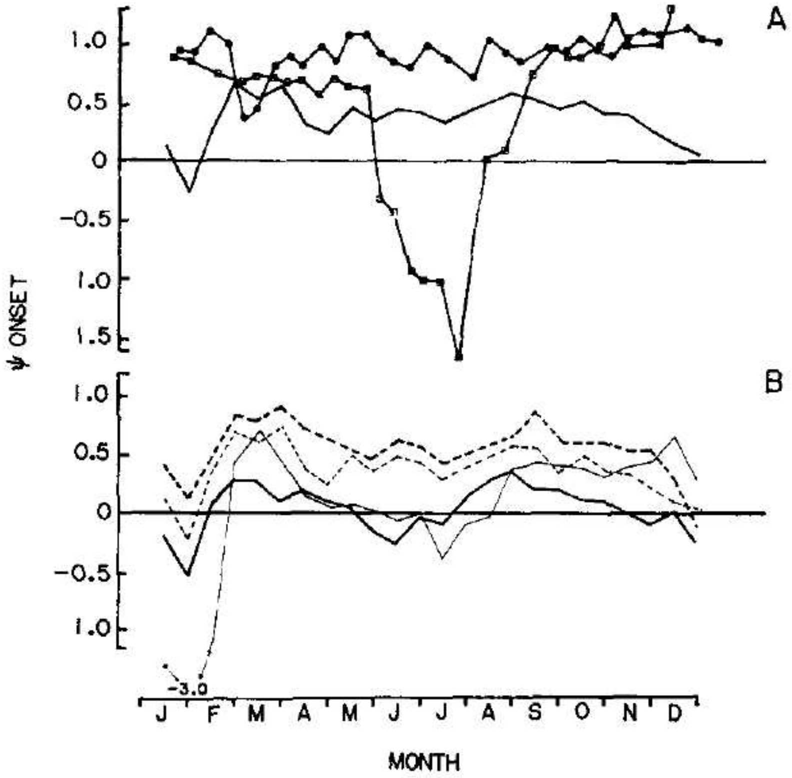

Fig. 2. Seasonal changes in the phase angle difference between the onset of activity and sunrise (Ψ onset) in grey squirrels. A — Nest box activity onset at 3 latitudes. B — Transmitter, nest box and feeding onsets of captive squirrels and onset of activity of wild squirrels at Cedar Creek.

and largest Ψ end in mid-summer. These differences have been found to be less pronounced in both birds and mammals in lower latitudes.

Values for Ψ onset for all squirrels as a function of season are presented in Figure 2. Records from the photocells on the nest boxes at Kuusamo, Andechs and Cedar Creek are shown in Figure 2A. The largest Ψ onset for the squirrel

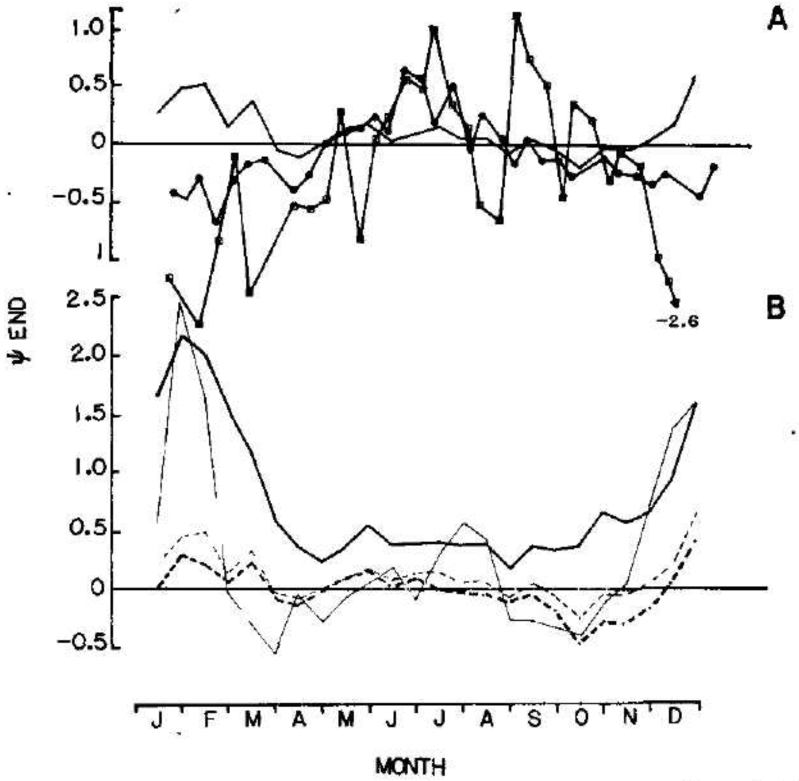

Fig. 3. Seasonal changes in the phase angle difference between the end of activity and sunset (Ψ end) in grey squirrels. A. Nest box activity end at 3 latitudes. B. Transmitter, nest box and feeding ends of captive squirrels and end of activity of wild squirrels at Cedar Creek.

living near the Arctic Circle occurred in mid-summer, which is in direct contradiction to the pattern described by Daan and Aschoff (1975). The Ψ onsets at Andechs and Cedar Creek do not exhibit as wide a change as at Kuusamo. The largest Ψ onset in captive squirrels occurred in late February and March for Cedar Creek and the lowest values were found in January and December. Both the highest and lowest values of Ψ onset at Andechs were found in February. Data from these localities do not appear to support the pattern described by Daan and Aschoff (1975). Aschoff's (1969) earlier evaluation of phase differences as positive or negative seems to be a more appropriate method for evaluating our data.

The four measurements of onset of activity at Cedar Creek, shown in Figure 2B, support using this approach. These curves summarize the averages of transmitter onset, nest onset and feeding onset for captive squirrels and of transmitter onset for wild squirrels. Though the absolute values are different, these curves reveal a maximum positive spring peak and a less obvious fall peak with minimum values occurring in mid-summer. This pattern of Ψ onset as a function of the season is similar to that reported in several species of day-active birds and mammals (Aschoff 1969, Aschoff et al. 1970 and Daan and Aschoff 1975).

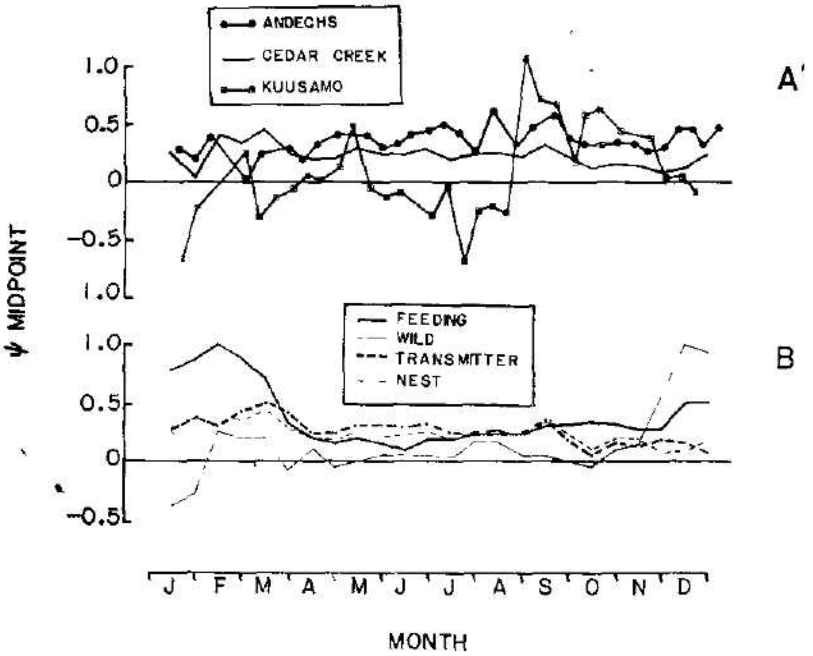

Fig. 4. Seasonal changes in the phase angle difference between the midpoint of activity and true noon (Ψ midpoint) in grey squirrels. A — Nest box activity midpoint at 3 latitudes. B — Transmitter, nest box and feeding midpoints of captive squirrels and midpoint of activity of wild squirrels at Cedar Creek.

A large negative value of Ψ onset in late January and February is especially apparent for the wild squirrels, but also appears in the three curves for the captive squirrels at Cedar Creek. The large shift in the onset of activity after sunrise produces the short activity time.

Data on Ψ end are summarized in Figures 3A and 3B, similar to Ψ onset. The curve from the squirrel at Andechs fits Aschoff's (1969) rules very well, with the largest positive values of Ψ end occurring in summer and the highest negative values in winter. At the Artic Circle, however, the squirrel exhibited two positive peaks of Ψ end and one negative peak in mid-summer, with the end of activity being 0.6 hours later than sunset (Figure 3A).

In comparing the four measures of activity end at Cedar Creek (Figure 3B), one can observe the end of nest activity fluctuating about the 0 value from spring through fall, but reaching a high positive value in winter. This high value of Ψ end in winter was even more pronounced in feeding activity and in the activity pattern of the wild squirrels. The ends for feeding activity are 1.5—2.3 hours before the time of sunset, and are almost identical to data from wild squirrels.

Midpoint of activity

The phase angle difference between the midpoint of activity time and the midpoint between sunrise and sunset is usually used as the best value for measuring the entrainment of the circadian system by the light-dark cycle (for details see Aschoff 1969 and Daan and Aschoff 1975). Values for Ψ midpoint of nest activity at Andechs and Cedar Creek are similar (Figure 4B). These values varied from 0.0 to 0.6 hours and do not show trends similar to other day-active animals described in the circadian literature. The curve of Ψ midpoint for the squirrel near the Arctic Circle indicates that both the maximum negative value and the maximum positive value occurred in summer, indicating a very large phase shift at that time of the year.

All values of Ψ midpoint from the four Cedar Creek measurements are extremely stable between April and November (Figure 4B), with a range of less than 0.5 hour. The wild squirrels showed negative values in January but large positive phase shifts in the second half of November through December. Phase of feeding midpoint is shifted by about 1 hour in the winter season. There are no such Ψ midpoint seasonal changes in other day-active species reported in the literature.

Activity time as a function of photoperiod

Activity time (α), the time interval between onset and end of activity, usually follows the length of the photoperiod, i. e., the time interval between sunrise and sunset. Averages for all squirrels are shown in Figure 5. The top 2 data sets represent activity as indicated by nest box photocells for squirrels in Kuusamo and Andechs. The data sets labeled Cedar Creek TA, NA and FA *represent transmitter activity, nest activity and feeding activity summarized* for all captive squirrels at Cedar Creek. The bottom data set summarizes averages for all wild squirrels monitored by telemetry.

The activity time of the grey squirrel near the Artic Circle paralleled the photoperiod and was larger or equal to it when day length was between 5 and 19 hours. Length of activity deviated from length of daylight when the photoperiod was 3 to 5 hours and 19 to 22 hours. No S-shape, such as that described by Daan and Aschoff (1975), can be detected in the Kuusamo data. However, the curve is similar to that reported for the Great Spotted Woodpecker *(Dendrocopus major)* (Aschoff 1969, Figs 12—13). Aschoff believed that the pattern was related to the late breeding season of this woodpecker.

All three measurements of nest box activity, at Andechs, Kuusamo and Cedar Creek, *and thansmitter activity in the nest boxes at Cedar Creek, show that* the activity time is longer but parallel to the photoperiod. In addition, the feeding activity of captive squirrels also parallels the length of the photoperiod, but is generally shorter. Feeding time and length of daylight were approximately equal when the day length was 13 to 14 hours. At longer photoperiods the lenght of feeding again became shorter. There is a strong similarity in the pattern of feeding activity (FA) in captive squirrels and activity of wild squir-

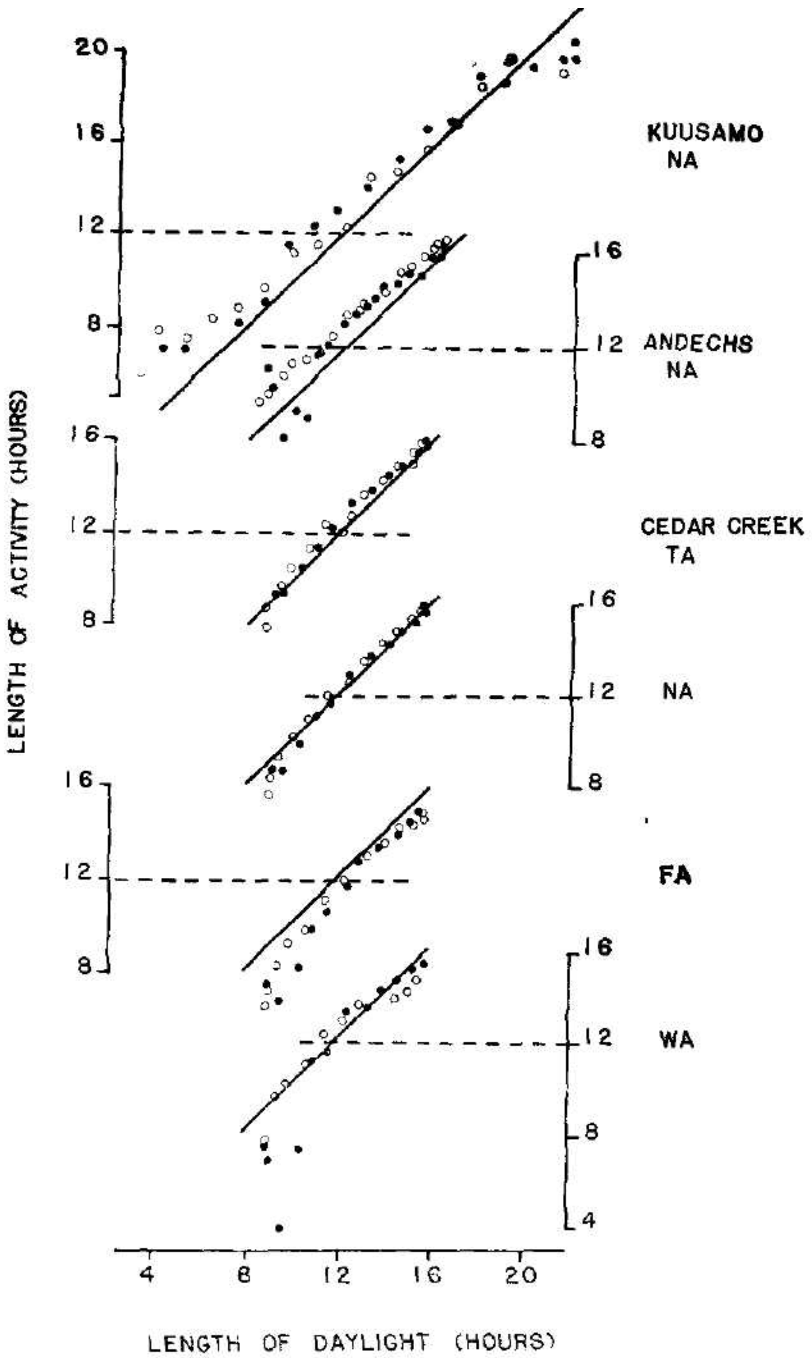

Fig. 5. Length of activity (α) of grey squirrels as a function of the photoperiod at 3 latitudes. Closed circles indicate the first half and open circles the last half of the year. The diagonal line represents a 1:1 ratio between α and photoperiod. Nest activity

rels (WA) measured by radiotelemetry. We did not detect changes in the length of activity time in spring, due to changes in testosterone levels, such as those reported for starlings (*Sturnus vulgaris*) by Gwinner and Turek (1973).

At all three locations activity time deviated greatly from photoperiod during midwinter when days were short. However, the greatest independence was recorded during day lengths shorter than 10 hours in Andechs, on FA of caged squirrels, and especially on wild squirrels. As far as we know, such a relation between activity time and photoperiod has not been reported. It appears that the photoperiod is not able to completely fulfill the "role" of the strongest Zeitgeber and force the circadian oscillation to synchrony with the light cycle. In day-active birds, as described by Daan and Aschoff (1975), a "hysteresis" was noted, especially at high latitudes. This did not occur in grey squirrels.

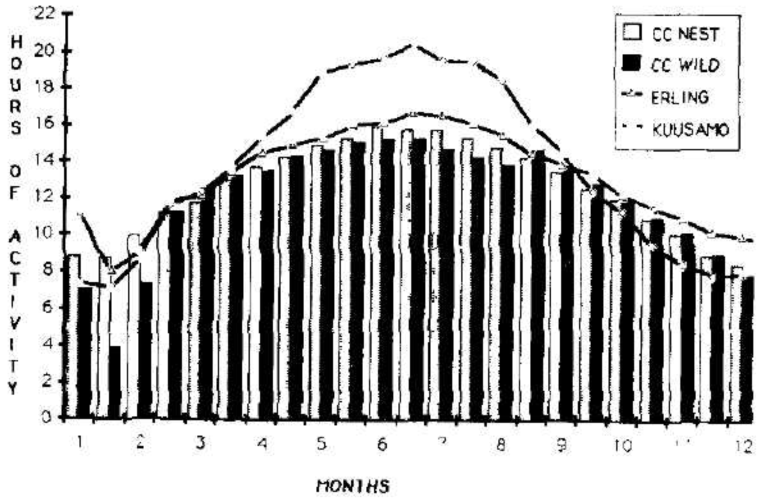

Fig. 6. Comparison of nest box activity of grey squirrels measured at 3 latitudes with transmitter activity of wild squirrels at Cedar Creek.

Activity time as a function of the year

Comparison of activity time (α) measured by different techniques and at different locations is presented in Figure 6. As expected, the longest activity time occurs in the summer months at Kuusamo near the Artic Circle. The second longest activity time occurs at Andechs. Duration of activity in summer at Cedar Creek is shortest because the latitude at Cedar Creek is the lowest, resulting in the shortest photoperiod. Data obtained by radiotelemetry in captive squirrels at Cedar Creek are similar to data recorded from the nest boxes and show similar trends; therefore, they are not included in Figure 6. Feeding activity times were shorter than nest activity, but showed the same trend.

(NA) is shown for all locations and transmitter activity (TA), feeding activity (FA) and wild activity (WA) are also shown for Cedar Creek.

