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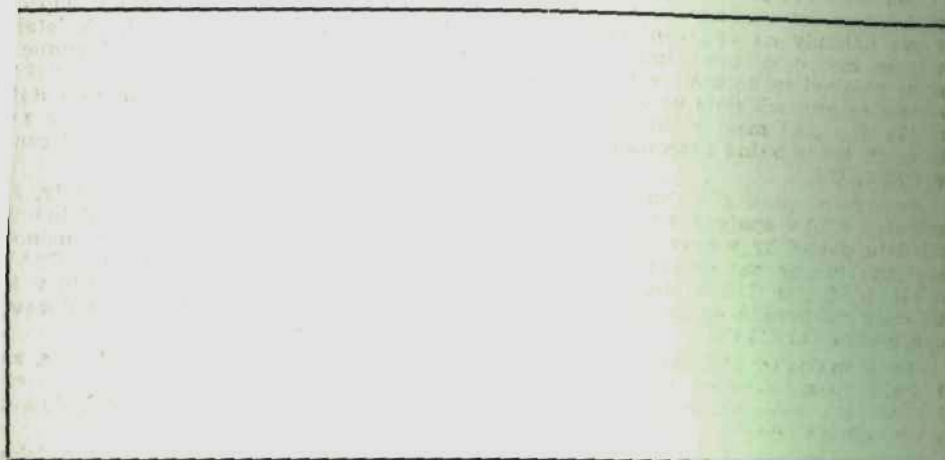
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OBSAH—CONTENTS

Johal M. S., Kingra J. S., Chagal J. S.: Age, growth and length-weight relationship of <i>Colisa fasciata</i> (Perciformes: Belontiidae, Trichogasterinae)	241
Máca J.: Description of the female of <i>Poecilochirus subterraneus</i> (Acarina: Parasitidae)	249
Mlíkovský J.: Brain size in birds: 3. Columbiformes through Piciformes	252
Moravec F., Sey O.: Some amphibian trematodes from Vietnam and Papua New Guinea	265
Petrova G., Živkov M.: A contribution to the methodology of the study of predator fish food	280
Pokorný P.: Birds in the centre of Prague	291
Sablina O. V., Zima J., Radjabli S. I., Kryštufek B., Goleniščev F. N.: New data on karyotype variation in the Pine vole <i>Pitymys subterraneus</i> (Rodentia, Arvicolidae)	295
Soldán T., Campbell I. C., Papáček M.: A study of dispersal phoretic association between <i>Sphaerium (Musculinum) tasmanicum</i> (Heterodonta, Sphaeriidae) and <i>Sigara (Tropocorixa) truncatipala</i> (Heteroptera, Corixidae)	300
Závěta J., Velebný M.: The growth of the fry of the Bream (<i>Abramis brama</i>) and the Pike-perch (<i>Stizostedion lucioperca</i>) in the Orlik valley water reservoir in 1983	311

**AGE, GROWTH AND LENGTH-WEIGHT RELATIONSHIP OF COLISA FASCIATA
(PERCIFORMES: BELONTIDAE, TRICHOGASTERINAE)**

Mohinder Singh JOHAL, Jagpal Singh KINGRA and Jagjit Singh CHAHAL

Department of Zoology, Panjab University, Chandigarh — 160014, India

Abstract. Age, growth and length weight relationship of *Colisa fasciata* (Schneider) from a village pond near Ludhiana (latitude 30°54' N; longitude 75°57' E) Punjab, India using scale method have been described. Annulus is formed on the ctenoid scales during the months of May-June. Factors like high temperature and maturity of gonads are considered to be responsible for annulus formation. Annual increment in weight increases with the increase in age. Phenomenon of growth compensation has been recorded in the age class 3+.

Length-weight relationship has been found to be:

$$\begin{aligned}W &= aL^n \\ \text{Log } W &= \text{log } a + n \text{ log } L. \\ \text{log } W &= -2.97 + 2.56 \text{ log } L \\ W &= 0.1071519 L^{2.56}\end{aligned}$$

INTRODUCTION

Colisa fasciata (Schneider) is a common freshwater perch inhabiting the shallow waters of India with thick growth of macro and microphytes, where the level of oxygen is much lower than the optimum level. It is not a commercial fish, but tribal people consider it as a delicacy. This fish species has high rate of survival even under adverse conditions because of the presence of the accessory respiratory organs. In Indian freshwaters its presence is considered essential because it feeds voraciously upon insects and mosquito larvae, thus controlling the malaria disease to some extent in the rural areas. Considering this type of importance in the biological control of malaria, the present studies on the age determination using scales, growth and length-weight relationship have been undertaken for the first time from Northern India.

MATERIAL AND METHODS

Scales from 91 specimens of *Colisa fasciata* (Schneider) ranging from 23.00—71.80 mm collected during May—June 1985 from Parain village pond (average depth 2 meters and area 2.00ha) near Ludhiana (latitude 30°54' N; longitude 75°57' E) Punjab State, India using cast net for the present investigations. Immediately after the collection the fishes were preserved in 10% formaldehyde solution and brought to the laboratory for further studies. The method of scale collection, their preparation for the study and age determination has already been described by Johal (1980) and Sanjose (1984).

OBSERVATIONS AND DISCUSSION

The ctenoid scale of *Colisa fasciata* is more broad than its length. On the posterior side there are present ctenii. The general structure of the scale is similar to other perches as described by Bishai (1980), Bortone and Hollingsworth (1980), Johal (1980), Schmitt and Hubert (1982) and Davis and Kirkwood (1984). Each scale has distinct circuli having two types of arrangements i.e. closely and widely spaced circuli showing slow and fast growth periods respectively. As the material was collected during the months of May-June 1985, most of the scales have marginal annulus. It is evident that high temperature and low water level during these months are one of the important factors responsible for annulus formation.

Linear relationship between total fish length and lateral scale radius has been observed (Fig. 1), with high coefficient of correlation ($r = 0.9743$). The regression equation between these two parameters is as follows:

$$Y = a + bX \\ -3.1211 + 3.2456X$$

Where X = total fish length

Y = lateral scale radius.

A correction factor of 4 mm has been observed (Fig. 1).

In the members of Perciformes various hard parts such as scales (Radhakrishnan, 1957; Kutty, 1962; Hopson, 1965; Toor, 1968, Siefer, 1969; Dudley, 1974; Marcy and Richards, 1974; Landau, 1979;

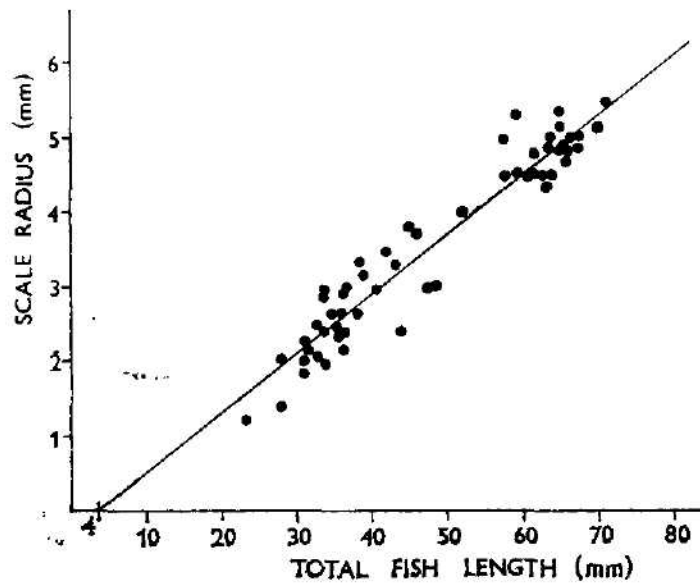


Fig. 1. Relationship between total fish length and lateral scale radius of *Colisa fasciata*. Total fish length (mm) along abscissa and scale radius (mm) along ordinate. $y = -3.1211 + 3.2456X$; $r = 0.9743$.

Bishai, 1980; Johal, 1980; Mayo et al. 1981; Schmitt and Hubert, 1982; Wells and Jorgenson, 1983; Davis and Kirkwood, 1984; Sanjose, 1984; Edwards, 1985), vertebrae (Jayaprakash, 1973; Bishai, 1980; Bortone & Hollingsworth, 1980; Manooch and Mason, 1984; Edwards, 1985; Mason and Manooch, 1985), Otoliths (Radhakrishnan, 1957; Kutty, 1962; Toor, 1968; Bortone and Hollingsworth, 1980; Francis, 1981; Mayo et al. 1981; Boehlert and Yoklavich, 1984; Harris, 1985), cleithra (Schmitt and Hubert, 1982) urohyal bone (Mason and Manooch, 1985) and opercular bone (Le Cren, 1947) have been employed.

Linear relationship between total fish length and the hard parts has been described by Siefer (1969), Dudley (1971), Marcy and Richards (1974), Johal (1980), Wells and Jorgenson (1983) and Sanjose (1984) indicating indeterminate type of growth pattern in perches.

Different correction factors have been described in the same species with little change (Johal, 1980; Sanjose 1984) indicating that the growth does differ under different ecological conditions. Most of the workers except Johal (1980) and Sanjose (1984) did not observe the correction factor in the perches.

Time of annulus formation has not been described in any Indian perch, whereas this aspect has been worked out to some extent outside the Indian sub-continent. In some members of the order Perciformes the annulus is formed in March-June (Siefer, 1969; Marcy and Richards, 1974; Bishai, 1980; Mason and Manooch, 1985), September to December (Davis and Kirkwood, 1984), December to March (Hopson, 1965) and October to January (Dudley, 1974). Most of the workers who worked on the age and growth of perches had the clear understanding that the annuli are formed annually. Siefer (1969) and Dudley (1974) were of the opinion that in young or immature fish the annulus is formed earlier than the mature specimens. As the present sample has been collected during the short time period therefore the observations of Siefer (1969) and Dudley (1974) could not be confirmed. As the older specimens belonging to the age classes 2+ and 3+ were sexually mature and had complete marginal annuli, and the younger specimens had little growth beyond the annulus, hence it could be concluded that sexual maturity can delay the annulus formation. Hopson (1965) observed that spawning, adverse environmental conditions especially food shortage are responsible for annulus formation in *Lates niloticus* from Lake Chad, Nigeria. He further stated that the scale ring usually formed under tropical conditions are not strictly comparable with those of temperate species, which are laid down as a consequence of difference between summer and winter growth rate and where changes in temperature is most important factor. He observed the winter mark (when temperature was around 12 °C) in addition to spawning mark. In the northern part of India, distinct summer and winter periods exist, but in most of the fish species spawning mark plays an important role in the annulus formation. During pre south-west monsoon the temperature of water rises, in isolated waters, ponds, waterlogged areas the depth also decreases and the total dissolved solids increases. The monsoon decreases little water temperature but due to flooding more solids are added to the water from the surroundings.

This results in imbalance of osmoregulation and as a result dehydration of

the body tissues takes place. This factor is in addition to the other factors described above is also responsible of annulus formation. In the present sample winter mark has not been recorded. Boehlert and Kappenman (1980) described high rate of growth in females in two species of *Sebastes* and recorded increased growth in higher latitudes. In the northern part of India delayed annulus formation observed in freshwater species with the decrease in both longitude and latitude. It appears that the annulus formation in this region directly depends upon the onset of south-west monsoon. During the monsoon period, most of the time, days become cloudy, resulting in the increase in carbon-di-oxide in most of the waterbodies due to decreased photosynthetic activity. This factor could also be considered for the annulus formation not described earlier.

Scales have been frequently used for the age determination in perches because they may be more economical to prepare for study and easier to obtain (Bortone and Charles, 1980), however Schmitt and Hubert (1982) experienced difficulty in ageing the old perch (*Perca fluviatilis*) scales, therefore, they preferred the use of cleithra in old yellow perch. The

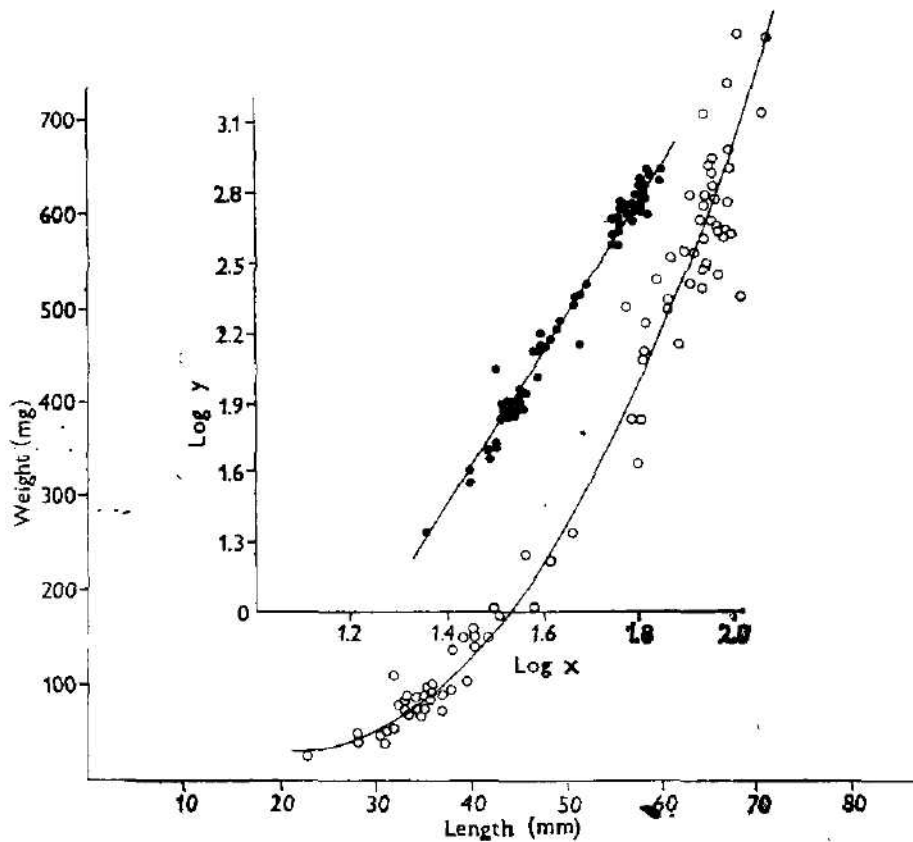


Fig. 2. Length-weight relationship of *Colisa fasciata*. Length (mm) along abscissa; weight (mm) along ordinate. ○ — original readings; ● — logarithmic values

Table 1. Back-calculated lengths of *Colisa fasciata* (Schneider) from Ludhiana collected during May, June 1985

Age Class	No. of	Average & Range	Back-calculated lengths in mm		
			l_1	l_3	l_3
0	1	23.00 (23.00-23.00)			
1	28	36.35 (31.2-48.1)	25.65 (15.11-41.15)		
2.	17	46.64 (35.00-63.10)	25.07 (17.99-38.87)	37.97 (19.99-57.01)	
3.	45	63.84 (40.70-71.80)	23.06 (12.99-32.77)	36.31 (17.58-50.41)	54.04 (32.87-61.65)
0 to 3	91	42.45 (23.00-71.80)	24.59 (12.99-41.15)	37.14 (17.58-57.01)	54.04 (32.87-61.65)
	<i>h</i>		24.59	12.55	16.90
	<i>W</i>		6.6 gm	15.19 gm	34.69 gm
	<i>Aw</i>		6.6 gm	8.59 gm	19.50 gm

h = annual increment; *W* = calculated weight using *L-W* relationship; *AW* = annual increase in weight.

present sample belonged to only three age classes, therefore the authors did not face any such problem in the present sample as far as age determination using scales is concerned.

Length-weight relationship has been calculated separately in the samples collected during the months of May and June respectively and the entire sample using the following equation (Fig. 2).

$$W = aL^n$$

$$\log W = \log a + n \log L$$

May, 1985 sample:

$$\log W = -2.24 + 2.11 \log L$$

$$W = 0.00575439 L^{2.11}$$

June, 1985 sample:

$$\log W = 3.5 + 2.86 \log L$$

$$W = 00031622 L^{2.86}$$

Clubbed sample:

$$\log W = -2.97 + 2.56 \log L$$

$$W = 0.1071519 L^{2.56}$$

From the above observations it is evident that the value of 'n' increased considerably during the month of June. According to Le Cren (1947) and Tandon (1961) the length-weight relationship is helpful in the determination of spawning season, well being, onset of sexual maturity etc. From the above observation based on the value of 'n' has indicated that there is quick growth

of ova (confirmed by visual observations also) in the month of June which has resulted in the increased value of 'b'. Vasnetsov (1953) found that the value of 'n' changes when the fish passes through different stages and each of which may have different length-weight relationship. Here, in this sample apparent difference has been observed during the different stages of maturity. Considering this fact it is necessary to calculate a number of regressions one for each group/phase of fish before pooling (Le Cren, 1951). However within a stage or for particular period which includes all the phase of life history, it is usual to calculate some average relationship that can be used in growth production and other studies. Hence, length-weight relationship of the pooled data has been used for calculating the average weight in each class.

In Table 1, back-calculated lengths in each previous year of life, weight attained in each year (calculated from the length-weight relationship), annual increment and annual increase in weight are presented. In the present sample of ninety one specimens, forty six belonged to age class 3+, followed by age classes 1+, 2+ and 0+ respectively. Phenomenon of growth compensation has been observed in the age class 3+. This phenomenon has been described in Indian cyprinids by Tandon and Johal (1983) and Johal and Tandon (1986).