Table 1. Correlation of activity time of grey squirrels to ambient air temperature in east-central Minnesota

Period	Average	min	max	Maximum amplitude/24 hrs	r
Jan 1st half	−14.9	−33.1	0.6	24.1	0.45
Jan 2nd half	−11.7	−35.4	4.4	25.4	0.64
Feb 1st half	−7.9	−31.8	9.2	31.9	0.86
Feb 2nd half	−0.7	−13.9	13.9	18.3	0.41

Activity data on wild squirrels at Cedar Creek differ in several ways from data on captive squirrels. From June to August the activity time of these animals was shorter than for captive squirrels at the same location. An abrupt increase in the activity time of the wild squirrels is observed in late August. From this date until the end of December the curves for both captive and wild squirrels are nearly identical.

At all localities, regardless of latitude, a decrease in the length of activity time in the second half of January was recorded. This decrease was especially pronounced in the wild squirrels. It is likely that the observed decrease was due to the influence of a strong abiotic factor or perhaps more than one. Air temperature could be such a factor. Temperature data from Cedar Creek are given in Table 1. The correlation coefficients suggest a positive relationship between daily activity time and air temperature. This relationship may explain,

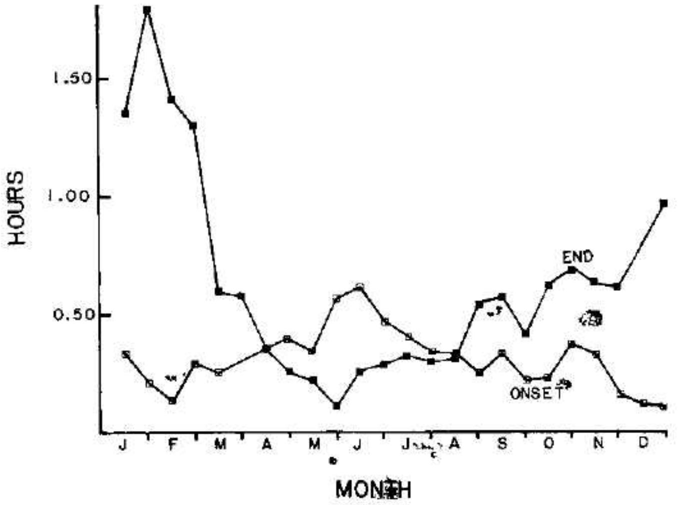

Fig. 7. Seasonal changes in the phase angle difference between onsets and ends of nest box activity and feeding activity in a male and female grey squirrel held in the same pen. The onset curve indicates the time difference between the onset of activity measured as the squirrel left the nest box and the time it began feeding. The end curve shows similar data for cessation of feeding and entering the nest box for the last time in the evening.

at least in part, the breakdown of the coupling between activity time and photoperiod, especially in wild squirrels.

The values of the length of α from all localities and from different types of measurements are most identical in March and September. This is probably evoked by the maximum strength of the Zeitgeber at that time of year (Aschoff 1969).

Nest box and feeding activity as a function of season

Time between the onset of nest box activity and feeding activity shows a definite seasonal pattern (Figure 7). The shortest time between these two points occurred in February and December, with the pattern showing the smallest values throughout the winter. The largest value, 0.6 hours, occurred in summer. The seasonal pattern in the difference between feeding end and nest box end shows the opposite pattern with the highest value, 1.8 hours, occurring in the second half of January, and the lowest, 0.1 hours, in the second half of May.

Squirrels began foraging soon after awakening in winter. In summer they left the nest box and were active in the pen for long periods before beginning to feed. Identical time intervals between locomotor and feeding activities in the morning and evening occurred in the first half of April, after the spring equinox, and in the first half of August, before the fall equinox. The longest interval between the ends of feeding and locomotor activity occurred in winter, but the shortest intervals for the ends of feeding and nest activity accurred

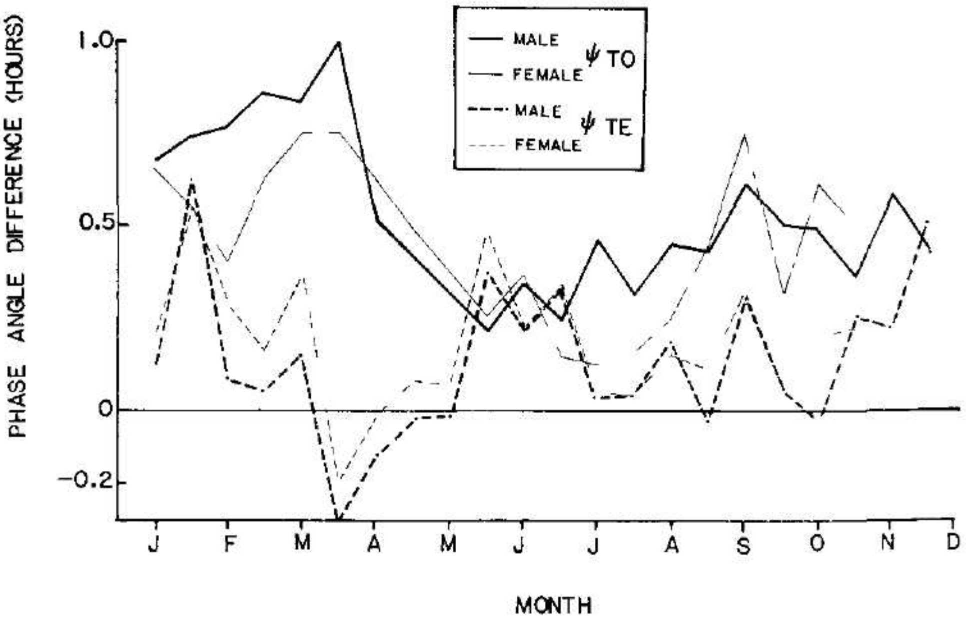

Fig. 8. Seasonal changes in phase angle difference between transmitter activity onset and sunrise and transmitter activity end and sunset in a male and female grey squirrel held in the same pen at Cedar Creek.

Table 2. Sexual differences between beginning and end of activity of captive grey squirrels in east-central Minnesota

			J	F	M	A	M	J	J	A	S	0
Inside nest	Morning ♂	before ♀	+	+	+	−	−	−	+	+	0	−
	Evening ♂	after ♀	0	+	+	+	+	+	+	−	0	−
Leaving or entering nest	Morning ♂	before ♀	−	+	0	−	−	−	+	+	+	+
	Evening ♂	after ♀	−	+	0	−	−	+	+	0	−	−

\+ Largest number of days with predominance
− Largest number of days without predominance
0 Number of days equal

in late spring and summer. In other words, foraging ended in winter long (more than 1 hour) before the end of locomotor activity. In summer, feeding activity ended about 15 to 25 minutes before the end of nest activity.

Sex differences in activity rhythms

Aschoff and Wever (1962) predicted in Rule 3 that the males of light-active species began activity earlier than females and follow the female to rest in the evening. The design of our experiment at Cedar Creek made it possible to monitor the individual activity of a male and female squirrel kept in the same cage and using the same nest box and feeding box. Data from the photocell on the nest box and from the radio transmitters were used to establish the activity pattern for each squirrel. However, it was sometimes not possible to recognize which individual was the first to leave the nest box in the morning or the last to enter in the evening (see Methods for details). We attempted to evaluate sexual differences on the basis of two types of phase angle measurements, transmitter (TA) onsets and ends and nest box (NA) onsets and ends of the male and female.

Data on phase angle differences in TA (Figure 8) indicate that larger, or more positive, values for the male occurred conspicuously from January through March and from June through mid-August. During these periods the male began activity in the nest box earlier than the female. Shorter, or more negative, Ψ end values for the male occurred from February through May indicating that the male was active in the nest box later than the female. During the remainder of the year, both Ψ ends for the female and male were almost identical.

The number of days in which the male left the nest box before the female in the morning and the number of days the male followed the female in the evening calculated for each month varied from 13–25. The total number of days through the year when the male was known to begin nest box activity first was 114. The female began nest box activity first on 71 days. With respect to the end of activity, the male entered the nest box later on 104 days and the female on 204 days.

The pattern in which the male began activity before and ended after the female did not generally follow the predictions of Aschoff's Rule 3

(Table 2). Full agreement with Rule 3 occurred only in February and July in both types of measured activity, and in March for activity into the nest box. Activity in all other months did not correspond with the predicted model.

DISCUSSION

It is apparent from our data that there are no marked differences in results obtained by the different measurement techniques on either captive or wild squirrels. With regard to the mechanism of entrainment of circadian rhythms by an exogenous Zeitgeber, it appears that some of the major seasonal parameters of the circadian rhythm are not following the predicted models (Aschoff, Wever 1962; Aschoff 1969, Daan and Aschoff 1975).

Activity time (α) as a function of the photoperiod does not show the pronounced S-curve predicted by Daan and Aschoff (1975 page 309—310) as one of the 3 most important generalizations of their study. This is especially noticeable in high latitudes, where activity of squirrels closely follows the extreme length of photoperiod (Fig 5-KUUSAMO). It is important to note that the long and short photoperiods are strong enough to entrain the circadian oscillation at this high latitude.

At Andechs and Cedar Creek, the shortest α occurred in early spring when the length of the photoperiod was increasing (Fig. 5). In most other species, activity time follows the length of photoperiod. Since this did not occour in the squirrels, an additional exogenous factor appears to be influencing the activity time.

The extremely short α that occurred in the wild, as also reported by Bland (1977), differs from α's of squirrels in captivity. This short α is produced by high negative values of Ψ onset and by high positive values of Ψ end, which are nearly similar. This results in the value of midpoint being close to the 0 line, the time of true noon.

A short activity period in grey squirrels has been observed in natural habitats by several authors. Shorten (1954) stated that in short days activity is restricted to foraging. Thompson (1976) and Bland (1977) found a seasonal winter peak and believed that squirrels may have selected the warmest portion of day in which to be active. Wild squirrels at Cedar Creek are under a strong influence of daily temperature changes in January and February, as shown in Table 1. At that time they either spend their resting time in the trees or in nests built of dry leaves. The protection provided by nests and dens is probably necessary to maintain their critical physiological temperature. The European squirrel, *Sciurus vulgaris,* is able to keep the nest temperature 20—30 °C higher than the ambient air temperature after a warming phase of 10—30 minutes (Pulliainen, 1973) in the coldest winter months.

Low temperature could reduce the sensitivity of the circadian system to light and shorten activity time, but not to the extent shown in Figure 5. The activity time for captive squirrels is langer than for wild squirrels, which might be caused by higher temperatures in the nest boxes. One should also consider daily maximum temperature amplitude, temperature values, and direction and velocity of the wind and its chill factor as possible additional modifying factors (exogenous) which might exert a stronger influence than the photoperiod.

Length of activity time in wild squirrels is markedly increased in the second half of August. The end of August through November is the period of nut gathering behavior (Bland 1977; Thompson 1976). We believe it is this behavior that shifts the end of activity beyond sunset. This phenomenon did not occur in captive squirrels.

The strongest Zeitgeber (L:D ratio of 1.0 and shortest twilight) (Hoffman 1969, Wever 1967) occurs at the time of the vernal and autumnal equinox and produces the greatest precision of the circadian rhythm (Aschoff et al. 1972). One can presume that the day-to-day variations in timing of the rhythm of activity will be lowest about the time of the equinoxes, and that the length of activity time will be close to the L:D ratio of 1.0. The grey squirrel rhythm meets these conditions in late February and early March, slightly before the time of the vernal equinox, and in early October, slightly later than the autumnal equinox. These findings fully follow the predicted model (Aschoff 1969, Wever 1962).

The "seasonal rule" formulated by Aschoff (1964) predicts that the summer increase in photoperiod should produce an incerased phase-angle difference in day-active animals. This increase should be enhanced by the length of twilight in mid-summer (Wever, 1967). The activity patterns of grey squirrels *did not follow this rule. Even at the Arctic Circle, a high negative value was* recorded in July and August rather than the expected high positive value. We found a high positive value in feeding activity of caged squirrels, emphasized by a high phase-angle difference between the end of feeding activity and sunset from January through March and slightly in December. From late November through late January the values of Ψ midpoint in wild squirrels were first highly positive but then negative. This extremely large negative value in January was produced mainly by a late onset of activity with respect to sunrise, which corresponded with low morning ambient temperatures (see Table I). Conversely, high ambient temperature was probably responsible for the bimodal activity pattern developed in the summer months in both captive and wild squirrels. These results agree with the findings of Bland (1977).

Circadian Rule 3 (Aschoff and Wever 1962) predicts a longer activity time and a higher positive phase-anglie difference in day-active animals compared to night-active animals. This was supported by data from many species of day-active birds. The circadian rhythm of activity in grey squirrels does not follow this rule.

The circadian oscillation in day-active mammals and its entrainment by photoperiod in natural habitats show irregularities in comparison to birds. Kenagy (1978) found deviations in the circadian system in the day-active squirrel, *Ammospermophilus leucurus,* and the night-active Kangaroo rat, *Dipodomys meriami,* and stated "... the type of seasonal temporal organization cannot be predicted on the basis of the circadian system."

Daily rhythms could be influenced by internal, time-limited, behavior, such as courtship and nesting of birds, food gathering of squirrels or construction of winter houses by muskrats and beaver. These behavioral activities occur under natural conditions, but usually not in captivity. They could be triggered by exogenous stimuli, such as the length of photoperiod or temperature cycles, or both acting together, and/or by social stimuli as described by many authors (see summaries in Regal and Connolly 1980). Activation of an internal behavioral block usually results in feedback by hormonal pathways which may influence the frequency of the circadian oscillation. This is displayed as an abrupt or slow change in phase angles. Study of **these circadian parameters** in wild animals will provide new insights on **the circadian organization of animals** related to their natural habitats.

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OCCURRENCE OF ENDOHELMINTHS IN THREE SPECIES OF CYPRINIDS (ABRAMIS BRAMA, RUTILUS RUTILUS AND SCARDINIUS ERYTHROPHTHALMUS) OF THE MÁCHA LAKE FISHPOND SYSTEM, CZECHOSLOVAKIA

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Received April 16, 1985

Abstract: A comparison, both qualitative and quantitative, of the endohelminth faunae of three species of cyprinids — bream, roach and rudd of the Mácha Lake fishpond system, N. Bohemia, Czechoslovakia (the Elbe R. basin) has been made, being based on examinations of 83 specimens of *Abramis brama* (L.), 71 *Rutilus rutilus* (L.) and 73 *Scardinius erythrophthalmus* (L.), carried out during all seasons. A total of 16 endohelminth species have been recorded in these fishes: 5 Trematoda, 3 Cestoda, 6 Nematoda and 2 Acanthocephala. In addition to data on the prevalence and intensity of infection, the paper describes for some helminth species seasonal changes in the degree of infection and maturation as also the preference to the various size groups of the fish hosts. An epizootological significance of these three species of cyprinids for the distribution and maintainance of populations of some pathogenic parasites of economically important fishes in the locality is stressed.

During long-term observations on endohelminths in the populations of fishes of the Mácha Lake fishpond system, Czechoslovakia, directed above all to the study of the bionomy of helminths of some fish species of economic importance, numerous materials of these parasites were also obtained from three species of subsidiary fishes — from bream *(Abramis brama* (L.)), roach *(Rutilus rutilus* (L)) and rudd *(Scardinius erythrophthalmus* (L)); all these cyprinids are very frequent in this locality (see Moravec, 1979). The material not only made it possible to compare the endohelminth faunae of the three named fish species in the locality under investigation, but it contributed as well to a recognition of some aspects of the biology and ecology of these parasites. In view of the close relationship of these cyprinid species, this being also reflected in a similar composition of their parasite faunae, the results obtained are dealt with in a single paper. This is a continuation of the previous studies devoted to the bionomy of endoparasitic helminths of pike, carp, tench, eel and perch in the same locality (Moravec, 1979, 1984a, b, 1985a, b; Scholz, 1984).

MATERIALS

The Mácha Lake fishpond system has already been characterized in a previous paper (Moravec, 1979). All fishes were collected by electrofishing in the interconnecting canal between the ponds Břehyně and Mácha Lake. The occurrence of endohelminths was studied in bream (*Abramis brama* /L./), length 14—32 cm (age 2—8 years), roach (*Rutilus rutilus* /L./), length 7—26 cm (age 2—8 years), and rudd (*Scardinius erythrophthalmus* /L./), length 5—26 cm (age 2—8 years). Samples of

Table 1. **Survey of *Abramis brama*, *Rutilus rutilus* and *Scardanius erythrophthalmus* examined** from the Mácha Lake fishpond system in the years 1966–1982

Month	*A. brama*		*R. rutilus*		*S. erythrophthalmus*	
	No. of fish examined	Body length in cm (mean, range)	No. of fish examined	Body length in cm (mean, range)	No. of fish examined	Body length in cm (mean, range)
January	10	25 (20–31)	14	16 (12–24)	10	17 (5–24)
February	11	21 (14–29)	14	20 (11–26)	16	18 (11–26)
March	3	24 (23–25)	2	19 (16–22)	14	20 (13–24)
April	13	25 (23–28)	21	14 (7–18)	4	16 (12–18)
May	30	22 (20–28)	6	17 (13–19)	3	20 (20–21)
June	4	24 (20–26)	4	17 (14–21)	1	12 (12)
July	0	—	1	15 (15)	0	—
August	1	22 (22)	3	15 (11–19)	1	14 (14)
September	2	24 (21–27)	1	20 (20)	0	—
October	1	32 (32)	0	—	1	19 (19)
November	5	22 (20–24)	4	18 (12–23)	17	16 (7–26)
December	3	23 (22–25)	1	24 (24)	6	20 (19–24)
Total	83	23 (14–32)	71	16 (7–26)	73	18 (5–26)

fishes were taken irregularly in various seasons in the years 1966–67, 1975–77, and 1981–82; a total of 83 specimens of bream, 71 of roach and 73 of rudd were examined from this locality. A survey of fishes examined in different months of a year is provided in Table 1. Additional 1180 fish specimens of 13 other species coming from the same locality were also examined (see Moravec, 1984). Besides endohelminths, some ectoparasites were occasionally recorded from bream, roach and rudd too, these included: in *A. brama: Dactylogyrus zandti* Bychowski, 1933, *Gyrodactylus vimbi* Schulman, 1953, *G. cyprini* Diarova, 1964, *Piscicola geometra* (Linnaeus, 1761) *Ergasilus sieboldi* Nordmann, 1832 and *Argulus foliaceus* (Linnaeus, 1758); in *R. rutilus: Dactylogyrus crucifer* Wegener, 1858, *D. similis* Wegener, 1909, *Piscicola geometra* and *Argulus foliaceus;* in *S. erythrophthalmus: Dactylogyrus micracanthus* Nybelin, 1937, *Gyrodactylus decorus* Malmberg, 1956, *Piscicola geometra, Argulus foliaceus* and *Anodonta* sp. glochidiae.*)

SURVEY OF ENDOPARASITIC HELMINTHS

Trematoda

1. *Phyllodistomum elongatum* Nybelin, 1926 juv.