Average weight attained in each age class has been calculated from the length-weight relationship (already described). The annual increment in weight increased with the increase in size (Table 1).

So far no growth data is available on *Colisa fasciata*, therefore, further discussion is not possible, however it is expected that the present observations will form the basis for future growth studies on this species.

SUMMARY

Age, growth based on 91 specimens based on scale studies and length-weight relationship of *Colisa fasciata* (Schn.) from a village pond near Ludhiana, Punjab, India have been described.

Ctenoid scales have been found to be suitable for age determination. The annulus is formed in the months of May-June. It appears earlier on the young species than the old ones. High temperature, low water level, sexual maturity and onset of southwest monsoon are some of the factors responsible for annulus formation.

Linear relationship between total fish length/scale radius with high degree of correlation has been observed. A correction factor of 4 mm has also been recorded.

The length-weight relationship has been found to be:

$$W = aL^n$$

$$\log W = \log a + n \log L$$

$$\log W = 2.97 + 2.56 \log L$$

$$= 0.1071519 L^{2.56}$$

An increase in the value of the exponent 'n' of L—W relationship has been observed in the month of June due to advanced stage of maturity. This observation indicated that the value of 'n' has direct relationship with the seasonal maturity.

There is annual increase in weight with the increase in age and on the contrary linear increment decrease with the increase in age. Phenomenon of growth compensation has been recorded in the age class 3+.

Acknowledgements

Authors are thankful to Dr. K. K. Tandon, Prof. & Chairman, Department of Zoology, Panjab University, Chandigarh for providing facilities and encouragement during the period of investigations.

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**DESCRIPTION OF THE FEMALE OF POECILOCHIRUS SUBTERRANEUS
(ACARINA: PARASITIDAE)**

Jan MÁČA

Institute of Parasitology, Czechoslovak Academy of Sciences,
Branišovská 31, 370 05 České Budějovice

Abstract: Female of the mite *Poecilochirus subterraneus* (Müller, 1859) belonging to the family Parasitidae is described for the first time. It has common features mainly with the female of *P. davydovae* Hyatt, 1980; however, it differs mainly in the shape of tectum, structure of 2nd legs and chaetotaxy.

The original description of *Poecilochirus subterraneus* (Müller, 1859) has been given on the base of deutonymph; the type material has been collected on the territory of present-day Czechoslovakia. Only deutonymphs were known until 1969, when Holzmann described the larva. Davydova (1969, 1976) gave description of both male and female which she presumed to belong to this species, but Hyatt (1980) associated them with the newly described deutonymph under the name *P. davydovae* Hyatt. Subsequently, Christie (1983) described the male of true *P. subterraneus*. Thus, in the present paper female of *P. subterraneus* is described for the first time. Morphologic terminology is adopted after Hyatt (1980).

Main diagnostic characters of the female of *P. subterraneus* are as follows: Fixed digit of chelicera with simple membranous process (like the deutonymph of *P. subterraneus* and both female and deutonymph of *P. davydovae*). To the contrary of *P. davydovae*, thorn-like appendage on 2nd legs is developed only on the femur; prongs of trispinate tectum are long and narrow; opisthonotal bristles are long, their apices often extend beyond bases of succeeding bristles (this last character is common with the deutonymph of *P. subterraneus*; both female and deutonymph of *P. davydovae* have short opisthonotal bristles).

Idiosoma 616 μm long and 410 μm wide.

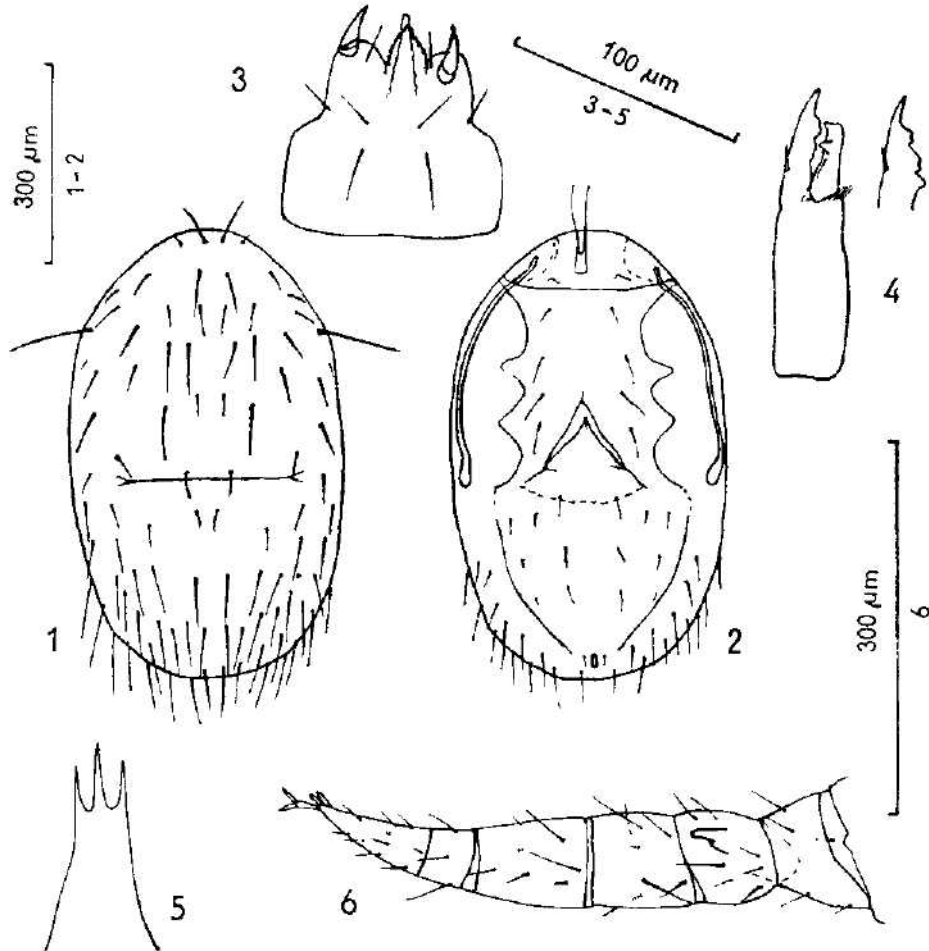
Dorsum (Fig. 1): Podonotal shield moderately sclerotized, with surface pattern indistinct. It bears 20 pairs of setae of varying lengths, none of them definitely rudimentary. Humeral bristle (as well as other setae) without plumage. Opisthonotal shield fits closely behind the podonotal, suture dividing both shields disappears laterally. Posteriorly the opisthonotal shield turns indistinctly into posterior membrane.

Venter (Fig. 2): Tritosternum with narrow base, laciniae not pilose. Pre-sternal shields elongated in transverse direction. Sternal shield without dark areas, sternal setae about as long as in *P. davydovae*. Genital shield pointed anteriorly, slightly demarcated against the opisthogastric shield (as in *P. davydovae*). The latter is subparallel cranially and tapering caudally. Anal orifice elongate (in *P. davydovae* almost rounded). Setae of opisthogastric shield mostly short, those of the surrounding membrane generally longer.

Tectum (Fig. 5) of characteristic shape, remembering deutonymphs of *P. austroasiaticus* Vitzhum or *P. carabi* C.& R. Canestrini. Chelicera as in Fig. 4; the free digit with only one prominent tooth, except apical point. Differences

in the figures of the fixed digit between left and right chelicera are mainly due to the fact that they are observed under somewhat different aspects. Bristles of palp trochanter and genu all setiform. Corniculi situated apically on their mounds — as in Fig. 3 (they are shifted laterad in *P. carabi*, mediad in *P. davydovae*). Setae of legs not pilose, 2nd leg (Fig. 6) except of the appendage of femur without analogous formations on the anteroventral side but with tiny denticle (very short bristle) on the dorsal surface of genu and tibia each. Tarsus with a false joint subbasally (as in the male of this species), with a pair of thickened bristles at apex.

Material examined: 1 ♀, South Bohemia, Hluboká nad Vltavou — Nová obora, Fagetum, 5. 7. 1988, from the hair of *Clethrionomys glareolus* (dead). Collected by the staff of the Department of Medical Entomology, Institute of Parasitology, České Budějovice, deposited in the collection of this institution.



Figs 1—6. *Poecilochirus subterraneus*, female. 1 — dorsum, 2 — venter, 3 — venter of gnathosoma, 4 — left chelicera and fixed digit of right chelicera, 5 — tectum, 6 — 2nd leg.

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I am much grateful to Mr. K. H. Hyatt (British Museum, Natural History, London), who provided me with valuable literature.

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BRAIN SIZE IN BIRDS: 3. COLUMBIFORMES THROUGH PICIFORMES

Jiří MLÍKOVSKÝ

Department of Evolutionary Biology, Czechoslovak Academy of Sciences,
Sekaninova 28, 128 00 Praha 2, Czechoslovakia

Abstract. Brain size in 194 bird species and its relation to body size in 7 families of birds are estimated. The following avian orders are considered: Columbiformes, Psittaciformes, Cuculiformes, Strigiformes, Caprimulgiformes, Apodiformes, Coliiformes, Trogoniformes, Coraciiformes and Piciformes.

Table 1. Brain size and encephalization in Columbiformes.

n = number of measured brains or cava crania, S = body mass (g), E = brain mass (g), I_{rel} = relative brain mass (%), Q_r = coefficient of relative encephalization. See Mlíkovský (1988) for the calculation of these indices. Author = who measured brains or cava crania. The figure in parentheses after the family name gives number of extant species of that family (after Wolters 1975—1982)

Taxon	n	S	E	I_{rel}	Q_r	Author
Columbidae (296)						
<i>Caloenas nicobarica</i>	1	600	2,9	0,48	-3,22	8
<i>Goura cristata</i>	5	2200	5,5	0,25	-10,87	2, 4, 8
<i>Ocyphaps lophotes</i>	2	145	1,7	1,17	24,96	1
<i>Geophaps smithii</i>	1		1,6			8
<i>Phaps chalcoptera</i>	2	300	1,7	0,57	-16,59	8
<i>Zenaidura macroura</i>	3	120	1,3	1,08	6,16	8
<i>Zenaida aurita</i>	1	130	1,23	0,95	-3,93	5
<i>Columbigallina talpacoti</i>	1	45	0,75	1,67	5,66	8
<i>Scardafella squamata</i>	1		1,0			8
<i>Geopelia cuneata</i>	7	40	0,52	1,30	-21,78	4-6, 8
<i>Oena capensis</i>	2	40	0,7	1,75	5,29	8
<i>Turtur afer</i>	4	60	0,9	1,50	8,05	3, 5
<i>Streptopelia senegalensis</i>	2	105	1,3	1,24	14,34	8
<i>Streptopelia turtur</i>	3	125	1,4	1,12	11,76	8
<i>Streptopelia roseogrisea</i>	3	115	1,1	0,96	-8,02	6
<i>Streptopelia risoria</i>	3	145	1,2	0,83	-11,79	4, 5
<i>Streptopelia decaocto</i>	4	275	1,6	0,58	-17,61	8
<i>Columba livia</i> (wild)	39	300	2,2	0,73	7,94	4, 7
<i>Columba oenas</i>	3	275	2,2	0,80	13,29	8
<i>Columba palumbus</i>	12	500	2,6	0,52	-3,98	4-6, 8
<i>Ducula oceanica</i>	1		1,9			8
<i>Ducula lacernulata</i>	1		2,4			8
<i>Didunculus strigirostris</i>	1	450	3,0	0,67	17,48	8
Raphidae (3)						
No data						

1 = Hrdlička 1905, 2 = Girard 1908, 3 = Waterlot 1912, 4 = Portmann 1947, 5 = Vaughan 1949, 6 = Senglaub 1963, 7 = Löhmer und Ebinger 1980, 8 = Mlíkovský this paper

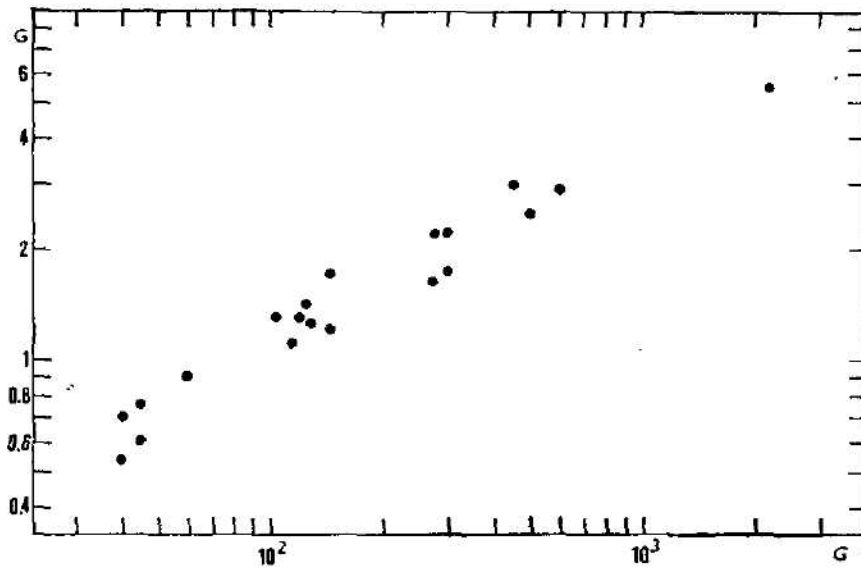


Fig. 1. Relationship between the brain size (Y axis) and the brain size (X axis) in Columbidae. See Table 1 for exact data.

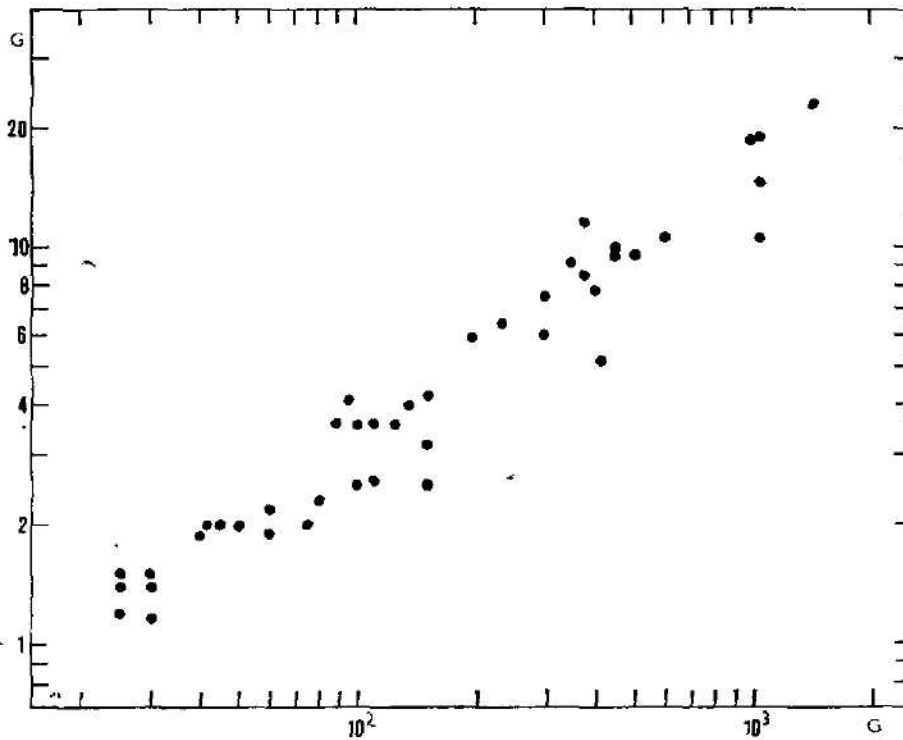


Fig. 2. Relationship between the brain size (Y axis) and the body size (X axis) in Psittacidae. See Table 2 for exact data.

INTRODUCTION

This is a continuation of my review of the brain size in birds (Mlíkovský 1989 a, b). See Mlíkovský (1989a) for the sections on Material and Methods.

RESULTS AND DISCUSSION

Columbiformes

The data on the brain size and the body size in Columbiformes are presented in the Table 1 and Figure 1. The data were sufficient for the calculation of regression equation in the family Columbidae only. Here, brain size and body size are positively correlated ($r_H = 2.052 \pm 0.236$; $p < 0.001$) and their allometrical relation is $E = 0.0855 S^{0.556 \pm 0.309}$ ($n = 19$). The slope of this regression is significantly lower than the Jerison's constant ($t_s = -3.581$; $p < 0.001$), but does not significantly differ from the Dubois' constant ($t_s = -0.129$; $p < 0.05$).

Psittaciformes

The data on the brain size and the body size in Psittaciformes are presented in the Table 2 and Figure 2. In the Psittacidae, the only family of this order, brain size and body size are positively correlated ($r_H = 2.062 \pm 0.156$; $p < 0.001$) and their allometrical relation is $E = 0.123 S^{0.703 \pm 0.0463}$ ($n = 43$). The slope of this regression is significantly higher than the Dubois' constant ($t_s = 3.089$; $p < 0.01$), but does not significantly differ from the Jerison's constant ($t_s = 0.785$; $p > 0.05$).