Juvenile specimens (body length about 1 mm) of this species were found in the urinary bladder of only two *S. erythrophthalmus* (length 17 and 24 cm) examined in March and April (overall prevalence 2.7 %, intensity 1 and 3 specimens per fish). Although *Ph. elongatum* has been reported in the literature from many species of cyprinids, it was not found neither in bream nor in rudd of this locality. Adult trematodes of this species were infrequently found here only in *Tinca tinca* (prevalence 5.1 %, intensity 1–30) and juvenile specimens

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*) Monogeneans were identified by Dr. R. Ergens, Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, to whom my thanks are due.

also in *Cyprinus carpio* (prevalence 3.2 %, intensity 1—22) (Moravec, 1984a, 1985a). In the Mácha Lake pond system, Moravec (1985a) found the mussel *Anodonta cygnea* to serve as the intermediate host of *Ph. elongatum*.

2. *Asymphylodora tincae* (Modeer, 1790) juv.

A single non-gravid specimen of *A. tincae* was found in the gut of one *R. rutilus* (body length 14 cm) (overall prevalence 1.4 %), caught in April. It is evidently an accidental finding, because *A. tincae* is a specific parasite of *Tinca tinca*, in which it is very frequent in this locality (prevalence 69 %, intensity 1—420) (Moravec, 1985a). Probably it cannot attain gravidity in *R. rutilus*, an unsuitable host, this being also evidenced by the present record. Moravec (1985a) found the prosobranchiate snail *Bithynia tentaculata* to serve as an intermediate host for *A. tincae* in the Mácha Lake pond system.

3. *Diplostomum spathaceum* (Rudolphi, 1819) metacercariae

It is obvious from Table 2 that *D. spathaceum* occurs in fishes of the Mácha Lake system throughout the year; however, the limited material does not make it possible to compare data from individual months. In the monthly samples when at least 10 fishes were examined the prevalence in bream and roach ranged within 73—100 % and 21—92 %, respectively. But Chubb (1979) reports that if incidence and intensity of infections of *D. spathaceum* metacercariae in fishes are high, seasonal patterns in the life cycle of the trematode are masked. The length of life of the metacercariae, exceeding 3 1/2 years in bream and roach according to Shigin (1964), also obscures the seasonal patterns. Burrough (1978) mentions that some earlier population studies have shown that *D. spathaceum* does not vary seasonally, except in terms of periods of infection, resulting often in seasonal increases in intensity. Since this parasite may overwinter in snails, infections of fishes by cercariae occur from spring through to autumn (Burrough, 1978).

Distinct differences exist, however, in the degree of infection among the individual size groups of bream and roach. Fig. 2A indicates a linear increase in prevalence with the body size of roach, attaining its maximum in largest fish; the mean intensity reaches its peak in fish 19—22 cm long, falling suddenly in the group of largest roach. Also in bream (Fig. 1A) the prevalence attains its maximum in largest specimens, while the mean intensity somewhat decreases in fish 20.5—23.5 cm long, increasing again in larger fish. A long life span in the fish host and a repeated exposure to cercariae are probably the factors responsible for the tendency to accumulate parasites throughout life, resulting often in parasitic cataract in host fishes (Burrough, 1978). However, the decline in mean intensity in the largest roach, observed also by Burrough (1978) in England, which is contrary to the general trend, may be a result of selective mortality of the most heavily parasitized individuals (Burrough, 1978). However, this decline may be also connected with a more pronounced resistence of the largest fish against new invasions and with a limited length of life of metacercariae (see Moravec, 1984a). A decline in both prevalence and mean intensity of *D. spathaceum* infection in largest fish specimens was observed in carp of this locality by Moravec (1984a). A considerable drop in prevalence in oldest fish was also observed by Titova (1957) in *Abramis brama* from Lake Ubinsk in Siberia.

Table 2. Survey of infection of *Abramis brama*, *Rutilus rutilus* and *Scardinius erythrophthalmus* by the metacercariae of *Diplostomum spathaceum*

Month	*Abramis brama*			*Rutilus rutilus*			*Scardinius erythrophthalmus*		
	No. of fish examined	No. of fish infected (prevalence)	Intensity (mean, range)	No. of fish examined	No. of fish infected (prevalence)	Intensity (mean, range)	No. of fish examined	No. of fish infected (prevalence)	Intensity (mean, range)
January	10	8 (80%)	19 (5–49)	14	3 (21%)	12 (1–32)	10	0	—
February	11	8 (73%)	18 (6–54)	14	13 (92%)	14 (7–42)	16	0	—
March	3	2	33 (28–37)	2	0	—	14	0	—
April	13	13 (100%)	25 (8–62)	21	9 (43%)	16 (3–45)	4	1	1 (1)
May	30	30 (100%)	22 (2–120)	6	6	15 (2–49)	3	1	1 (1)
June	4	4	13 (5–29)	4	4	3 (1–8)	1	0	—
July	0	—	—	1	1	9 (9)	0	—	—
August	1	1	40 (40)	3	1	102 (102)	1	0	—
September	2	2	40 (28–52)	1	1	210 (210)	0	—	—
October	1	1	14 (14)	0	—	—	1	0	—
November	5	2	52 (15–89)	4	1	4 (4)	17	0	—
December	3	3	59 (31–105)	1	1	16 (16)	6	0	—
Total	83	74 (89%)	25 (2–120)	71	40 (56%)	20 (1–210)	73	2 (3%)	1 (1)

In addition to bream, roach and rudd, many other fish species, mainly cyprinids, were parasitized by this pathogenic helminth in the locality investigated: *Cyprinus carpio* (prevalence 33 %, intensity 1—19), *Carassius carassius* (prevalence 25 % ,intensity 1), *Gobio gobio* (prevalence 87.5 %, intensity 2—30), *Leuciscus cephalus* (1 specimen found in 1 fish examined), *Leucaspius delineatus* (1 specimen in 1 fish examined), *Tinca tinca* (prevalence 5.3 %, intensity 1—3), *Gymnocephalus cernuus* (prevalence 50 %, intensity 1—5) and *Esox lucius* (prevalence 1.4 %, intensity 1—12). Bream *(A. brama)* seems to be the principle host of *D. spathaceum* metacercariae in this locality.

The main definitive hosts of *D. spathaceum* in Czechoslovakia are gulls *(Larus ridibundus)*, while snails of the genus *Lymnaea* are reported as its first intermediate hosts (see Vojtek, 1974, 1981).

4. *Tylodelphys clavata* (Nordmann, 1832) metacercariae

The metacercariae of *T. clavata*, localized in the humour of the eye, were recorded from 38 % of roach examined, the intensity being 1—200 (average 34) metacercariae per fish; it occurred sporadically in bream and rudd: prevalence in *S. erythrophthalmus* 10 %, intensity 1—12 (average 3) metacercariae per fish; prevalence in *A. brama* 6 %, intensity 1—4 (average 2) trematodes per fish. The findings from these cyprinids were recorded in all seasons (all months except October), but the limited material did not enable to evaluate the dynamics of infections. According to Scholz (1984) tracing seasonal changes of *T. clavata* in the population of perch in this locality, the prevalence in this host attained here its maximum in summer and early autumn, whereas the mean intensity was highest at the end of spring and during summer. After Kennedy and Burrough (1977) and Burrough (1978) *T. clavata* has, in contrast to *D. spathaceum*, an annual life span in the fish host.

Infections of *T. clavata* were found in roach 11—24 cm long, in rudd 6—8 cm long, and in bream 20—25 cm long. Fig. 2B shows a distinct dependence of *T. clavata* infections on the body length of roach: while prevalence attained its maximum in fish with length 15—18.5 cm, its values suddenly decreasing in larger roach, the mean intensity gradually increased with the size of fish, reaching its maximum in the group of largest roach. A marked increase of the values of the mean intensity of *T. clavata* with the increasing size of host fishes was also recorded by Scholz (1984) in perch of the Mácha Lake pond system and by Wootten (1974) and Kennedy and Burrough (1978) in some water reservoirs in Britain; also Moravec (1979), following dependence of *T. clavata* infections on the body size of pike in the Mácha Lake pond system, observed a sudden increase of mean intensity in pike 40—50 cm long, but it again dropped in the group of largest pike. The considerable increase of the values of mean intensity in *T. clavata* is often explained by a gradual accumulation of metacercariae in the body of the host fish or by its higher susceptibility to infection with increased size and surface area, but this phenomenon is apparently determined by many other factors (see Burrough, 1978). The decline of *T. clavata* prevalence found in larger roach might be associated as well, to a certain extent, with the mortality of heavily infected fish; it is known that massive cercarial penetrations are capable of causing host death (see Burrough, 1978).

In the locality investigated, in addition to roach, rudd and bream, *T. clavata* was also recorded from *Perca fluviatilis* (prevalence 80 %, intensity 1—244), *Gymnocephalus cernuus* (prevalence 67 %, intensity 1–26), *Esox lucius* (prevalence 26 %, intensity 1–150), and *Leuciscus cephalus* (63 metacercariae found in 1 fish examined) (Moravec, 1979; Moravec and Scholz, 1984, Scholz, 1984).

Definitive hosts of T. clavata are grebes, mainly *Podiceps cristatus*, and some other waterbirds, its first intermediate host being the snail *Lymnaea ovata* (Niewiadomska, 1960).

5. *Cotylurus pileatus* (Rudolphi, 1802) metacercariae

In the only rudd (body length 13 cm), examined in November 1981 (prevalence 1.4 %), 32 metacercariae of this parasite, encysted in whitish, oval cysts localized in the abdominal cavity of the fish were found. It was also recorded here from carp (see Moravec, 1984a). The development of this species is not sufficiently known. Its definitive hosts are fish-eating birds of the family Laridae, in Czechoslovakia *Larus ridibundus* (see Vojtek, 1974, 1981).

Cestoda

6. *Caryophyllaeus laticeps* (Pallas, 1781)

In the given locality, this intestinal parasite was recorded only from *A. brama*, in which the overall prevalence was 17 %, intensity 1–76 (average 8) cestodes per fish; it exhibits a considerably overdispersed distribution in the local population of bream. All the finds of this cestode species were from the period January–June, the highest infection of bream being in April (prevalence: January 10 % (intensity 1), February 0 %, March 0 %, April 30 % (intensity 1–76), May 27 % (intensity 1–26), June 25 % (intensity 4)). It appears, in view of the relatively small number of bream examined and an infrequent occurrence of *C. laticeps* in these fish hosts, that the seasonal dynamics of *C. laticeps* occurrence in this locality is similar to that found in most other localities. The parasite is usually present in fishes throughout the year, most frequent being, however, in the spring and summer, whereas the numbers of these parasites in fishes are strongly reduced in the autumn and winter (see e. g. Izyumova, 1960; Komarova, 1964; Lyubarskaya, 1970, Anderson, 1974; Wierzbicka, 1978).

As it is obvious from Fig. 1B, *C. laticeps* infections show a considerable dependence on the size (age) of host fish. The smallest fish harbouring this parasite measured 21–22 cm (age 4 years). The values of prevalence and mean intensity increased with the size of host fish, reaching maximum in the group of the largest fish (body length exceeding 26 cm, age 5^+ and more); in the latter group, also a marked increase of mean intensity, in comparison with foregoing size groups, is visible. These observations are in accordance with those by Anderson (1974) who studied in detail the population dynamics of *C. laticeps* in *A. brama* in a gravel pit near Dagenham, Essex, England; he found that infections of this parasite were related to the age structure of the fish population, because the various age groups of fish had markedly different feeding habits; according to him, the younger fish, the 1^+, 2^+ and 3^+ fish, fed mainly on planktonic crustaceans except during the spring months when they fed on bottom dwelling organisms, while older mature fish fed primarily on bottom dwelling invertebrates including tubificids, chironomid larvae and molluscs; the 0+ age group fed mainly on phytoplankton. Since the source of *C. laticeps* are tubificids, it explains why this parasite was not recorded in bream younger than four years in the Mácha Lake pond system.

In the present material, samples of *C. laticeps* from all the months when this parasite was recorded (January, April, May, June) contained gravid spe-

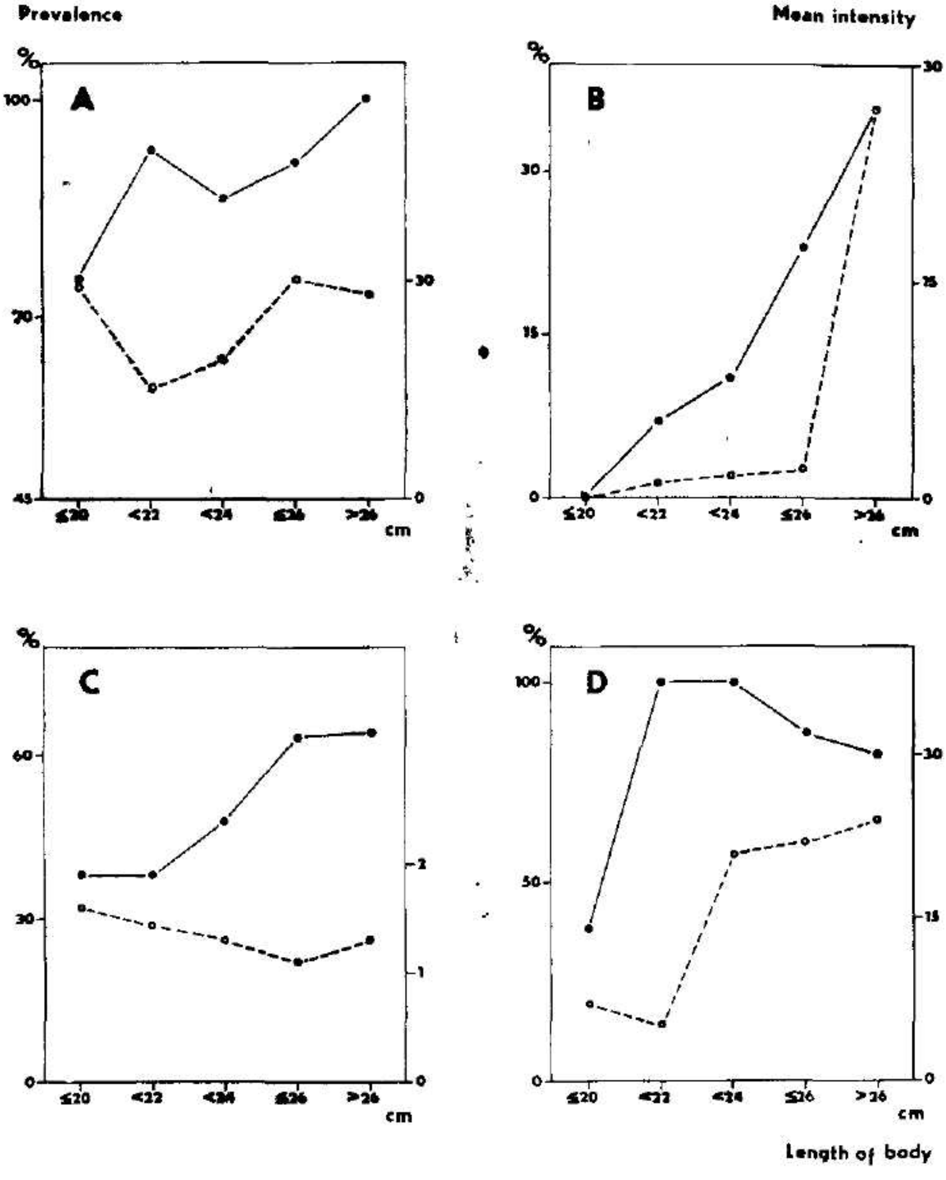

Fig. 1. Relationship of prevalence (———) and mean intensity of infection (– – – – –) to body length of *A. brama:* A — *Diplostomum spathaceum,* B — *Caryophyllaeus laticeps,* C — *Ligula intestinalis,* D — *Philometra ovata.*

cimens in addition to small, non-gravid ones. Kennedy (1968) found gravid *C. laticeps* in *Leuciscus leuciscus* of the River Avon, England, from January to July and Halvorsen (1972) in *A. brama* of the R. Glomma, Norway, from May to August. But Anderson (1974) found in *A. brama* in England that gravid *C. laticeps* were present in fish all months; however, the proportion of mature, egg-producing parasites varied seasonally, the largest proportion arose in the summer months. The warm water temperatures probably act as a stimulus to reproductive development and hence egg production (see Chubb, 1982).

The life cycle of *C. laticeps* involves an oligochaete intermediate host *(Tubifex tubifex, T. barbatus, Limnodrilus claparedeanus)* (see Bykhovskaya-Pavlovskaya et al., 1962).

7. *Caryophyllaeides fennica* (Schneider, 1902)

This cestode was found to be a rare intestinal parasite of roach and rudd in the locality in question; it was not recorded here from other cyprinids. The overall prevalence in *R. rutilus* was 5.6 %, intensity 1–2 cestodes per fish, that in *S. erythrophthalmus* 2.9 %, intensity 1–2; the body length of infected fishes was 11–19 cm and 20–21 cm in roach and rudd, respectively. The finds were from January, April, May, August and November, gravid specimens with eggs were present in August in roach and in May and November in rudd. The present material is very limited, not making it possible to evaluate a seasonal dynamics in the occurrence and maturation of *C. fennica*. According to Kažić (1970) and Alvarez Pellitero et al. (1978), *C. fennica* exhibits in *Rutilus rubilio* at Lake Skadar, Yugoslavia, and in cyprinids of the rivers in the Duero and Sil basins, Spain, a well-defined annual cycle of one generation per annum. According to Chubb (1982), *C. fennica* occurred in *R. rutilus* at Llyn Tegid, Wales, in all months of the year except January; gravid specimens also occurred in all months except January and August.