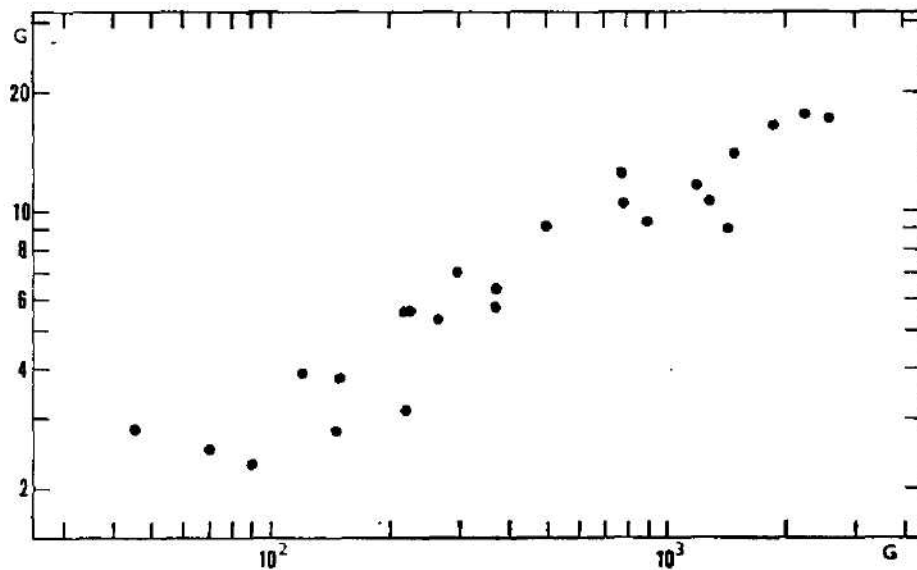


Fig. 3. Relationship between the brain size (Y axis) and the body size (X axis) in Strigidae. See Table 4 for exact data.

Table 2. Brain size and encephalisation in Psittaciformes.
See Table 1 for explanation

Taxon	n	S	E	I_{rel}	Q_r	Author
Psittacidae (327)						
<i>Loriculus stigmatus</i>	1	30	1,5	5,00	11,63	8
<i>Loriculus galgulus</i>	1	25	1,5	6,00	26,89	8
<i>Loriculus vernalis</i>	1	25	1,4	5,60	18,43	8
<i>Agapornis taranta</i>	3	60	2,2	3,67	0,57	8
<i>Agapornis pullarius</i>	3	30	1,4	4,67	4,19	8
<i>Agapornis roseicollis</i>	3	45	2,0	4,44	11,92	8
<i>Agapornis fischeri</i>	2	42	2,0	4,76	17,48	5
<i>Agapornis personatus</i>	7	40	2,0	5,00	21,58	6-8
<i>Forpus passerinus</i>	4	25	1,2	4,80	1,51	8
<i>Boborhynchus lineola</i>	1	50	2,0	4,00	3,93	8
<i>Anodorhynchus hyacinthinus</i>	1		24,5			8
<i>Ara ararauna</i>	3	1000	18,4	1,84	16,39	5-6
<i>Ara chloroptera</i>	3	1450	23,4	1,61	13,99	5-6, 8
<i>Aratinga canicularis</i>	1	150	3,1	2,07	-25,58	8
<i>Brotogeris jugularis</i>	1	60	1,9	3,17	-13,14	1
<i>Amazona leucocephala</i>	7	235	6,4	2,72	12,05	1
<i>Amazona amazonica</i>	3	300	7,5	2,50	10,60	2-3, 8
<i>Amazona aestiva</i>	2	300	6,0	2,27	-11,52	6, 8
<i>Amazona ochrocephala</i>	12	380	9,0	2,37	12,40	1, 8
<i>Amazona farinosa</i>	1	380	11,5	3,03	43,62	8
<i>Amazona versicolor</i>	5	400	7,8	1,95	-6,04	5
<i>Pionites leucogaster</i>	1		5,1			8
<i>Picocephalus robustus</i>	1		8,0			8
<i>Psittacus erithacus</i>	11	350	9,0	2,57	19,09	1, 5, 8
<i>Psittacula cyanocephala</i>	1	80	2,3	2,88	-14,11	8
<i>Psittacula krameri</i>	4	110	3,6	3,27	7,47	2, 8
<i>Psittacula eupatria</i>	1	95	4,1	4,32	35,69	5
<i>Psittacula alexandri</i>	3	125	3,6	2,88	-1,76	8
<i>Prioniturus plauturus</i>	1		4,2			8
<i>Prosopija personata</i>	1	420	5,1	1,21	-40,64	8
<i>Alisterus scapularis</i>	1		3,1			8
<i>Trichoglossus haematodus</i>	8	150	2,5	1,67	-39,99	5, 8
<i>Eos fuscata</i>	2	150	4,2	2,80	0,82	8
<i>Eos squamata</i>	1		3,8			8
<i>Chalcopsitta atra</i>	1	195	5,9	3,03	17,77	8
<i>Psephotus haematonotus</i>	1	75	2,0	2,67	-21,84	8
<i>Platycercus eximius</i>	4	110	2,6	2,36	-22,38	8
<i>Platycercus elegans</i>	2	135	4,0	2,96	3,40	8
<i>Eunymphicus cornutus</i>	2	100	3,6	3,60	14,92	8
<i>Melopsittacus undulatus</i>	19	30	1,15	3,83	-14,42	1, 3-6, 8
<i>Strigops habroptilus</i>	1	1050	14,5	1,38	-11,37	8
<i>Probosciger aterrimus</i>	1	1050	18,5	1,76	13,08	8
<i>Calyptorhynchus magnificus</i>	2	1050	10,3	0,98	-37,04	8
<i>Cacatua galerita</i>	1	450	10,0	2,22	10,89	8
<i>Cacatua sulphurea</i>	2	450	9,4	2,09	4,24	5, 8
<i>Cacatua moluccensis</i>	2	600	10,3	1,72	-6,70	1, 8
<i>Nymphicus hollandicus</i>	11	100	2,5	2,50	-20,19	1, 4-6, 8
<i>Nestor meridionalis</i>	1	510	9,5	1,86	-3,53	8
<i>Nestor notabilis</i>	1		15,5			8

1 = Hrdlička 1905, 2 = Lericque and Girard 1905, 3 = Girard 1908, 4 = Portmann and Vischer 1943, 5 = Portmann 1947, 6 = Senglaub 1963, 7 = Krompecher and Lipák 1966, 8 = Mlikovský this paper

Table 3. Brain size and encephalization in Cuculiformes.
See Table 1 for explanation

Taxon	n	S	E	I _{rel}	a _r	Author
Musophagidae (22)						
<i>Corythacola cristata</i>	1		6,2			3
<i>Musophaga violacea</i>	1		3,7			3
<i>Musophaga rosae</i>	2		4,2			3
<i>Tauraco erythrolophus</i>	1		3,1			3
<i>Tauraco lewinsonii</i>	1		2,9			3
<i>Tauraco persa</i>	1		2,9			3
<i>Corythaizoides concolor</i>	4		3,6			3
Cuculidae (130)						
<i>Guira guira</i>	2	120	2,0	1,67	6,10	3
<i>Crotophaga ani</i>	18	100	1,85	1,85	10,80	3
<i>Centropus phasianinus</i>	1		4,0			3
<i>Centropus senegalensis</i>	3	150	2,7	1,80	23,48	1
<i>Coua caerulea</i>	1		4,2			3
<i>Geococcyx californianus</i>	2	290	3,4	1,17	0,31	3
<i>Saurothera merlini</i>	4		2,5			3
<i>Piaya cayana</i>	1	110	2,0	1,82	12,42	3
<i>Coccyzus minor</i>	1		1,2			3
<i>Clamator glandarius</i>	3	135	1,8	1,33	-11,70	3
<i>Cuculus canorus</i>	9	120	1,6	1,33	-18,46	2, 3
<i>Eudynamis scolopacea</i>	3	220	2,3	1,05	-18,46	3
<i>Rhinorhina chlorophaea</i>	1		1,3			3

1 = Waterlot 1912, 2 = Portmann 1947, 3 = Mlíkovský this paper

Cuculiformes

The data on the brain size and the body size in Cuculiformes are presented in the Table 3. The data were sufficient for the calculation of the regression equation in the family Cuculidae only.

In this family, brain size and body size are positively correlated ($r_s = 0.661$; $p < 0.05$) and their allometrical relation is $E = 0.0781 S^{0.665 \pm 0.158}$ ($n = 8$). The slope of this regression does not significantly differ either from the Jerison's constant ($t_s = -0.010$; $p > 0.05$) or the Dubois' constant ($t_s = 0.665$; $p > 0.05$).

Strigiformes

The data on the brain size and the body size in Strigiformes are presented in the Table 4 and Figure 3. In the Strigidae, the only modern family of this order, brain size and body size are positively correlated ($r_H = 1.746 \pm 0.204$; $p < 0.001$) and their allometrical relation is $E = 0.243 S^{0.552 \pm 0.0367}$ ($n = 25$). The slope of this regression is significantly lower than the Jerison's constant ($t_s = -3.124$; $p < 0.01$), but does not significantly differ from the Dubois' constant ($t_s = -0.218$; $p > 0.05$).

Caprimulgiformes

The data on the brain size and the body size in Caprimulgiformes are presented in the Table 5. The data do not allow the calculation of the regression equation for either of the families included.

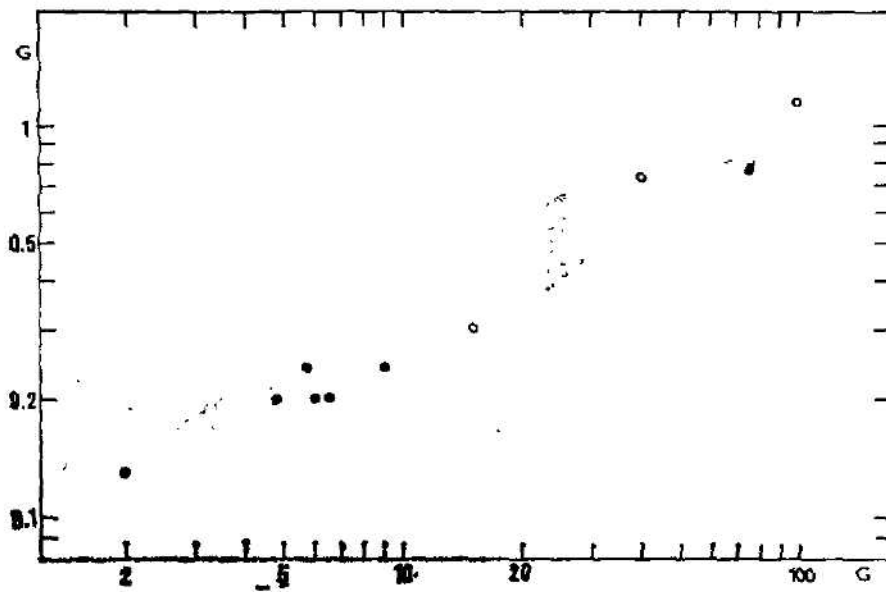


Fig. 4. Relationship between the brain size (Y axis) and the body size (X axis) in Apodidae (○) and Trochilidae (●). See Table 6 for exact data.

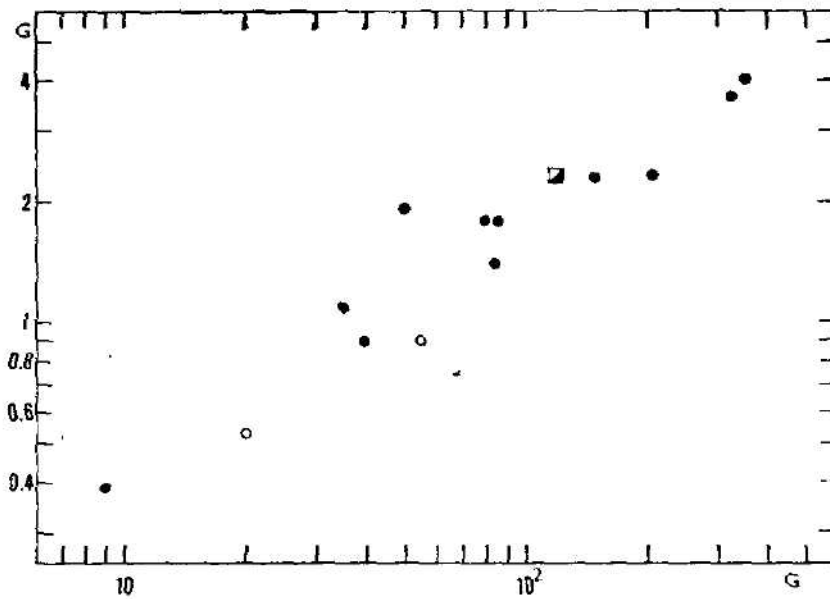


Fig. 5. Relationship between the brain size (Y axis) and the body size (X axis) in Alcedinidae (●), Meropidae (○), Momotidae (▲) and Trogonidae (*). See Tables 7 and 8 for exact data.

Table 4. Brain size and encephalization in Strigiformes.
See Table 1 for explanation

Taxon	n	S	E	I_{rel}	Q_e	Author
Strigidae (142)						
<i>Tyto alba</i>	36	275	6,7	2,44	24,15	1, 4, 5, 8, 11
<i>Asio flammeus</i>	14	370	5,7	1,54	-10,34	2, 7, 8, 11
<i>Asio clamator</i>	1	370	6,4	1,73	0,68	11
<i>Asio otus</i>	35	270	5,7	2,11	6,70	5, 7-9, 11
<i>Strix varia</i>	2	700	12,3	1,76	36,08	1
<i>Strix uralensis</i>	5	900	9,4	1,04	-9,47	11
<i>Strix nebulosa</i>	1	1300	10,5	0,81	-17,48	11
<i>Strix aluco</i>	32	500	9,2	1,84	22,56	4-5, 9, 11
<i>Strix perspicillata</i>	1	790	10,5	1,33	8,67	11
<i>Otus asio</i>	1	220	5,6	2,55	17,37	1
<i>Otus choliba</i>	1	145	2,8	1,93	-26,13	11
<i>Otus scops</i>	2	90	2,3	2,56	-21,04	5, 11
<i>Otus leucotis</i>	2	220	5,3	2,41	-11,08	11
<i>Bubo poensis</i>	1	1450	9,0	0,62	-33,39	11
<i>Bubo virginianus</i>	4	1500	14,9	0,99	8,24	1
<i>Bubo bubo</i>	47	2600	16,9	0,65	-9,38	5, 10, 11
<i>Bubo capensis</i>	1	1200	11,5	0,96	-5,51	11
<i>Bubo lacteus</i>	1	2200	17,5	0,80	2,90	11
<i>Nyctea scandiaca</i>	4	1900	16,0	0,84	2,01	1, 11
<i>Surnia ulula</i>	1	300	7,0	2,33	23,63	11
<i>Aegolius funereus</i>	2	150	3,3	2,53	-1,60	11
<i>Athene noctua</i>	23	120	4,0	3,33	17,15	3-6, 11
<i>Glaucidium minutissimum</i>	1	45	2,8	6,22	40,92	11
<i>Glaucidium passerinum</i>	2	70	2,5	3,57	-1,41	11
<i>Ninox scutulata</i>	1	220	3,1	1,41	-35,03	11

1 = Hrdlička 1905, 2 = Girard 1908, 3 = Dubois 1914, 4 = Portmann and Vischer 1943, 5 = Portmann 1947, 6 = Vaughen 1949, 7 = Skvorcova 1952, 8 = Senglaub 1963, 9 = Stork 1976, 10 = Picchocki, pers. communication, 11 = Mlíkovský this paper

Apodiformes

The data on the brain size and the body size in Apodiformes are presented in the Table 6 and Figure 4. The data do not allow the calculation of the regression equation for either of the families included.

In Trochilidae, brain size and body size are only marginally correlated ($r_s = 0.643$; $p < 0.1$). This clearly appears to be an artifact, caused by small number of included species and by restricted range of body size. Nevertheless, calculation of the regression equation is meaningless until the bias is removed.

Coliiformes

The data on the brain size and the body size in Coliiformes are presented in the Table 7. They do not allow the calculation of the regression equation for the Coliidae, the only family included.

Trogoniformes

The data on the brain size and the body size in Trogoniformes are presented in the Table 7 and Figure 5. The data do not allow the calculation of the regression equation for the Trogonidae, the only modern family included.

Table 5. Brain size and encephalization in Caprimulgiformes.
See Table 1 for explanation

Taxon	n	S	E	I _{rel}	Q _r	Author
Steatornithidae (1) <i>Steatornis caripensis</i>	2		3,3			2
Podargidae (12) <i>Podargus strigoides</i>	1		4,7			2
Aegothelidae (7) No data						
Nyctibiidae (5) No data						
Caprimulgidae (78)						
<i>Hydropsalis brasiliانا</i>	1		1,6			2
<i>Macropsalis creagra</i>	1		1,1			2
<i>Caprimulgus europaeus</i>	4	80	0,94	1,18		1-2
<i>Semiophorus vexillarius</i>	1	70	1,0	1,43		2

1 = Portmann 1947, 2 = Mlikovský this paper

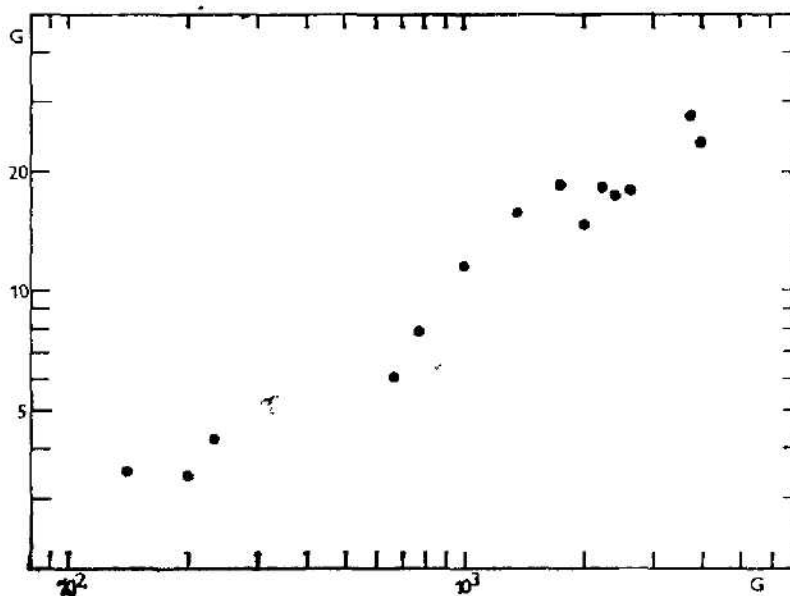


Fig. 6. Relationship between the brain size (Y axis) and the body size (X axis) in Bucerotidae. See Table 8 for exact data.