According to Bykhovskaya-Pavlovskaya et al. (1962), a presumed intermediate host of *C. fennica* is the oligochaete *Stylaria lacustris*.

8. *Ligula intestinalis* (Linnaeus, 1758) plerocercoids

Although all the three studied species of fish are reported in Czechoslovakia as the hosts of the plerocercoids of *L. intestinalis*, this pathogenic parasite of the abdominal cavity of fish was recorded only in bream *(A. brama)* in the Mácha Lake pond system. According to Dubinina (1980), this fish is the principle second intermediate host of *L. intestinalis* in Europe. In the present material, the overall prevalence in bream was 49 %, intensity 1–5 (average 1) plerocercoids per fish. The finds of *L. intestinalis* were from nearly all months of a year, except for July when no bream was examined, and October (only 1 fish examined).

Fig. 1C shows a distinct dependence of infections on the body size of fish, mainly if prevalence is considered; the values of prevalence gradually increased from 38 % in the group of the smallest bream (body length below 20 cm, age 3^+) up to 64 % in the largest bream (length 27–31 cm, age 5^+–7^+); on the other hand, the intensity has a somewhat decreasing tendency, but these differences are negligible, this being due to the fact that the absolute majority of fish of all size groups harboured one, less often two plerocercoids. Also Žitňan (1964), studying the age dynamics of *L. intestinalis* plerocercoids in

Table 3. Survey of infection of *Abramis brama* by *Ligula intestinalis*, *Philometra ovata* and *Raphidascaris acus*

Month	*Ligula intestinalis* larv.			*Philometra ovata*		*Raphidascaris acus* larv.	
	No. of bream examined	No. of bream infected (prevalence)	Intensity (mean, range)	No. of bream infected (prevalence)	Intensity (mean, range)	No. of bream infected (prevalence)	Intensity (mean, range)
January	10	9 (90%)	1 (1–2)	5 (50%)	19 (2–46)	2 (20%)	3 (2–3)
February	11	7 (64%)	1 (1)	7 (64%)	22 (3–92)	3 (27%)	2 (1–3)
March	3	3	2 (1–2)	3	27 (2–41)	0	—
April	13	10 (76%)	1 (1)	13 (100%)	22 (1–83)	7 (53%)	221 (1–1500)
May	30	2 (7%)	2 (2)	30 (100%)	10 (1–98)	9 (30%)	4 (1–10)
June	4	1	2 (2)	4	12 (2–24)	0	—
July	0	—	—	—	—	—	—
August	1	1	5 (5)	1	270 (270)	0	—
September	2	1	1 (1)	2	16 (3–29)	1	3 (3)
October	1	0	—	0	—	0	—
November	5	4	1 (1–2)	5	7 (2–18)	1	1 (1)
December	3	3	1 (1)	3	14 (7–18)	0	—
Total	83	)41 (49%)	(1–5)	73 (88%)	18 (1–270)	23 (28%)	69 (1–1500)

R. rutilus from the old sand-pit near Košice in eastern Slovakia, found a distinct increase in the prevalence of this parasite with the fish age when new infections were first acquired by fish in the second year of their life. Apparently, the increase of *L. intestinalis* infections with increasing size (age) of host fish is correlated with the amount of eaten plankton and the life span of larval cestodes in the body of fish.

The life cycle of *L. intestinalis* involves two intermediate hosts; the first one are various copepods *(Cyclops, Acanthocyclops, Eucyclops, Diaptomus)* in the haemocoel of which the larva attains the stage of procercoid. while the second one are different species of cyprinids in which a plerocercoid develops. Adult cestodes are the intestinal parasites of many species of piscivorous birds (see Bykhovskaya-Pavlovskaya et al., 1962; Dubinina, 1980).

Nematoda

9. *Skrjabillanus scardinii* (Molnár, 1966)

This specific tissue parasite of rudd was found rather often in *S. erythrophthalmus* of this locality (overall prevalence 60 %, intensity 1–14 (average 3) nematodes per fish). The parasites were localized most frequently under the serose cover of posterior part of the swimbladder (both males and gravid females); female nematodes, including gravid ones, were also found in the abdominal cavity, mesonephros, urinary bladder, orbits and in the humour of the eye; no differences in localization were found among differently advanced female nematodes. The males of *S. scardinii* were less common than females, the ratio of both sexes being approximately 1:4.

S. scardinii was recorded in the period from October until May, when the prevalence ranged within 41–78 % in the monthly samples including at least

10 rudd specimens; gravid females with larvae in their uteri were found in all the months when this parasite was recorded. *S. scardinii* was not found from June to September, this being probably due to the fact that only two fish specimens were examined in this period. But it is possible that the seasonal

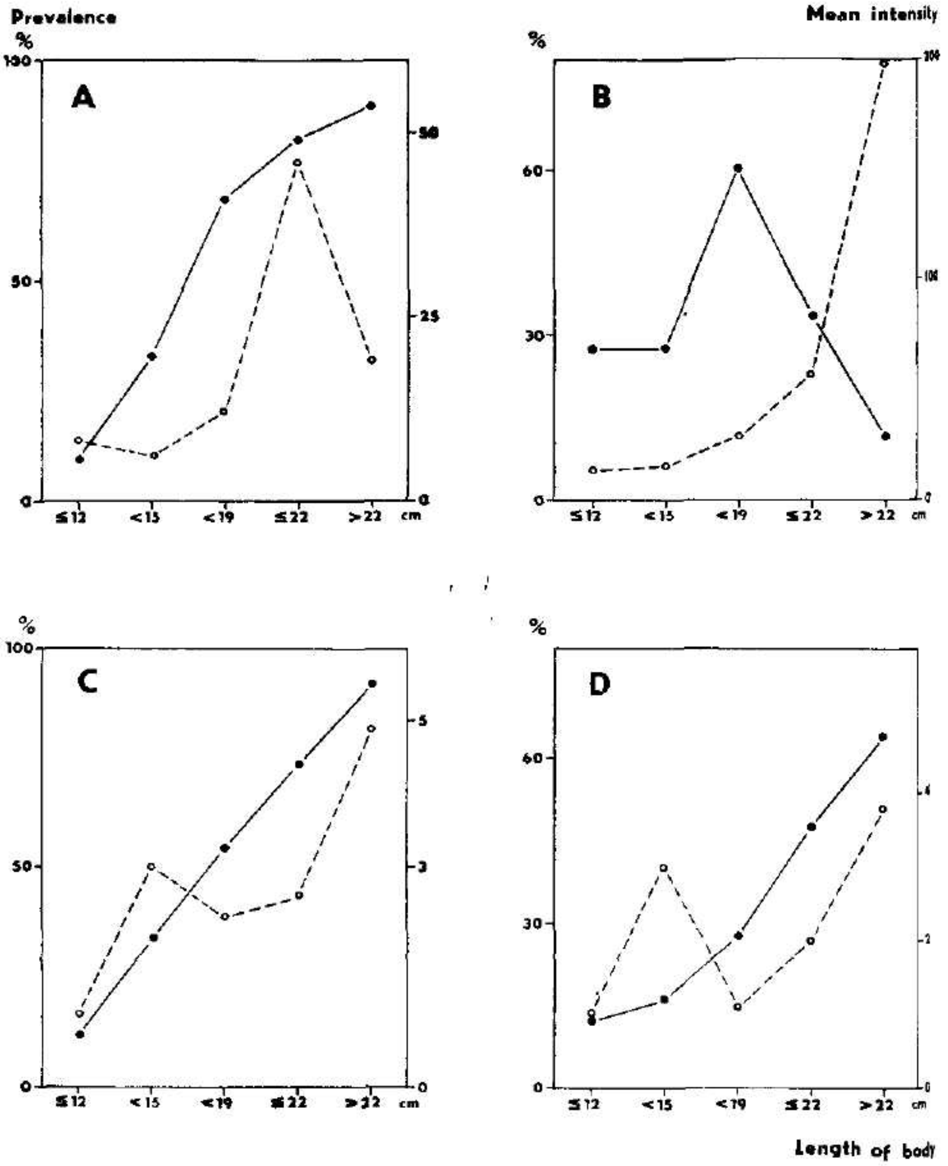

Fig. 2. Relationship of prevalence (———) and mean intensity of infection (– – – – –) to body length of host fish: A – *Diplostomum spathaceum* in *R. rutilus*, B – *Tylodelphys clavata* in *R. rutilus*, C – *Skrjabillanus scardinii* in *S. erythrophthalmus*, D – *Molnaria intestinalis* in *S. erythrophthalmus*.

Table 4. Survey of infection of *Scardinius erythrophthalmus* by *Skrjabillanus scardinii*, *Molnaria intestinalis* and *Raphidascaris acus*

Month	No. of rudd examined	*Skrjabillanus scardinii*		*Molnaria intestinalis*		*Raphidascaris acus* larv.	
		No. of rudd infected	Intensity (mean, range)	No. of rudd infected	Intensity (mean, range)	No. of rudd infected	**Intensity (mean, range)**
January	10	5 (50%)	3 (1–5)	6 (60%)	3 (1–11)	1 (10%)	1 (1)
February	16	9 (56%)	4 (1–8)	6 (37%)	1 (1–2)	2 (12%)	1 (1)
March	14	11 (78%)	4 (1–14)	6 (43%)	2 (1–2)	2 (14%)	2 (1–2)
April	4	1	1 (1)	0	—	1	2 (2)
May	3	3	2 (1–5)	0	—	0	—
June	1	1	1 (1)	0	—	0	—
July	0	—	—	—	—	—	—
August	1	0	—	0	—	1	1 (1)
September	0	—	—	—	—	—	—
October	1	1	2 (2)	0	—	0	—
November	17	7 (41%)	3 (1–5)	6 (35%)	3 (1–10)	1 (6%)	1 (1)
December	6	6	4 (1–13)	3	3 (2–4)	1	1 (1)
Total	73	44 (60%)	3 (1–14)	27 (37%)	2 (1–11)	9 (12%)	1 (1–2)

cycle of maturation of *S. scardinii* is similar in this locality to that of the related species *S. tincae* from tench; in the latter, Moravec (1985a) also found the presence of gravid females only from October until May of the next year, whereas the nematodes were absent from tench in June and July and only very young nematodes were present in August and September. If it were so, it would mean that *S. scardinii* has a pronounced annual cycle in maturation when new infections occur mainly in late summer and in autumn. Since both these species have the same intermediate host here *(Argulus foliaceus)* and the conditions of the outer environment are also much the same, this pattern of the seasonal maturation of *S. scardinii* is very probable. The seasonal dynamics of the occurrence of *S. scardinii* has hitherto been studied only by Tikhomirova (1975a) in rudd of the Agrakhan Bay in the south of the European part of the USSR. She found a maximum infestation of fish by this parasite in summer, but the author does not mention the state of maturity of the nematodes found.

It is obvious from Fig. 2C that *S. scardinii* infections exhibit a distinct dependence on the body size (age) of host fish. The length of the smallest rudd harbouring this parasite was 13 cm (age 4 years); the prevalence and mean intensity increased with fish size, reaching maximum values in the largest fish specimens. Similar dependence was found in this species by Tikhomirova (1975a); the author explains it by the gradually increasing contacts between host fish and branchiurid intermediate hosts.

The life cycle of *S. scardinii* involves an intermediate host, a branchiurid of the genus *Argulus* (Tikhomirova, 1975b). Since only *Argulus foliaceus* occurs in fishes of the Mácha Lake fishpond system, it can be considered to be the only intermediate host of *S. scardinii* in here.

10. *Molnaria intestinalis* (Dogiel et Bychowsky, 1934)

This species has been reported in the literature mostly as ***M. erythrophthalmi*** (Molnár, 1966); only recently Moravec (1983) has synonymized the latter with *M. intestinalis* (Dogiel et Bychowski, 1934).

Like the foregoing species, also this skrjabillanid nematode was found exclusively in rudd in the Mácha Lake pond system; the overall prevalence was 37 %, intensity 1—11 (average 2) nematodes per fish. The parasites were mostly localized in the abdominal cavity (males and females), but also under the serosa of the swimbladder (males and females), in the intestinal lumen (males), mesonephros (male) and urinary bladder (male); no differences were found among differently advanced nematodes. The males of *M. intestinalis* were less frequent than females, the ratio of both sexes being approximately 1:2.

M. intestinalis was recorded only in the cool period from November until March of the following year with the prevalence ranging within 35—60 %, gravid females with larvae in their uteri were present in all these months. Although only a small number of rudd was examined in the spring and summer, it is probable that *M. intestinalis* has, in this locality, a similar pattern of the seasonal cycle of maturation as the two related skrjabillanid species, *S. tincae* and *S. scardinii*, in which gravid females occur in fish hosts only from the autumn until the spring; all the three nematode species have here a common intermediate host, *Argulus foliaceus*, the population dynamics of which is probably applied, beside other factors, in producing seasonal cycles in these parasites. According to Tikhomirova (1975a), both the prevalence and intensity of *M. intestinalis* in the rudd of the Agrakhan Bay in the USSR reached their maximum in summer months, while the intensity decreased in winter months as a result of a disappearing of nematodes of the old generation; juvenile forms of the nematode prevailed in samples from May to June.

It is obvious from Fig. 2D that the values of *M. intestinalis* prevalence have a linear increase with the increasing size of host fish; despite certain fluctuation, also the mean intensity shows an increasing tendency, reaching its maximum value, like the prevalence, in the group of largest fish. Also Tikhomirova (1975a) observed an increasing infestation of fish by *M. intestinalis* with the increasing size of their body; like in *S. scardinii*, the author explains it by the gradually increasing contacts between fish and branchiurid intermediate hosts.

According to Tikhomirova (1975b), crustaceans of the genus *Argulus* (Branchiura) serve as the intermediate hosts of *M. intestinalis;* they acquire infection by sucking on invaded host fish. In their haemocoel an invasive larva develops that, during repeated sucking of this ectoparasite on fish, penetrates through the crustacean's mouth organs into the skin of fish; further development of the parasite takes place after its migration into internal organs of the fish.

11. *Philometra ovata* (Zeder, 1803)

Beside *Diplostomum spathaceum, Ph. ovata* is the most frequent parasite of *A. brama* in the locality, the overall prevalence being 88 %, intensity 1—270 (average 18) nematodes per fish. It was recorded less often in *R. rutilus*, in which the overall prevalence was only 7 % and intensity 2—5 (average 3) nematodes. Besides *Ph. ovata* males and young females localized on the swimbladder (under the serosa of its posterior sac), also developing subgravid and gravid females in the abdominal cavity were found in both above mentioned fish host species; these moved freely among the viscera of fish, penetrating rarely into ovaries; smaller females were rarely found as well in the lumen of intestine. Accordingly, both the fish species can be considered definitive hosts of *Ph. ovata*. Also Molnár (1966a, b, 1969) found *A. brama* and more rarely *R. rutilus* to be the only definitive hosts of this parasite at Lake Balaton in Hungary. In the literature, also some other species of cyprinids have been reported as the definitive hosts of *Ph. ovata*, but *A. brama* appears to be the principle host for this nematode in which the prevalence is often found to reach 100 %. In the Mácha Lake pond system this species was recorded, in addition to bream and roach, also in 14 % of *Tinca tinca* (intensity 1—36) and in the only *Leuciscus cephalus* examined (intensity 1), but only young females,

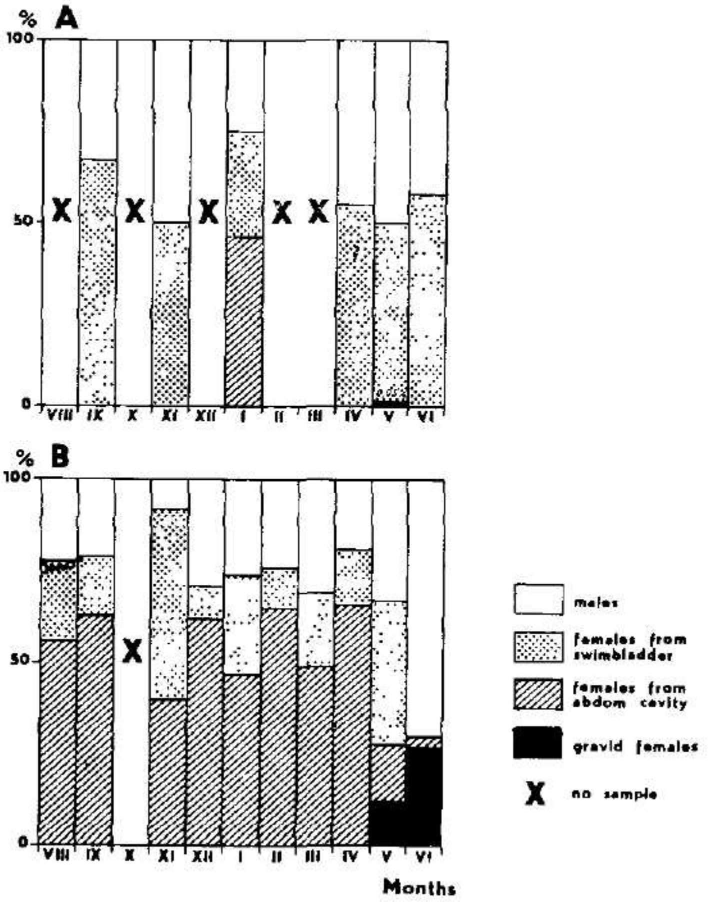

Fig. 3 Monthly changes in state of *Philometra ovata* maturity in *A. brama* of the Mácha Lake pond system during the year. The data are expressed as percentages of the total number of *Ph. ovata* found per month. A — ligulid-free bream, B — ligulid-infected bream.

males and larvae on the swimbladder were found, no developing females in the abdominal cavity (see Moravec, 1978a, 1985a); these fishes can be considered as only paradefinitive hosts (Moravec, 1985a).