Table 6. Brain size and encephalization in Apodiformes.
See Table 1 for explanation

Taxon	n	S	E	I _{rel}	A _r	Author
Hemiprocnidae (4)						
No data						
Apodidae (82)						
<i>Apus melba</i>	11	100	1,13	1,13		5, 8
<i>Apus apus</i>	26	40	0,72	1,80		4-8
<i>Cypsiurus parvus</i>	1	15	0,3	2,00		2
Trochilidae (317)						
<i>Glaucus hirsuta</i>	1	6,5	0,20	3,08		8
<i>Colibri coruscans</i>	1	9,0	0,24	2,67		8
<i>Amazilia tzacatl</i>	1	4,8	0,20	4,17		3
<i>Lampornis amethystinus</i>	1	6,0	0,20	3,08		1
<i>Glyptolaema rubricauda</i>	1		0,28			8
<i>Ocreatus underwoodi</i>	1		0,14			8
<i>Agelaiocercus kingi</i>	1		0,22			8
<i>Agelaiocercus coelestis</i>	1		0,22			8
<i>Heliothryx barroti</i>	1	5,7	0,24	4,21		8
<i>Mellisuga minima</i>	1	2,0	0,13	6,50		1

1 = Lapeque 1908, 2 = Waterlot 1912, 3 = Crile and Quiring 1940, 4 = Portmann and Vischer 1943, 5 = Portmann 1947, 6 = Skvorecova 1952, 7 = Senglaub 1963, 8 = Mlíkovský this paper

Coraciiformes

The data on the brain size and the body size in Coraciiformes are presented in the Table 8 and Figures 5-6. The data were sufficient for the calculation of the regression equations in the families Alcedinidae and Bucerotidae only.

In Alcedinidae, brain size and body size are positively correlated ($r_s = 0.967$; $p < 0.01$) and their allometrical relation is $E = 0.0964 S^{0.639 \pm 0.0339}$ ($n = 9$). The slope of this regression is significantly higher than the Dubois' constant ($t_s = 2.330$; $p < 0.05$), but does not significantly deviate from the Jerison's constant ($t_s = -0.816$; $p > 0.05$).

Table 7. Brain size and encephalization in Coliiformes and Trogoniformes.
See Table 1 for explanation

Taxon	n	S	E	I _{rel}	Q _r	Author
Coliidae (6)						
<i>Colius striatus</i>	1	55	1,1	2,00		1
<i>Urocolius indicus</i>	2	60	1,2	2,00		1
Trogonidae (39)						
<i>Trogonurus cucurui</i>	1	50	1,9	3,80		1
<i>Pratelus lemnurus</i>	1		1,2			1
<i>Pharomachrus mocino</i>	1	205	2,3	1,12		1

1 = Mlíkovský this paper

Table 8. Brain size and encephalization in Coraciiformes.
See Table 1 for explanation

Taxon	n	S	E	I _{rel}	Q _r	Author
Alcedinidae (91)						
<i>Ceryle rudis</i>	3	80	1,7	2,13	7,23	2, 5
<i>Chloroceryle amazona</i>	1		3,6			5
<i>Chloroceryle americana</i>	1	35	1,1	3,14	17,67	5
<i>Streptoceryle torquata</i>	2	325	3,7	1,14	-4,71	5
<i>Streptoceryle alcyon</i>	1	150	2,6	1,73	9,74	5
<i>Dacelo novaeguineae</i>	2	360	4,1	1,14	-1,09	1
<i>Halcyon myrnenensis</i>	2	95	1,8	1,89	1,73	5
<i>Todiramphus chloris</i>	2	85	1,4	1,65	-15,05	5
<i>Alcedo althuis</i>	7	40	0,9	2,25	-11,60	4-5
<i>Ispidina picta</i>	3	9	0,39	4,33	-0,64	2
Todidae (5)						
No data						
Momotidae (9)						
<i>Momotus momota</i>	1	120	2,3	1,92		5
Meropidae (25)						
<i>Merops apiaster</i>	3	55	0,89	1,62		4-5
<i>Merops rubicus</i>	1		0,9			5
<i>Merops albicollis</i>	3	20	0,53	2,65		2
Coraciidae (11)						
<i>Coracias garrulus</i>	6	160	2,2	1,38		5
<i>Eurystomus glaucurus</i>	1		1,8			5
Brachypteracidae (5)						
No data						
Leptosomatidae (1)						
No data						
Upupidae (1)						
<i>Upupa epops</i>	12	60	0,98	1,63		4-5
Phoeniculidae (6)						
No data						
Bucerotidae (46)						
<i>Tockus erythrorhynchus</i>	2	140	3,25	2,32	16,82	5
<i>Tockus monteiri</i>	1	200	3,2	1,60	-9,39	5
<i>Tockus alboterminatus</i>	2	235	4,2	1,79	6,76	5
<i>Rhyticeros undulatus</i>	1	2250	18,5	0,82	3,74	5
<i>Rhyticeros phacatus</i>	1	1750	18,5	1,06	22,74	5
<i>Anthracoseros malayanus</i>	1	1000	11,5	1,16	10,94	5
<i>Bycanistes fistulator</i>	3	765	8,3	1,08	-4,21	5
<i>Bycanistes bucinator</i>	1	670	6,0	0,90	-24,33	5
<i>Bycanistes cylindricus</i>	2		11,5			5
<i>Bycanistes subcylindricus</i>	13		14,3			5
<i>Ceratogymna elata</i>	2	2000	14,8	0,74	-10,20	5
<i>Ceratogymna atrata</i>	1	1350	15,5	1,15	22,33	5
<i>Buceros rhyticeros</i>	2	2400	17,8	0,74	-4,40	5
<i>Buceros bicornis</i>	2	2600	17,8	0,68	-9,38	5
<i>Bucorvus abyssinicus</i>	4	4000	23,4	0,59	-10,70	5
<i>Bucorvus cafer</i>	4	3800	27,3	0,72	7,82	3, 5

1 = Hrdlička 1905, 2 = Waterlot 1912, 3 = Crile and Quring 1940, 4 = Portmann 1947,
5 = Mlíkovský this paper

Table 9. Brain size and encephalization in Piciformes.
See Table 1 for explanation

Taxon	n	S	E	I_{rel}	Q_r	Author
Galbulidae (15)						
<i>Galbula galbula</i>	1	21	0,6	2,86		6
Bucconidae (32)						
No data						
Caprimidae (81)						
<i>Megalaima virens</i>	1		2,2			6
<i>Trachyphonus margaritatus</i>	2		1,2			6
<i>Eobucco bourcieris</i>	1	34	1,1	3,24		6
Indicatoridae (16)						
No data						
Ramphastidae (33)						
<i>Selenidera maculirostris</i>	1		3,0			6
<i>Ramphastos tucanus</i>	3		5,3			6
<i>Ramphastos toco</i>	2		6,3			6
<i>Ramphastos sulphuratus</i>	1		4,8			6
<i>Ramphastos vitellinus</i>	2	350	4,7	1,34		6
Picidae (204)						
<i>Dendrocopos major</i>	36	85	2,8	3,29	-1,55	2-6
<i>Dendrocopos medius</i>	4	70	2,3	3,29	-7,39	3, 5, 6
<i>Dendrocopos minor</i>	4	22	1,2	5,45	8,38	4-6
<i>Picoides tridactylus</i>	4	65	3,2	4,92	35,68	5
<i>Melanerpes formicivorus</i>	1	75	2,5	3,33	-4,07	6
<i>Centurus aurifrons</i>	1	55	2,2	4,00	4,82	6
<i>Centurus superciliosus</i>	3	85	2,6	3,06	-8,58	6
<i>Colaptes cafer</i>	1	110	2,7	2,45	-20,70	6
<i>Picus canus</i>	6	110	3,6	3,27	5,73	3, 5-6
<i>Picus viridis</i>	15	200	4,4	2,20	-14,86	1-6
<i>Dryocopus lineatus</i>	1	180	4,3	2,39	-10,45	6
<i>Dryocopus martius</i>	6	250	7,7	3,08	27,50	3, 6
<i>Jynx torquilla</i>	9	35	0,9	2,57	-41,21	2-3, 6

1 = Girard 1908, 2 = Portmann and Vischer 1943, 3 = Portmann 1947, 4 = Vaughan 1949, 5 = Skvorecva 1954, 6 = Mlikovský this paper

In Alcedinidae, brain size and body size are positively correlated ($r_s = 0.967$; $= 2.207 \pm 0.277$; $p < 0.001$) and their allometrical relation is $E = 0.102 S^{0.669-0.0367}$ ($n = 14$). The slope of this regression is significantly higher than the Dubois' constant ($t_s = 2.970$; $p < 0.01$), but does not significantly differ from the Jerison's constant ($t_s = 0.064$; $p > 0.05$).