Molnár (1966b, 1969) has reported that in *A. brama* the young fertilized females of *Ph. ovata* can migrate into the abdominal cavity of the host fish to complete their development there only when the fish is also infected by the plerocercoids of *Ligula intestinalis* or *Digramma interrupta;* on the other hand, in fish free from ligulid plerocercoids the migration of females into the abdominal cavity does not take place and only young females (not attaining 3 mm) and males occur on the swimbladder of such fish. A similar dependence was observed in bream of the Mácha Lake system, although its validity did not proved to be absolute. *Ph. ovata* was found here in 90 % of ligulid-infected *A. brama*; 4 % of bream examined were infected by *Ligula* alone, while 45 % of the bream harbouring *Ph. ovata* were free from *Ligula*. It can be seen from Fig. 3 that the *Ph. ovata* females developing in the abdominal cavity constituted a considerable proportion in all samples of ligulid-infected bream, whereas young females and males on the swimbladder were almost the only representatives of this parasite species in ligulid-free fish; the presence of several subgravid females was observed only in one ligulid-free bream in January and one gravid female of *Ph. ovata* was found in the abdominal cavity of one bream, not harbouring *L. intestinalis,* in May. In contrast, *Ligula*-infected bream harboured usually up to several tens of subgravid or gravid females of *Ph. ovata* in their abdominal cavity. According to Molnár (1969), the plerocercoids might either improve the conditions for growth of *Ph. ovata* or reduce the host resistence to this parasite.

As to *R. rutilus,* Molnár (1969) found at Lake Balaton that some 2.5 % of *Ligula*-free fish harboured fully developed or developing, abdominally localized females of *Ph. ovata,* whereas these were present in 100 % of roach with ligulosis. In the Mácha Lake system roach were not found to be infected by *L. intestinalis* at all. Out of the 5 roach specimens infected by *Ph. ovata,* subgravid females were found in the abdominal cavity in 3 of them; the females were 23—25 mm long and their uteri contained eggs.

Molnár (1966b) has indicated that *Ph. ovata* first appears in fishes two years old. In the present material, the smallest bream harbouring this parasite measured 20 cm (age 3^+) and the smallest roach 14 cm (age 3^+). Fig. 1D shows a distinct relation of infections to the body size of host fish; while the intensity increased with the size of fish, attaining the highest value in largest bream, the prevalence first suddenly increased, reaching its maximum in bream 20.5—23.5 cm long, but there was a certain decline in larger bream. The decreasing prevalence in large bream may be associated with a decreased proportion of plankton in their diet. Increasing infections of *Ph. ovata* with host's growth were also observed by Moravec (1985a) in tench in the same locality.

The life cycle of this parasite was described in detail by Molnár (1966b) at Lake Balaton, Hungary, who had found a distinct annual cycle in its maturation; gravid females containing larvae occurred in fish only from the second half of May until the beginning of June. In the present material from the Mácha Lake pond system this cycle was followed in ligulid-infected bream and the timing of the events in the cycle were found to be similar to those described by Molnár (1966b).

Gravid females of *Ph. ovata* with motile larvae in their uteri were present in fish here only from the second half of May until mid-June (see Fig. 3) (only in one case a single gravid female was found in the first days of July 1977 in the bream that is not included in the present material). In this period the larvae are released into the water, because besides gravid females, also emptied remnants of their bodies were found in the abdominal cavity of fish in mid-June.

According to experimental data by Moravec (1980), the development of larvae in copepod intermediate hosts lasts approximately one week at summer temperatures, so that new infections may occur in fish as early as in June. After acquiring infection by a suitable definitive host, the development of these nematodes continues apparently very quickly on the swimbladder; having finished a copulation, young fertilized females migrate from the swimbladder into the abdominal cavity of fish. A rapid nematode development during this period is documented by the find of a female 5.3 mm long as early as in the second half of June. But it is probable that this development takes place mostly in July; however, no bream were examined in this month.

Mature females, attaining the length 2.0—2.9 mm, exceptionally up to 4.0 mm, and males, length 2.0—3.2 mm, were present only on the swimbladder. Further development of fertilized females takes place after their migration into the body cavity of fish, whereas males and a part of young females remain on the swimbladder without any development; these forms were present in fish throughout the year and they probably survived up to the next year. In ligulid-free bream, the migration of females and their further development in the abdominal cavity occurs only exceptionally; so *Ph. ovata* can complete its development in most cases only in ligulid-infected bream.

The length of most *Ph. ovata* females from the abdominal cavity of bream obtained in August was 17—20 mm, width 0.38—0.50 mm. These females were whitish, with uterus containing numerous eggs 0.012—0.020 mm in diameter; the uterus occupies a considerable part of their body, pressing gradually the intestine to the body wall. Their mouth papillae and lateral caudal projections were already visible and the rudimentary vulva was still present, appearing like a minute, forwardly bent spike. Similar females were found in September.

During November almost all females attained the length of 25—30 mm and width up to 0.54 mm; in the following two months (December, January) their development was arrested apparently due to low temperatures, so that these did not differ from females found in November. In February and March the nematodes measured already 30—40 mm, with width up to 0.78 mm, and their colour was gradually growing from white to red. In April the length of these females was already 40—50 mm, width up to 0.88 mm, their uterus occupying almost the whole body contained numerous eggs.

In mid-May approximately one half of nematodes in the abdominal cavity of bream was constituted by advanced subgravid females, with body length about 60 mm, with eggs in ureri, whereas the second half was represented by gravid females 64—80 mm long and 1.0—1.2 mm wide, with motile larvae in their uteri. In June, besides gravid females, also empty remnants of their bodies were found; but at the same time, also one juvenile female of the next generation was already found. Single developing females, whose bodies were substantially smaller (6—15 mm) than that of other females in the corresponding month, occurred in the abdominal cavity in samples from all months; also males and young females on the swimbladder were present all the year round.

Hence it is obvious that *Ph. ovata* exhibits a pronounced annual cycle of maturation in this locality.

The development of *Ph. ovata* involves one intermediate host, various species of cyclopoid copepods *(Cyclops, Macrocyclops, Acanthocyclops)* (Molnár, 1966b; Moravec, 1980).

12. *Philometra obturans* (Prenant, 1886) larvae

Larvae of *Ph. obturans* were found in one case in the humour of the eye of rudd *(S. erythrophthalmus)* (body length 24 cm) examined in March 1976 (see also Moravec and Dyková, 1978); prevalence was 1.3 %, intensity 3 larvae per fish. Moravec and Dyková (1978) found these larvae also in *Perca fluviatilis* in this locality, in which irrespective of the season the prevalence was 10.4 %, intensity 1—7 larvae per fish. According to the later data given by Scholz (1984) ,these larvae occurred in 19 % of perch of this locality, the intensity being 1—38 (average 4) larvae per fish.

The fishes, in which *Ph. obturans* larvae occur, serve as paratenic hosts for this parasite, being an important source of infection for the definitive host, pike (Moravec and Dyková, 1978). Gravid females of *Ph. obturans* are parasitic in the dorsal aorta and gill arteries of pike *(E. lucius)*; occurrence of this parasite in pike of the Mácha Lake fishpond system is dealt with in the paper by Moravec (1979). Various species of cyclopoid copepods *(Cyclops, Acanthocyclops, Macrocyclops, Eucyclops)* serve as its intermediate hosts (Molnár, 1976; Moravec, 1978b).

13. *Raphidascaris acus* (Bloch, 1779) larvae

Larvae of this pathogenic parasite were found in the abdominal cavity, liver and intestine of all the three fish species investigated; bream was most heavily infected (overall prevalence 28 %, intensity 1—1500 (average 69) nematodes per fish); the overall prevalence in roach was 12 %, intensity 1—7 (average 2), and that in rudd 8 %, intensity 1—2 (average 1). Larvae were either free or covered by a thin connective coating; their body length was 1.05—6.25 mm, width 0.068—0.136 mm, and they represented the third- and fourth-stage larvae (see Smith, 1984).

Larvae of *R. acus* occurred in these fish species throughout the year. Cyprinids, mainly bream, are here the main source of *R. acus* infection for the definitive host, pike, in which Moravec (1979) found the overall prevalence 16 %; eel was found to be a subsidiary definitive host. According to some authors, bream is very receptive to *R. acus* infection, this resulting often in a considerable mortality of heavily infected fish, as found for example in several lakes in the USSR (Osmanov, 1954; Bauer and Zmerzlaya, 1973). Heavy infections in bream by *R. acus* were also recorded in the Mácha Lake pond system. In this locality, *R. acus* larvae were also found in *Tinca tinca* (prevalence 5 %, intensity 1—3), *Cyprinus carpio* (prevalence 5 %, intensity 1—7), *Esox lucius* (encysted larvae: prevalence 2 %, intensity 1—9), *Anguilla anguilla* (encysted larvae: prevalence 1 %, intensity 27) and *Perca fluviatilis* (prevalence 0.3 %, intensity 1).

The intermediate hosts of *R. acus* are various fish species, mainly cyprinids, whereas numerous invertebrates serve as the paratenic hosts of preinfective larvae (Moravec, 1970; Smith, 1984); a recent record of the *R. acus* third-stage larva from *Gammarus pulex* from Ireland (Bradley, 1980) may indicate a possible role of invertebrates as intermediate hosts of *R. acus* too as earlier suggested by e. g. Supryaga and Mozgovoy (1974).

14. *Streptocara crassicauda* (Creplin, 1829) larva

A single larva of this species was found in the liver of *S. scardinius* (body length 24 cm) caught in March 1976 (see also Moravec, 1978). Body length of larva 4.69 mm, maximum width 0.126 mm. Length of vestibule 0.087 mm, of muscular oesophagus 0.495 mm, of glandular oesophagus 1.16 mm. Distance of nerve ring from anterior extremity 0.180 mm, of excretory pore 0.237 mm, of small deirids 0.108 mm. Tail 0.159 mm long, ending in a knob-like projection 0.006 mm long.

The life cycle of this parasite involves an intermediate host, an amphipod of the genus *Gammarus*, definitive hosts are various waterbirds. Fish serve as only paratenic hosts of invasive larvae. In Czechoslovakia, Moravec (1971) has reported these larvae from both naturally and experimentally infected fishes *(Noemacheilus barbatulus, Phoxinus phoxinus, Rutilus rutilus, Salmo trutta* m. *fario).*

Acanthocephala

15. *Neoechinorhynchus rutili* (Müller, 1780)

N. rutili was found to be a rare parasite of the three species of cyprinids investigated: in *A. brama* prevalence was 11 %, intensity 1–13 (average 3) acanthocephalans per fish, in *R. rutilus* prevalence 8 %, intensity 1–3 (average 1), and in *S. erythrophthalmus* prevalence was 3 %, intensity 1–13 (average 7). The finds were from January ,March, April, May and December. In all cases, acanthocephalans were represented only by males (body length 2–6 mm) and young females without eggs (length 2–8 mm). According to Moravec (1984a, b), the principle host of *N. rutili* in this locality is carp in which the prevalence attains some 50 %; in this host the females of the parasite become gravid and produce eggs during May. Young females and males of *N. rutili* were recorded here also in several other fish species: *Tinca tinca* (15 %), *Gobio gobio* (6 %), *Esox lucius* (2 %), *Perca fluviatilis* (1 %) (see Moravec, 1984a, b).

The life cycle of *N. rutili* involves an intermediate host, various species of ostracods (Merrit and Pratt, 1964; Walkey, 1967).

16. *Acanthocephalus lucii* (Müller, 1776)

Occasional finds of this acanthocephalan in the intestine of large bream (body length 26–28 cm) vere recorded in April; overall prevalence was 2 %, intensity 1–8 (average 4) acanthocephalans per fish; only males and non-gravid females of *A. lucii* were found in this host. According to Moravec (1985b), the principle hosts of *A. lucii* are here *Perca fluviatilis* (prevalence 62 %), *Gymnocephalus cernuus* (33 %), *Anguilla anguilla* (31 %) and *Esox lucius* (63 %) in which the parasite females become gravid. In addition to *A. brama*, also *Cyprinus carpio* (prevalence 21 %), *Tinca tinca* (4 %), and *Gobio gobio* (5 %) were recorded as facultative hosts of *A. lucii* in this locality; these fishes may become infected either while feeding on the intermediate host, *Asellus aquaticus*, or by accidental swallowing up small perch, a current definitive host of *A. lucii*.

Table 5. Comparison of the endohelminth faunae of *Abramis brama*, *Rutilus rutilus* and *Scardinius erythrophthalmus* in the Mácha Lake fishpond system

Helminth species	*A. brama*	*R rutilus*	*S. erythrophthalmus*
Trematoda:			
Phyllodistomum elongatum juv.	–	–	+
Asymphylodora tincae juv.	–	+	–
Diplostomum spathaceum larv.	+	+	+
Tylodelphys clavata larv.	+	+	+
Cotylurus pileatus larv.	–	–	+
Cestoda:			
Caryophyllaeus laticeps	+	–	–
Caryophyllaeides fennica	–	+	+
Ligula intestinalis larv.	+	–	–
Nematoda:			
Vkrjabillanus scardinii	–	–	+
Molnaria intestinalis	–	–	+
Philometra ovata	+	–	–
Philometra obturans larv.	–	–	+
Raphidascaris acus larv.	+	+	+
Streptocara crassicauda larv.	–	–	+
Acanthocephala:			
Neoechinorhynchus rutili	+	+	+
Acanthocephalus lucii juv.	+	–	–

CONCLUSIONS

There is an extensive literature dealing with the parasite fauna of bream *(A. brama)*, roach *(R. rutilus)* and rudd *(S. erythrophthalmus)*, but most papers are faunistical ones; the present knowledge of the ecology of individual endohelminth species remains rather poor. The same concerns the data from Czechoslovakia, where the endohelminths of the three named species of cyprinids have been treated in a number of papers. Reviews of this literature has shown that in Czechoslovakia a total of 32 endohelminth species were recorded in *A. brama* (Trematoda 16, Cestoda 5, Nematoda 7, Acanthocephala 4), 32 in *R. rutilus* (Trematoda 16, Cestoda 6, Nematoda 7, Acanthocephala 3), and 28 in *E. erythrophthalmus* (Trematoda 17, Cestoda 4, Nematoda 5, Acanthocephala 2); the relationship of the three named species of fishes and similarity in their ecology are reflected also in the composition of their faunae of endohelminths in which the species common to all the three cyprinids are prevailing; larval helminths, especially those of trematodes, are representing then a considerable proportion of the helminth fauna of either fish species. However, these data relate to the whole territory of Czechoslovakia, i. e. to the various basins and environmental types inhabited by these fishes, including both standing and streaming waters.

In comparison with it, the helminth faunae of these three fish species in the Mácha Lake pond system seem to be rather heterogenous and relatively rich in species. A total of 8 species of endohelminths was found in bream, 7 in roach and 11 in rudd (see Table 5); larval stages and juvenile forms prevail in the endohelminth faunae of all these fish species, while adult forms were represented by only 3 species in bream, 2 species in roach and 3 species in rudd.

Table 5 shows that only 4 species of endohelminths *(D. spathaceum, T. clavata, R. acus, N. rutili)* were found to be common for all the three fish species in this locality; besides, only 1 species *(Ph. ovata)* was common only for bream and roach and 1 species *(C. fennica)* only for roach and rudd. The highest number of species found in only one species of fish was recorded in rudd (6), 3 species in bream and only 1 species in roach. Hence, the greatest differences in the composition of the endohelminth fauna existed between bream and rudd, this being due not only to the degree of their phylogenetic affinities, but also to differences in the ecology and ethology of both these fish species.

According to the degree of host specificity, the parasites of these three species of cyprinids can be divided into approximately 4 groups: 1. strictly specific species occurring only in one fish species *(S. scardinii, M. intestinalis)*, 2. species occurring and maturing also in other cyprinids *(Ph. elongatum, C. laticeps, C. fennica, Ph. ovata)*, 3. species occurring also in fishes of other families, for which these cyprinids serve as obligate hosts *(D. spathaceum, T. clavata, C. pileatus, L. intestinalis, R. acus, N. rutili, A. lucii)*, and 4. species for which these cyprinids are only facultative hosts; the latter group is rather heterogenous, including the species for which, in this case, cyprinids serve as either a paratenic host *(Ph. obturans, S. crassicauda)* or a paradefinitive host *(A. tincae)*. It follows from a comparison among the individual groups that most species (13) belong to the obligate parasites of these cyprinids, whereas facultative parasites are represented by 3 species only. This situation is similar to that found in other cyprinids of this locality, e. g. carp or tench (Moravec, 1984a, 1985a), but very different from that in pike (see Moravec, 1979) in which those species prevail, for which this fish serves as only a facultative host; these differences are associated with different ways of nourishment between cyprinids and piscivorous pike.

In 8 helminth species it was possible to consider the relation between infections and the size (age) of the host fish. In some species *(S. scardinii, M. intestinalis, C. laticeps ,D. spathaceum, L. intestinalis)*, there is an obvious increase in the values of prevalence (and mostly also in mean intensity) with increasing size of host fishes: in other species *(T. clavata, Ph. ovata)*, the prevalence first increases with the body length of fish but then again decreases in larger fish groups; no distinct correlation was apparent for *R. acus* in bream. These quantitative changes in infestation of the individual size (age) groups of fishes are determined by many factors, being associated mainly with changes in the ecology and ethology of these fish hosts.

Out of the parasites recorded in bream, roach and rudd from the Mácha Lake pond system, seasonal changes in occurrence and maturation could be considered in some species only. *D. spathaceum, L. intestinalis* and *Ph. ovata* occurred in fishes throughout the year, while the occurrence of some species (e. g. *S. scardinii, M. intestinalis)* seems to be seasonally limited. Pronounced seasonal cycles in maturation were found in the nematodes *Ph. ovata, S. scardinii* and *M. intestinalis;* the gravid females (with larvae in uteri) of *Ph. ovata* were obtained only in a short period from the half of May until mid-June, whereas those of *S. scardinii* and *M. intestinalis* occurred from October to May and November to March, respectively.

Although bream, roach and rudd are only subsidiary fish species in the Mácha Lake fishpond system, these constitute an important proportion of the local ichthyofauna. It has been confirmed by the present study that there is a number of species among the endoparasites of these fishes that are known as the pathogenic fish parasites (e g *D spathaceum, C laticeps, L. intestinalis, R acus, N rutili)*, attacking also other cyprinids including carp and tench Hence, from this viewpoint, bream, roach and rudd have a considerable epizootological significance for the distribution and maintainance of the populations of these parasites in the given locality

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CONTRIBUTION TO THE DISTRIBUTION AND THE LIFE HISTORY OF ECHINOSTOMA REVOLUTUM (TREMATODA) IN CENTRAL EUROPE

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Abstract. In South Bohemia, Czechoslovakia, *Echinostoma* larvae with 37 collar spines were commonly found in several species of freshwater snails (mainly *Planorbarius corneus*). Based on the studies of the biology, rediae, cercariae, metacercariae and adults, regarded as *Echinostoma revolutum* (Froelich, 1802) were described to a great detail. The adult flukes were obtained from experimentally infected chickens at 8 and 14 day p. i. The number, shape and arrangement of fin folds on the tail of the cercaria were determined using SEM. The morphology of *Echinostoma revolutum* cercariae found is described, the literary data discussed and an urgent need for additional studies to elucidate the taxonomy of closely related species is stressed

Echinostomes with 37 collar spines are worldwide in distribution. Yamaguti (1971) reported on about 30 species of this fluke parasitizing in birds and mammals. The complete life history of only some species has been known (Yamaguti, 1975). During the last two decades several new species were described based on the cercariae (Lie and Umathevy, 1965, Lie and Basch, 1966, 1967, Hsu et al., 1968, Jeyarasasingam et al., 1972).

In Central Europe (mostly in Germany), 9 species of cercariae and 8 species of adult trematodes of this type were described. They were surveyed by Kanev and Odening (1983), who claimed that the descriptions of the individual development stages were usually incomplete or doubtful. Evidently different species were reported under the same name, and vice versa, echinostomes identical in size and morphology were given different names. Older descriptions often concern only a single developmental stage and usually do not provide all taxonomically important data. For these reasons, older descriptions are difficult to compare with the present findings.

In helminthological literature of the last three decades, all developmental stages of the species *Echinostoma revolutum* (Froelich, 1802) have been commonly recorded in Central Europe. The larval stages of this fluke from snails in Czechoslovakia were described by Zajíček (1963), Žďárská (1963, 1964), Nezvalová (1970), Balůsek and Vojtek (1973) and Ditrich and Vojtek (1977). Odening (1964) studied *Cercaria spinifera* La Valette, 1955 in the surroundings of Berlin and similarly as Ginetsinskaya (1959) considered it the larval stage of *Echinostoma revolutum*. The latest data on this cercaria were presented by Kanev and Odening (1983). The cercaria was reported from R.F.C. by Ahmed (1959), however, it was erroneously regarded as larval stage of a new species, *Echinoparyphium spiniferum* (Odening, 1964).

The adults of *E. revolutum*, parasitizing most frequently in the intestine of birds, were reported from Central Europe e. g. by Vojtek (1981), Odening (1978), Bezubik (1956) and Fagasiński (1962).

In addition to *Echinostoma revolutum*, some other related species, the identity and independence of which are disputable, have been reported from Central Europe. Vojtek (1981) and Odening (1965, 1978) reported on *Echinostoma paraulum* Dietz, 1909 from birds. Its larval stages were described by Zajíček (1963), Nezvalová (1970) and Ditrich and Vojtek (1977). The adults and larval stages of *E. revolutum* and *E. paraulum* were reported also by Supperer (1959) from Austria. Fagasiński (1962) recorded *Echinostoma robustum* Yamaguti, 1935 in Poland and supported the validity of this species. Prokopič and Genov (1974) and other authors cited in their paper recorded *Echinostoma armigerum* Barker et Irvine, 1915 in rodents inhabiting water or moist environment in Czechoslovakia. Odening (1978) placed the species to synonymy with *Echinostoma revolutum*.

In recent years, great attention has been paid to echinostomes with 37 collar spines in Bulgaria. Janchev et al. (1984) recorded the species *E. revolutum* *E. miyagawai*, *E. paraulum* and *E. robustum* parasitizing in birds. Based on the detailed studies of the larval stages and life cycles, Vasilev and Kanev (1979, 1981) and Kanev (1980, 1981) recorded three closely related species originally described from South Asia and South America — *Echinostoma audyi* Lie and Umathevy, 1965, *Echinostoma barbosai* Lie and Basch, 1966 and *Echinostoma lindoense* Sandground and Bonne, 1940. In addition, the cercariae of *E. lindoense* were found by Vasilev et al. (1982) in Poland and Czechoslovakia. In the years 1983—84 I studied the helminth fauna of water snails in South Bohemia, Czechoslovakia, from were the cercariae of *E. revolutum* (Zajíček, 1963, Žďárská, 1963, 1964), *E. paraulum* (Zajíček, 1963) and *E. lindoense* (Vasilev et al., 1982) had been described. High numbers of the cercariae, regarded as *Echinostoma revolutum*, were observed primarily in the snail *Planorbarius corneus*. The description of the cercariae and other development stages of this trematode are presented below.

MATERIAL AND METHODS

Spontaneously infected snails *Planorbarius corneus*, *Bathyomphalus contortus*, *Lymnaea stagnalis* and *Radix peregra peregra* were obtained in several localities neighbourhing České Budějovice, Veselí nad Lužnicí and Třeboň. Results presented below are based on the larval stages from *P. corneus*.

The majority of anatomical and morphological data on the rediae, cercariae and metacercariae were obtained from the studies of living organisms. Gland cells of cercariae and their ducts were stained with neutral red (Vasilev and Kanev, 1979), cuticular and collar spines with the diluted Lugol's solution. Permanent slides of cercariae with well visible genital primordia were prepared by a method described by Žďárská (1963). To obtain metrical data the cercariae fixed in 4 % hot (70 °C) formalin were used. The rediae and cysts containing the metacercariae were measured alive, under a slight pressure of a cover glas.

The surface structures of the body of cercariae and the fin folds on the tail were studied using SEM. For that purpose, the cercariae were fixed in hot (70 °C) 4 % formalin, post-fixed in 2 % OsO_4 solution in 0.1 M cacodylate puffer, washed, dehydrated in the series of alcohol and critical-point dried. The specimens were coated with gold and then examinated with a Tesla BS-300 scanning electron microscope at 15 kV.

Cercariae were administered to clean laboratory bred snails *Lymnaea stagnalis*, *Radix peregra peregra*, *Planorbarius corneus*, *Planorbis planorbis* and *Biomphalaria* *glabrata.* Fourteen-day-old metacercariae were introduced to chickens. The excysted metacercariae were obtained at dissection of animals 18 hrs p. i., the adults at 8 and 14 day p. i. The metacercariae and adult trematodes obtained from chickens were fixed in 70 % ethanol under a slight pressure of a cover glass a stained with borax carmine. All characteristic features of adults were based on permanent slides.

RESULTS

Cercariae of the given species were found in snails *P. corneus, B. contortus, L. stagnalis, R. peregra peregra.* The most frequent first intermediate host appears to be *P. corneus.* In other hosts mentioned the cercaria was found only sporadically.

Rediae. Cercariae develop in the light orange rediae located in the hepatopancreas of a snail. A typical redia is shown in Fig. 1A. A collar followed by a birth pore may be seen in the head end. Ventrolateral locomotor processes differ in location, but they are always situated in the posterior half of the body.

The measurements are based on 27 specimens. The rediae are 0.7-3.2(1.6) mm long and 168−368(280) µm wide. The pharynx is small, measuring 39−63(48)×

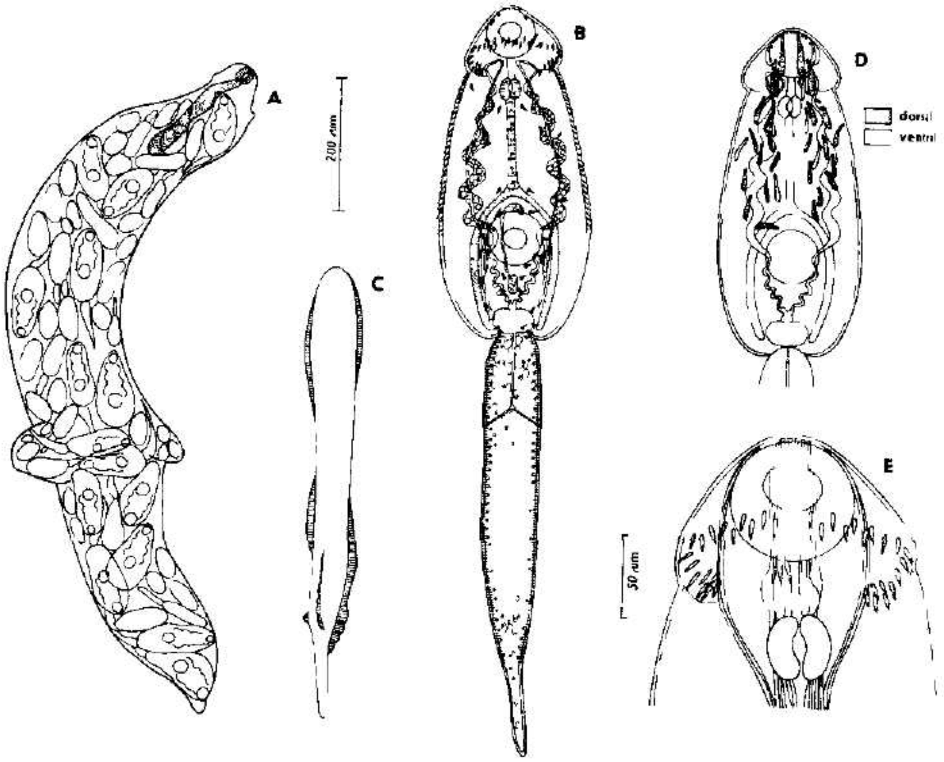

Fig 1 *Echinostoma revolutum* (Froelich, 1802), A – redia, B, C, D, E – cercaria (C – arrangement of fin folds on the tail, side view, D – arrangement of parasophageal gland cells in the anterior part of body, E – arrangement of collar spines and penetration gland cells outlets).

× 35–57(41) µm. The short narrow gut contains brown – red material. Each redia contains many cercariae at different stage of development. The number of mature cercariae in a redia ranged from 2 to 23, depending on its size.

Cercariae. The measurements are based on 30 specimens. The body (Fig. 1B) is 245–340(286) µm long and 123–145(135) µm wide. Minute body spines are seen at the anterior part, extending to the ventral sucker on the ventral side and behind this level on the dorsal side. The longest cuticular spines (about 3 µm) are located immediately behind the head collar, getting smaller posteriorly. The collar is well developed, 70–90(79) µm wide, bearing usually 37 spines (Fig 1E). The cercariae have a group of five corner spines 9–11 µm long, three oral and two aboral. Six lateral spines (10–11 µm) are arranged in a single row. Fifteen dorsal spines (11–12 µm) are arranged in a double row, 8 orally and 7 aborally (Plate I, Fig. 2).

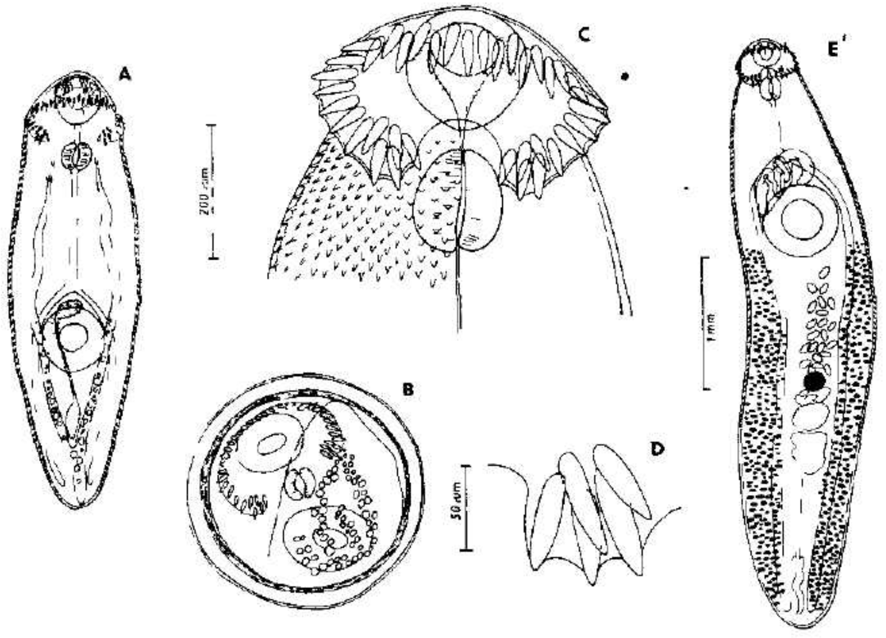

Fig. 2. ***Echinostoma revolutum*** (Froelich, 1802); A – excysted metacercaria, B – metacercaria in the cyst, C, D, E – adult worm (C – collar spines, D – corner spines).

The oral sucker is subterminal, 38–46(42) µm long and 36–45(41) µm wide A short prepharynx is followed by the well developed pharynx measuring 19–28(23) × 18–22(20) µm. The esophagus is formed by a column of six weakly distinguishable cells. It bifurcates just in front of the acetabulum. Ceca extend to the posterior end of excretory vesicle. The alimentary tract with coarsely granular content. The ventral sucker, 44–60(54) µm long and 51–62(56) µm wide ,situated postequatorially.

Three types of body glands may be distinguished in vivo: cystogenous, penetration and paraesophageal. Cystogenous cells extending from the posterior end of the body to the pharynx are weakly stainable with neutral red and contain rod-like bodies measuring 2–2.5 × 1 μm. Penetration gland cells are situated ventrolateral along both sides of the esophagus. Their numbers could not reliably be determined in my material, as they were overlapped by cystogenous cells. However, the number of penetration cells is likely to correspond with that ducts, opening on the dorsal lip of the oral sucker. I found 10 outlets there (Fig. 1E). Three ducts run on each side of the esophagus and pharynx, reach the oral sucker and open on its dorsal lip. Additional two pairs of ducts, situated laterally from the central ducts terminate dorsolaterally from the six above mentioned terminal outlets. The penetration gland cells and their ducts stain with neutral red rather weakly. In contrast, so-called paraesophageal glands show intensive staining. They may be found only in the anterior half of the body of the cercaria (Fig. 1D). They are oval, elongated, with granular contents and open on the body surface. The total number of paraesophageal gland cells ranged from 30 to 36. The ventral surface of the body possesses 6–10 outlets, the remaining ones are on the dorsal surface. Maximum number of outlets in the oral sucker region was eight.

The excretory system is stenostome. The main collecting tube contains usually 30–65 refractile excretory granules, measuring up to 11 μm in diameter. The most probable number of flame cells is 36. The excretory vesicle is divided into two parts. Two main collecting vessels open into a small anterior part from both sides. A markedly larger posterior part is adjacent to the tail base. A narrow tube leading from the posterior part of the excretory vesicle bifurcates at about one fifth of the tail lenght and short lateral branches open on the lateral surface.

The genital primordia are formed by two mutualy connected cell aggregations. One at the anterior margin of the acetabulum, and the other between the acetabulum and the excretory vesicle.

The tail of the cercaria is 422–554(501) μm long and 35–40(42) μm wide at its base, with last one fifth of its lenght being markedly attenuated. It possesses two dorsal, three ventral and two ventrolateral fin folds (Fig. 1C). The most conspicuous is the lower dorsal fin fold running nearly from the mid tail to the beginning of its attenuated part (Plate II, Figs. 1–2). The smallest fin fold was identified with certainty by SEM. It is located in the ventral part of the tail, between two ventrolateral fin folds (Plate II, Fig. 2). The cercariae are negatively phototactic.

Metacercariae. *E. revolutum* metacercariae were found mostly in the kidneys and pericardial sac of the spontaneously infected snails *Lymnaea stagnalis, Radix peregra peregra, Galba corvus, Physa fontinalis, Aplexa hypnorum, Planorbarius corneus, Bathyomphalus contortus* and *Segmentina nitida*. The metacercariae develop experimentally in the snails *P. corneus, Planorbis planorbis, Biomphalaria glabrata, L. stagnalis, R. peregra peregra*. Spherical cysts measure 139–158(148) μm in diameter (based on 30 specimens). Their wall 10–14 μm thick, is formed by three layers: a thin outer membrane, a median thick transparent and inner opaque wall (Fig. 2B). The excysted metacercariae were obtained from the chicken dissected 18 hrs after the cyst ingestion. They were 535–605(568) μm long and 139–170(161) μm wide. A collar, 120–135 (127) μm wide, bears 15–19 μm long spines, resembling in the arrangement those of the cercariae and the adults. Cuticular spines cover nearly the intire body surface. The oral sucker is 53–70(61) μm long and 58–65 (64) μm wide. On its dorsal lip the apertures of penetration cells, arranged similarly as in the cercariae (2+6+2), may be observed. The acetabulum is spherical to ovoid, located postequatorially, and measures 78—85(82) × 75—85(81) μm. A muscular pharynx, transversely oval, measures 33—40(37) × 39—43(41) μm. The main collecting tubes run from the pharynx along both sides of the body and fuse together in a certain distance behind the acetabulum region. Their posterior part and the tubular excretory vesicle both contain refractile granules. The body structure of the metacercariae is illustrated in Fig. 2A.

Adults. The adult trematodes were obtained experimentally from chickens dissected 8 and 14 days p. i. Eight- and fourteenday-old flukes did not much differ in the size and the number of eggs in the uterus. A characteristic individual is shown in Fig. 2E. The following measurements are based on the study of 23 fixed and stained worms. The adult is 3.04—4.48(3.86) mm long. The maximum body width, measured at the site of the acetabulum, is 0.67—0.93 (0.78) mm. The dorsal cuticular spines are developed only to the level of the ventral sucker, the ventral spines extending usually to the testes. The collar is 345—529(389) μm wide; the collar spines 58—83 μm long, arranged similarly as in the cercaria (Fig. 2C). The average length of dorsal spines (70 μm) is somewhat higher than that of the lateral (66 μm) and corner spines (64 μm). The corner spines maintain constant size proportion (Fig. 2D). The smallest one is usually the ventrooral or ventrolateral spin (average length 59 and 60 μm), the largest is always lateroaboral spine (70 μm).

The subterminal oral sucker is 140—240(184) μm long and 158—195(169) μm wide. A short prepharynx is followed by the oval muscular pharynx measuring 139—183(161) × 107—183(132) μm. The esophagus, 208—428(346) μm long, bifurcated at a short distance in front of the acetabulum. Ceca reach the posterior end of the body. The ventral sucker, 441—592(531) μm long and 435—560(508) μm wide, is located in the first quarter of the body. The size ratio of the ventral sucker to the oral sucker is 2.9 : 1.

The ovoid cirrus sac, 315—567(461) μm long and 126—320(197) μm wide, located between the intestinal bifurcation and the acetabulum. The testes, located in the posterior half of the body, are in tandem arrangement. They are rather variable in the shape and size, elongated or broadly oval, occasionaly slightly lobed. The posterior testis, measuring 158—328(325) × 113—315 (220) μm usually somewhat larger than the anterior one, measuring 107—271 (192) × 126—334(232) μm. The ovary, oval to rounded, 44—189(113) × 50—208 (131) μm, is situated in front of the testes. The egg number in the uterus was relatively low in experimentally recorved worms (max. 40). Brown-red eggs are ovoid, 108—120(114) μm long and 63—70(67) μm wide. The vitellaria, located along both sides of the body, extend from the posterior margin of the ventral sucker to the posterior end of the body.

DISCUSSION

The larval stages of *E. revolutum*, *E. paraulum* and *E. lindoense* have so far been reported from Czechoslovakia. The cercariae of all these species were recorded also in South Bohemia.

E. paraulum was recorded already by Rašín (1933) who observed the metacercariae in the snails *Radix peregra peregra*. The cercariae of that species were later described from *L. stagnalis* by Zajíček (1963) and Nezvalová (1970). These differed from the herein described cercariae by larger collar spines, arrangement of cuticular spines and absence of fin folds. Ditrich and Vojtek (1977) found *E. paraulum* metacercariae in the snails *Radix auricularia, R. peregra peregra, Galba turricula, G. corvus, Physa fontinalis, P. acuta* and *Valvata piscinalis*. These authors recorded much larger cysts than described in this paper.

E. revolutum cercariae were found in the snails *Lymnaea stagnalis, Radix peregra ovata, R. auricularia, Planorbarius corneus, Planorbis planorbis, Anisus vortex* and *Bathyomphalus contortus* and studied by Zajíček (1963), Žďárská (1963, 1964), Nezvalová (1970) and Balůsek and Vojtek (1973). The metacercariae of this species were recorded in *L. stagnalis, R. peregra ovata, L. palustris* (s. l.), *G. turricula, P. fontinalis, Aplexa hypnorum, P. corneus, Planorbis carinatus, Anisus vortex, A. leucostomus, Gyraulus albus* and *B. contortus* (Žďárská, 1963, 1964, Ditrich and Vojtek, 1977). Vojtková (1969) found *E. revolutum* metacercariae also in several species of turbellarians. The cercariae reported in this paper are similar in the size and structure of body to those of *E. revolutum* described by the above authors. Nevertheless, some differences in descriptions exist. All the authors mentioned a continuous dorsal and ventral fin fold on the tail. Different are also the data on the type of excretory system (Žďárská, 1964), number of flame cells (Zajíček, 1963) and phototaxy (Zajíček, 1963, Nezvalová, 1970). Comparison of other taxonomically important features (penetration and paraesophageal gland) is not possible as the relevant data were not reported in the above mentioned literature. Zajíček (1963) and Žďárská (1963, 1964) performed the research in the same region where my investigations were carried out. Nevertheless, I assume that the majority of the above papers deal with the cercariae of the same species studied by me.

I consider them identical with the cercariae *E. lindoense* reported from Czechoslovakia by Vasilev et al. (1982) too. I examined the snails from the same locality. The cercariae studied were common there in *Planorbarius corneus*. In contrast to my description, Vasilev et al. (1982) recorded 7–8 esophageal cells, only two fin folds on the ventral surface of the tail, 60–64 paraesophageal glands and 6 outlets of penetration gland cells. I observed 6 esophageal cells, 3 ventral fin folds on the tail, max. 36 paraesophageal cells and 10 outlets of penetration glands (2+6+2) on the dorsal lip of the oral sucker. The penetration gland cells described by me are most likely identical with subesophageal gland cells observed by Žďárská (1968, 1971) in the cercaria *Echinoparyphium aconiatum* and *Moliniella anceps*. It is also probable that Vasilev et al. (1982) considered the two lateral pairs of penetration gland cell outlets the apertures of paraesophageal gland cells. However, the cercaria recorded in my material from South Bohemia differ from those of *E. lindoense* Sandground and Bonne, 1940 described from South Asia and South America (Lie, 1966) in the arrangement and number of paraesophageal and penetration gland cell outlets.

Kanev and Odening (1983) considered *E. lindoense* from Europe, described by Vasilev and Kanev (1979, 1981) from Bulgaria and Vasilev et al. (1982) from Poland and Czechoslovakia identical with *Cercaria spinifera* La Valette, 1955. Odening (1964) studied the cercariae from the snail *Planorbarius corneus* in Berlin and its surroundings, amended and added more data to the original La Valette's description and those of other authors (Wesenberg-Lund, 1934). In contrast to 40–45 collar spines recorded by the above authors Odening found only 37 spines, similary as Ahmed (1959) and Zdun (1961). He considered *C. spinifera* identical with the cercaria *E. revolutum* described from the European part of the USSR by Ginetsinskaya (1959) and assumed it to be the larva of this species. Odening (1964) mentioned also erroneous opinion, maintained for a long time in the literature, that the larval stage of *E. revolutum* is *Cercaria echinata* Siebold, 1937. However, many authors demonstrated (Kanev and Odening, 1983) that *C. echinata* is the larva of the species *Echinoparyphium aconiatum*.

Kanev and Odening (1983) and Vasilev and Kanev (1981) described two dorsal, two ventral and two ventrolateral fin folds on the tail of *C. spinifera* and the cercaria of *E. lindoense*. They did not mention the third, reduced fin fold on the ventral surface of the tail. Nevertheless, from their drawings and photomicrographs its precence may be anticipated. As far as I know, this feature, definitively demonstrated here by SEM (Plate II, Fig. 2), has not been described in any closely related species. It will be interesting to find whether this is a group or species specific feature.

To complete these data, it should be noted that the cercaria is similar to those of *E. barbosai*, described by Kanev (1981) from the snail *P. corneus* in Bulgaria.

The characteristic features of the cercaria reported in this paper corresponded well with the cercaria described by Bock (1982). The specimen was recorded in Southern Europe (Yugoslavia) and remained species-undetermined by the author. However, the author noted its similarity with the cercaria *Echinostoma miyagawai* Ishii, 1932, studied by Kosupko (1969) and originally described from Japan, but placed to synonymy with *E. revolutum* by Japan authors (Yamaguti, 1971, 1975). The trematode was described as an independent species by Skryabin and Bashkirova (1956). Novostrueva (1953) reported on the life history of *E. miyagaway*, however, Bykhovskaya-Pavlovskaya (1962) assumed that the demonstrated rather the identity of that species with *E. revolutum* than the species independence.

The validity of other related Central European species *(E. armigerum, E. paraulum, E. robustum)* is disputable as well. The adults of these species resemble one another, differing more or less only in variable features (sizes, arrangement of the vittellaria, lobation of testes etc.). The data on the larval stages are lacking or are incomplete ,in some instances unreliable. E. g., Supperer (1959) compared the larvae and adults of the species *E. paraulum* and *E. revolutum* and supported the validity of the species *E. paraulum*. As *E. paraulum* metacercaria he undoubtedly described the metacercaria of *Moliniella anceps* (Žďárská, 1964), whereas the larval stages of *E. paraulum* reported by him resemble *E. revolutum* larvae as described by other authors. Beaver (1937), Bykhovskaya-Pavlovskaya (1962) and Yamaguti (1971) have regarded *E. paraulum* as a synonym of *E. revolutum*. Bezubik (1956) and Bykhovskaya-Pavlovskaya (1962) have reported also *E. robustum* identical with *E. revolutum*. However, based on more robust adults, Fagański (1962) and Yamaguti (1971) have regarded *E. robustum* as an independent species. Also the species *E. armigerum*, the larval stages of which have not been known, is considered identical with *E. revolutum* by some authors (Beaver, 1937, Odening, 1978).

The history of the species *E. revolutum*, described from Central Europe, has been reported by Skryabin and Bashkirova (1956). Until now, the basis for the determination of 37-spined echinostomes has been the study on the life history of the North American trematode, identified by Beaver (1937) as *E. revolutum*. The cercariae and adults from Beaver's experiments are very similar to those studied by me. The author noted a great variability of the adults of these trematodes.

In Central Europe, Lie and Kanev (1983) searched for a cercaria corresponding the Beaver's description of *E. revolutum*, but they did not succeed. Kanev and Fried (1982) studied the morphology and biology of echinostomes of this type in the same region of the USA and from the same snail species *(Helisoma trivolvis)* as Beaver (1937). They assumed that not *E. revolutum*, but another species, unknown in that period, had been studied by Beaver. They regarded the species to be identical with *Echinostoma rodriguesi*, described from South America by Hsu et al. (1968). The difference between these species were confirmed on the basis of electrophoretic studies of the adults by Vasilev et al. (1984).

I consider the life stages presented in this paper to be conspecific with the species determinated in Czechoslovakia and other Central European countries as *Echinostoma revolutum* (Froelich, 1802). *E. revolutum* was originally described from a near by region of Germany — the region from where Kanev and Odening (1983) confirmed recently findings of corresponding cercaria. The name *E. revolutum* should, therefore, be committed to the European species without regard to a definitive solution of a taxonomical position of the North American species, given by Beaver (1937) under the same name. More detailed studies of all larval stages morphology, complete life cycles, as well as intermediate and definitive host — ranges, are needed to elucidate the taxonomy of related species in Central Europe.

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The Plates I and II will be found at the end of this issue.

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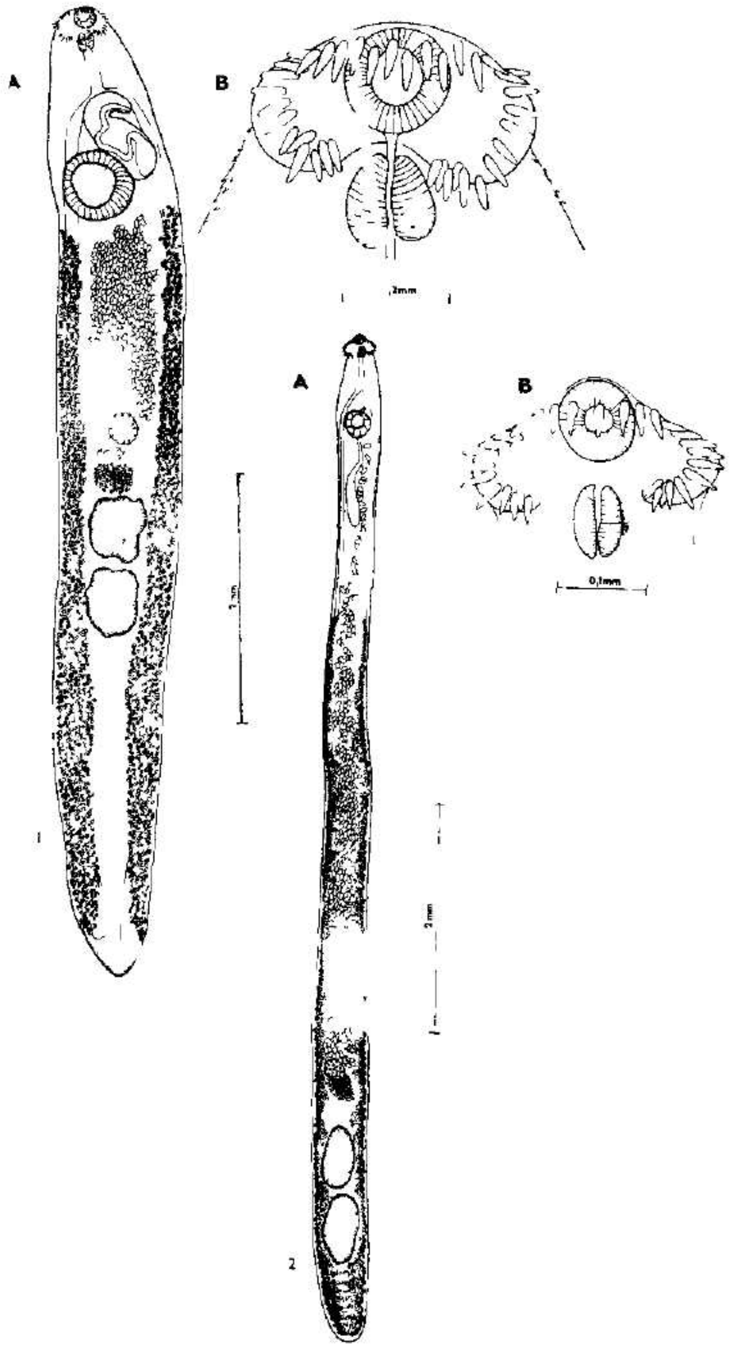
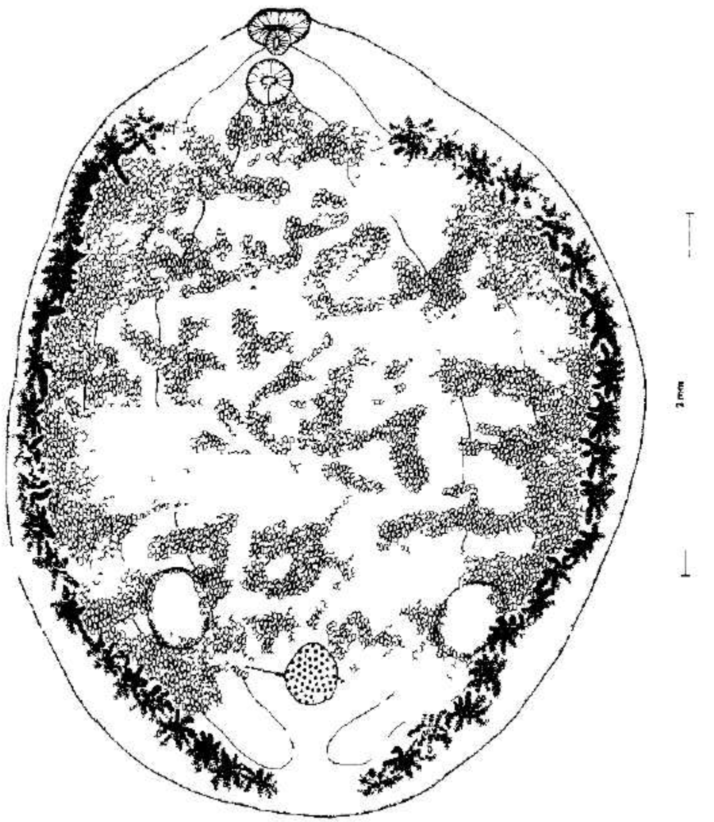


Fig. 1. A–B- *Echinostoma revolutum* (Frohlich, 1802) from *Chlidonias nigra* (A – general view, B – detail arrangement of spines

Fig. 2. A–B- *Himasthla secunda* (Nicoll, 1906) from *Sterna hirundo* (A – general view, B – detail arrangement of spines.



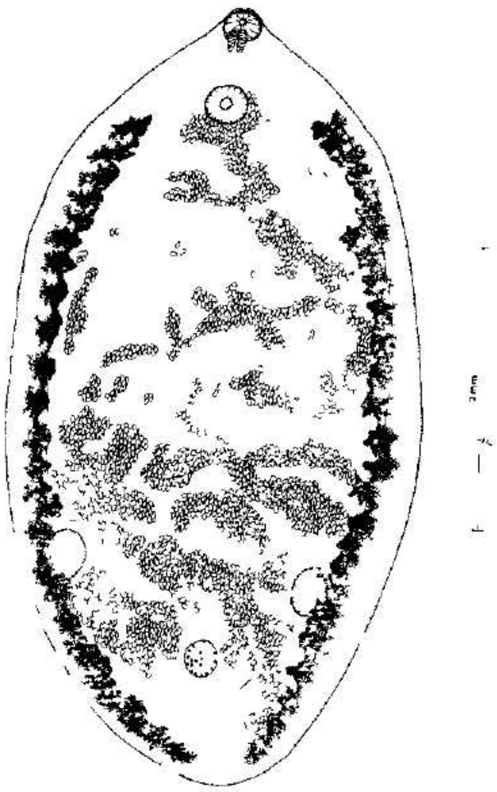
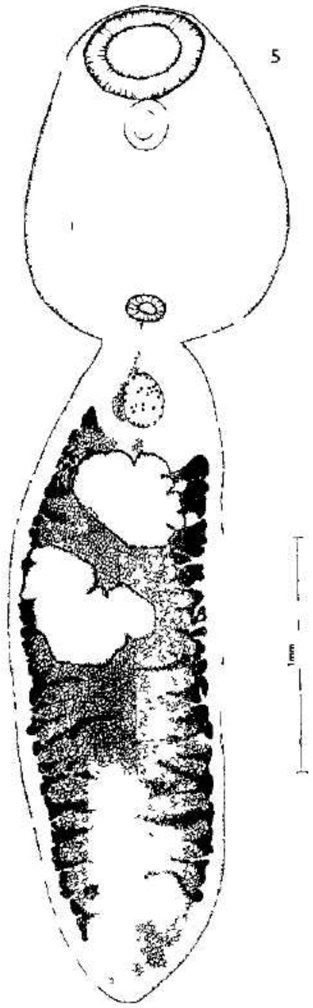


Fig 3 *Pachytrema calculus* Looss, 1907 from *Chlidonias nigra*
Fig 4 *Pachytrema paniceum*, Brinkmann, 1942 from *Sterna hirundo.*



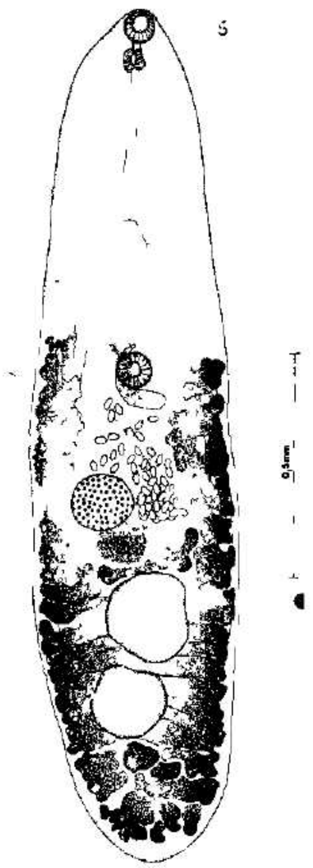
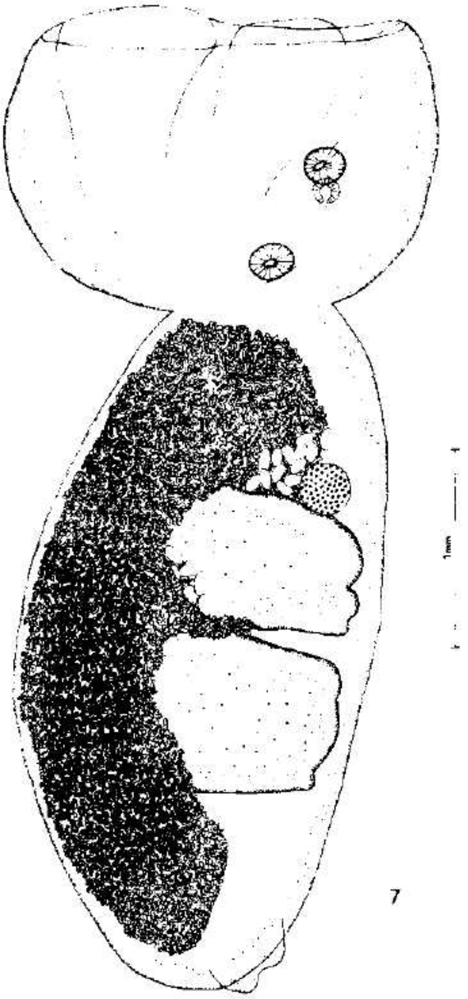


Fig. 5. *Cercarioides aharonii* Witenberg, 1929 from *Larus ridibundus.*
Fig. 6. *Apophallus muehlingi* (Jagerskiold, 1809) from *Sterna hirundo.*



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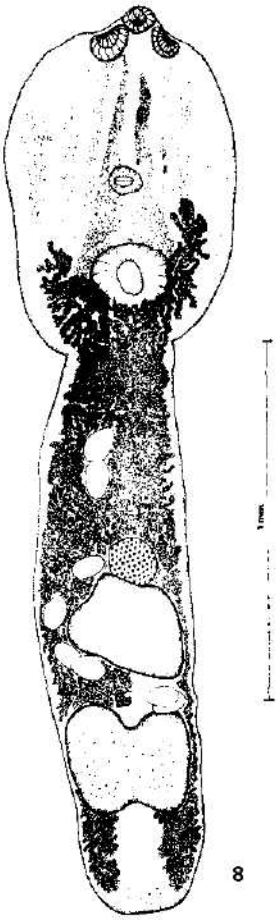

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Fig. **7.** *Cotylurus platycephalus* (Creplin, 1825) from *Sterna hirundo.*
Fig. **8.** *Diplostomum spathaceum* (Rudolphi, 1819) from *Sterna hirundo.*

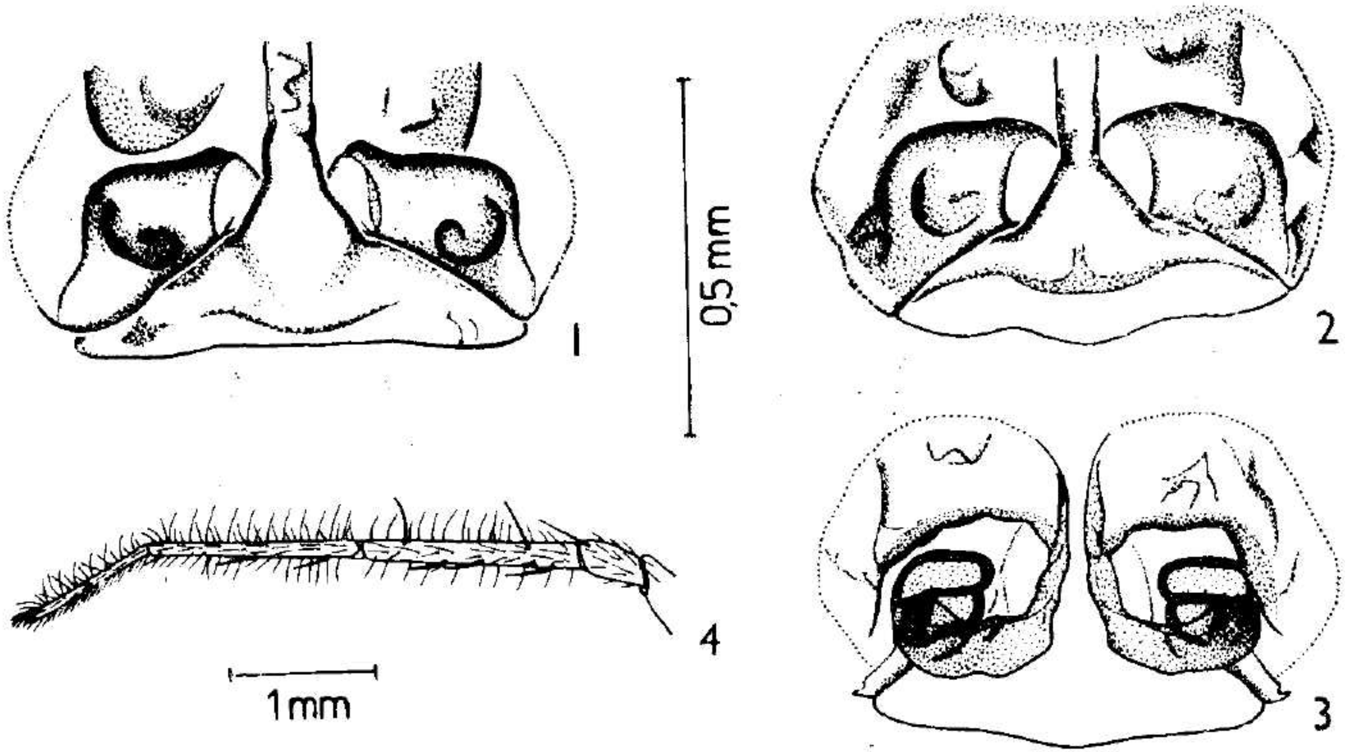


Abb. 1—4. *Aulonia kratochvili* sp. n.: 1 — Epigyne von ♀-Holo typus. 2—3 — Epigyne und Vulva von ♀-Paratypus aus Gobustan: 2 — Epigyne, 3 — Vulva von Dorsalseite. 4 — ♂-Bein I. (Abb. 4 von P. M. Dunin, alle übrigen von E. Laštovková gezeichnet).

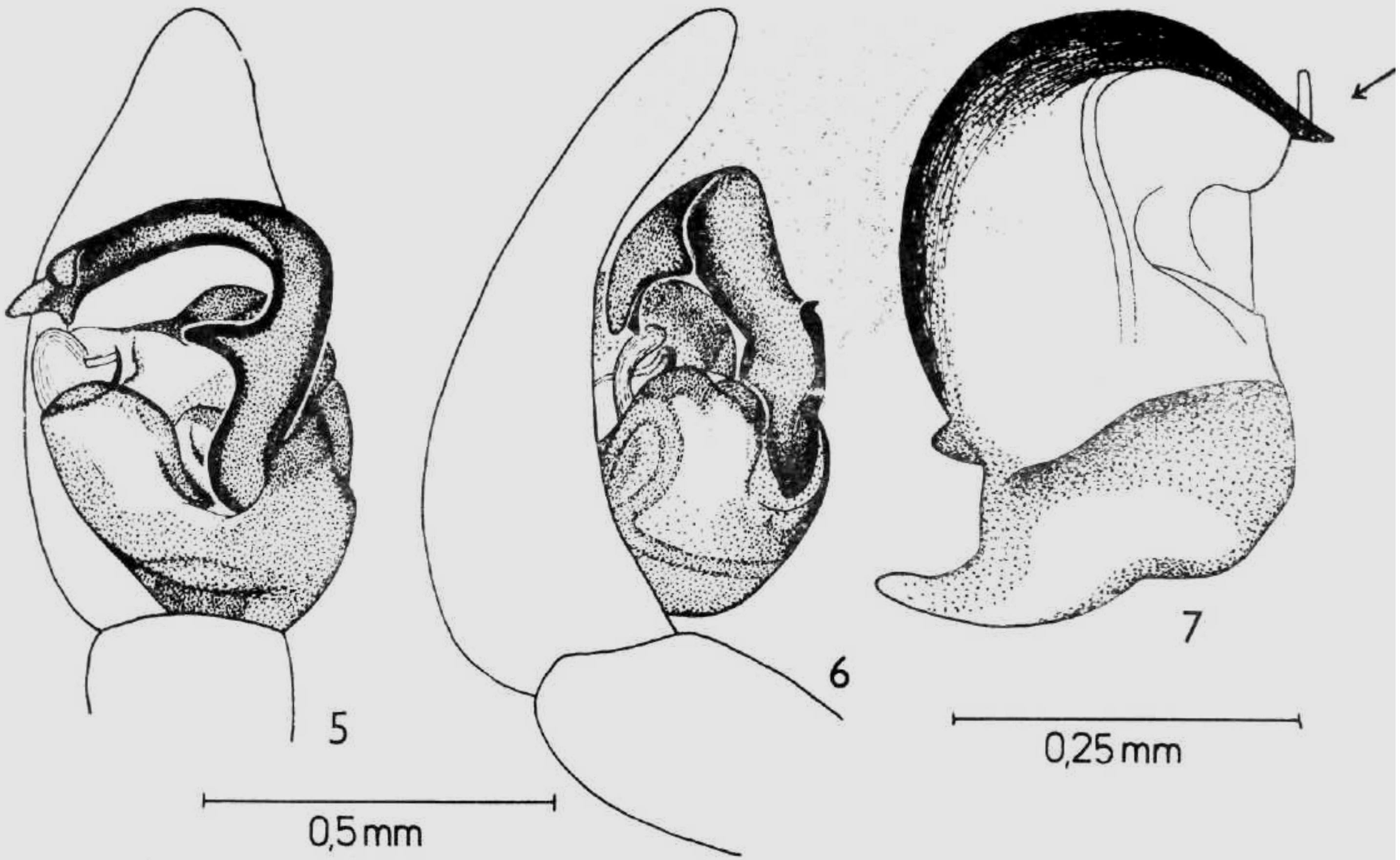
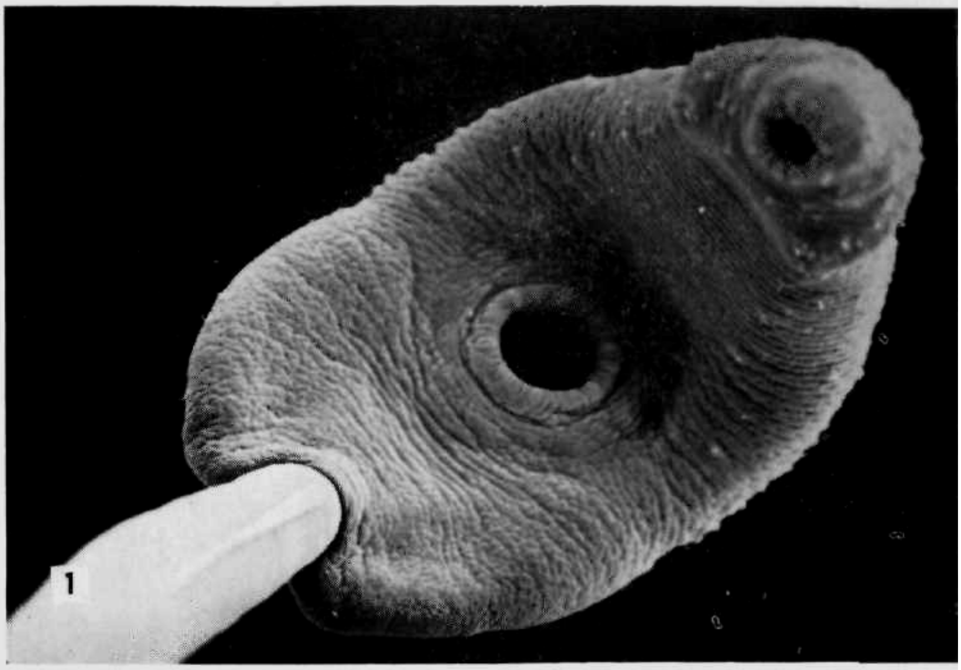


Abb. 5—7. ***Aulonia kratochvili*** sp. n., rechter ♂-Palpus: 5 — Bulbus von ventral, 6 — Bulbus von retrolateral, 7 — Embolusabschnitt; der Pfeil macht auf den Apicalteil des Embolus aufmerksam.



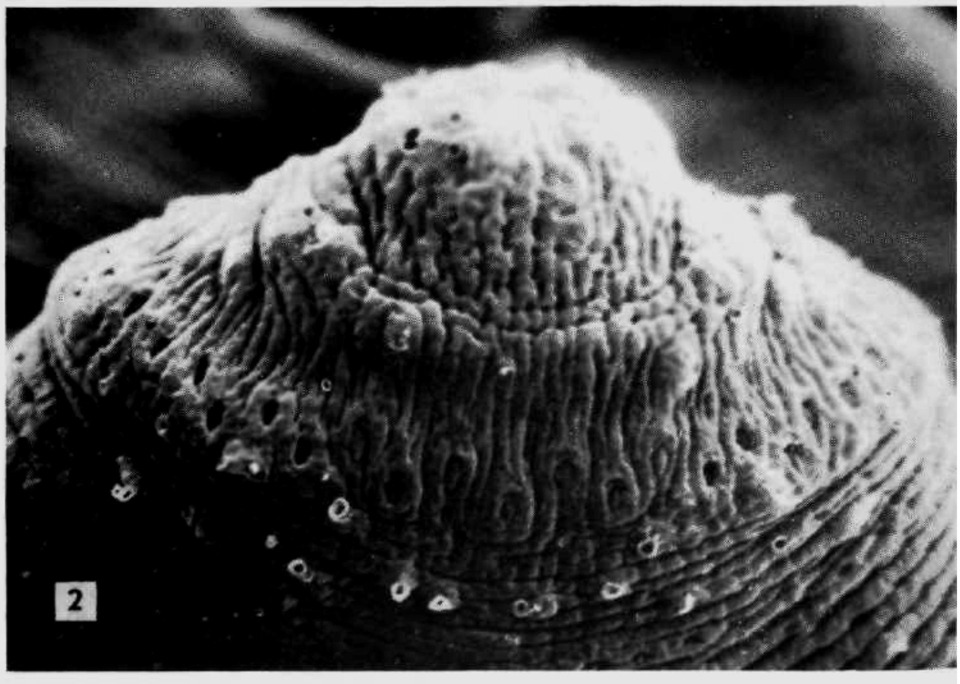


Plate I. Fig. 1. Ventral view of the *E, revolutum* cercaria body (×660).
Fig. 2. Dorsal collar spines of *E. revolutum* cercaria (×1800).

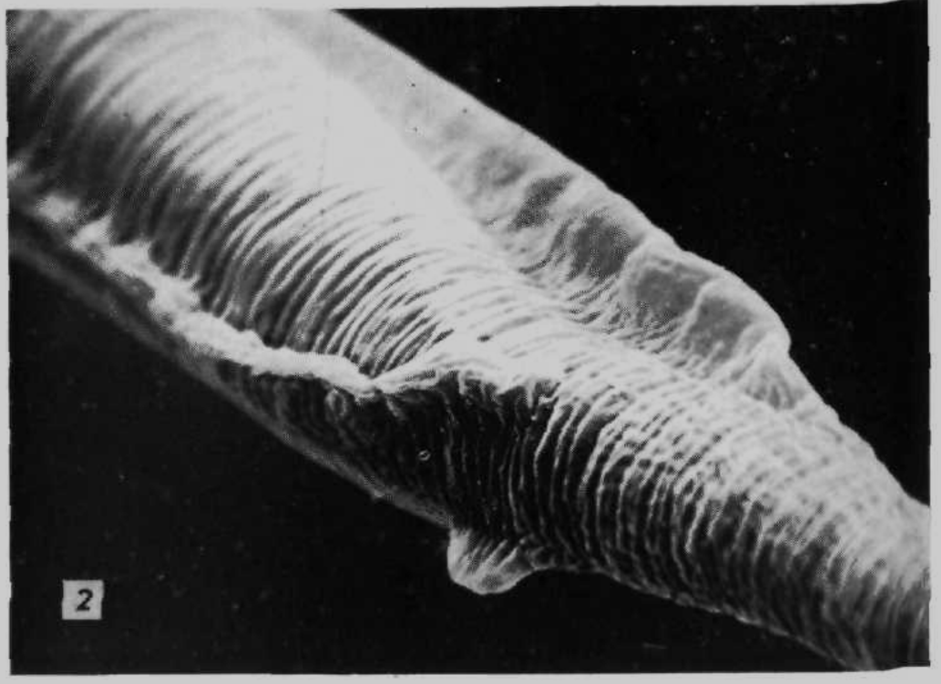


Plate II. Fig. 1. Dorsal fin folds on the tail of *E. revolutum* cercaria (×430).
Fig. 2. Arrangement of fin folds on the tail tip of *E. revolutum* cercaria (×2200).

POKYNY PRO AUTORY

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Vlastní práce: 1. Velmi stručný abstrakt, v rozsahu nejvýše 15 řádek, v angli tině. 2. Úvod do problematiky (stručně). 3. Materiál a metodika (u známých met pouze odkaz). 4. Vlastní část experimentální nebo popisná. 5. Diskuse. 6. Závěr. Seznam citované literatury (nikoliv bibliografie!). 8. Adresa autora. 9. Tabulky, te ty k obrázkům a grafům. Celý rukopis je průběžně stránkován.

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