Piciformes

The data on the brain size and the body size in Piciformes are presented in the Table 9 and Figure 7. The data were sufficient for the calculation of the regression equation only in the family Picidae.

In this family, if *Jynx* is excluded from calculations (see below), brain size

and body size are positively correlated ($r_H = 1.612 \pm 0.302$; $p < 0.001$) and their allometrical relation is $E = 0.128 S^{0.698 \pm 0.0751}$ ($n = 12$). The slope of this regression does not significantly deviate from both the Jerison's constant ($t_s = 0.417$; $p > 0.05$) and the Dubois' constant ($t_s = 1.838$; $p > 0.05$).

Considerable differences in encephalization between the picid subfamilies are worth mentioning. The ancestral Jynginae, represented here by *Jynx torquilla*,

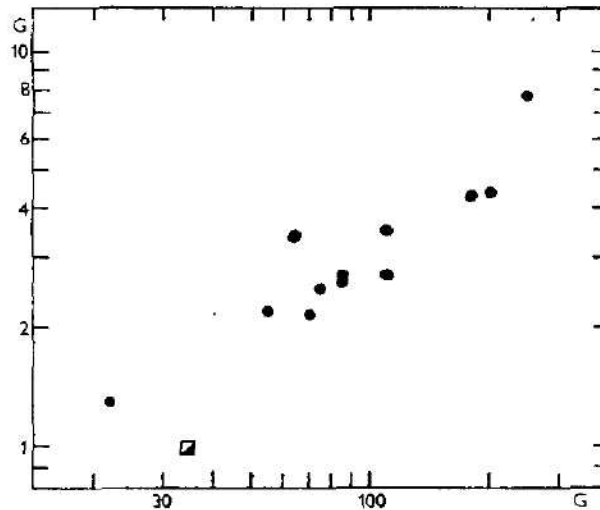


Fig. 7. Relationship between the brain size (Y axis) and the body size (X axis) in Picidae. ■ = *Jynx torquilla*. See Table 9 for exact data.

are markedly less encephalized than the derived Picinae, to which belong all other studied picid species (see Table 9 and Figure 7). This agrees well with the more primitive structural organization of the jyngine brain (Brandis 1896, Dennler 1919, Ruge 1971). Unfortunately, no data were available on encephalization and/or brain morphology of the Picuminae, another ancestral picid subfamily.

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**SOME AMPHIBIAN TREMATODES FROM VIETNAM AND PAPUA
NEW GUINEA**

František MORAVEC & Ottó SEY

¹Institute of Parasitology, Czechoslovak Academy of Sciences, Branišovská 31, 370 05 České Budějovice, Czechoslovakia and ²Department of Zoology, University of Agricultural Sciences, H-8361 Keszthely, Hungary

Abstract: An examination of small samples of five species of the frogs originating from North Vietnam (*Rana rugulosa* and *R. kuhlii*) and Papua New Guinea (*Cophixalus parkeri*, *Rana grisea*, *R. grunniens*) yielded altogether 10 species of trematodes, 6 of them being new to science. These include: *Glypthelmins staffordi*, *Batrachotrema vietnamensis* sp. n. (type host *R. rugulosa*), *Halipegus mehransis*, *Pleurogenes longivitellaris* sp. n. (type host *R. kuhlii*), *Pleurogenoides sphaericus*, and *Ganeo tigrinus* from Vietnam and *Halipegus zweifeli* sp. n. (type host *R. grunniens*), *Opisthoglyphe cophixali* sp. n. (type host *C. parkeri*), *Dolichosaccus grandiacetabularis* sp. n. (type host *R. grisea*), and *Dolichosaccus longibursatus* sp. n. (type host *R. grunniens*) from Papua New Guinea. The present paper is the first to report amphibian trematodes from Papua New Guinea; *Halipegus mehransis* is reported from Vietnam for the first time. All the trematode species are briefly described and illustrated and some problems concerning their taxonomy and distribution are discussed.

In spite of the fact that the territory of both Vietnam and Papua New Guinea are of particular interest from the viewpoint of zoogeography and animal evolution, the helminth faunas of amphibians of these regions have so far been studied only rarely (see Moravec and Sey 1985, 1986). As far as we know, the only papers dealing with trematodes from Vietnamese amphibians are those by Odening (1968) and Sey (1985), reporting a total of 7 species of these parasites, whereas there are hitherto no data concerning the trematodes of amphibians from Papua New Guinea (see Ewers 1973). Some data on amphibian trematodes exist only from the nearby Fiji and British Solomon Islands (Fischthal and Kuntz 1967).

In 1984, during his visit to Vietnam, the junior author (O. Sey) examined for helminths a certain number of amphibians collected in Hanoi. Of them, four species proved to harbour the trematodes. Two trematode species of this material, *Diplodiscus amphichrus* Tubanguil, 1933 from *Rana rugulosa* and *D. mehrai* Pande, 1937 from *Rana limnocharis* and *Paramesotriton deloustali* have already been reported by Sey (1985), while the remaining species, collected from *Rana rugulosa* and *R. kuhlii*, are the subject of the present paper. Nematodes have been dealt with by Moravec and Sey (1985).

The other species of trematodes presented in this paper were collected from small samples of the fixed specimens of Papua New Guinea frogs from the collections of the Department of Herpetology, American Museum of Natural History in New York that had been kindly provided for study by Dr. R. C. Zweifel. A part of nematodes of this collection has already been treated by Moravec and Sey (1986). The trematodes were recorded from *Cophixalus parkeri*, *Rana grisea* and *R. grunniens*.

According to Frost (1985), the distribution of *Rana rugulosa* is from Burma and southern China (north to Yangtze River and including Taiwan) to Thailand and was introduced in Borneo, while that of *Rana kuhlii* is from Assam (India) and Yunnan and Taiwan (China) through Indochina to the Greater Sundas as far as Celebes. As to the Papua New Guinea species of host frogs, the area of distribution of *Rana grisea* includes New Guinea and Ceram Isl., that of *Rana grunniens* Java, Celebes and Amboina Isl., whereas *Cophixalus parkeri* is distributed only over the central mountainous region of Papua New Guinea, from Chimbu Province to Morobe Province (see Frost 1985).

MATERIALS AND METHODS

The majority of Vietnamese trematode materials were collected from the hosts (*Rana rugulosa* Wiegmann, 1835 and *R. kuhlii* Tschudi, 1838) deposited in formaldehyde in the Department of Vertebrate Zoology, Hanoi University, while the lesser part was recovered from live hosts by the junior author (O. Sey) in Hanoi in 1984. All Papua New Guinea materials were obtained by dissecting anuran specimens deposited in 70% ethanol from the collections of the Department of Herpetology, American Museum of Natural History in New York: *Rana grunniens* Sonnini et Latreille, 1801 (Cat. No. 77618), *Rana grisea* van Kampen, 1913 (Cat. No. 77177), and *Cophixalus parkeri* Loveridge, 1948 (Cat. No. 66318).

The trematodes recovered from fixed hosts were placed in distilled water for 24 h and then, slightly pressed between two glasses, were re-fixed in 10% formaldehyde. After staining in carmine, the specimens were dehydrated and mounted in Canada balsam as permanent preparations. Most specimens have been deposited in the helminthological collection of the Institute of Parasitology, Czechoslovak Academy of Sciences, in České Budějovice, Czechoslovakia, representative specimens also in the Department of Zoology, Agricultural University in Keszthely in Hungary; representative specimens of Vietnamese species also in the Department of Vertebrate Zoology, Hanoi University, Vietnam. In the following account of the species encountered, measurements are given in millimetres.

REVIEW OF SPECIES

1. *Glypthelmins staffordi* Tubanguí, 1928 (Fig. 1 A—C)

Description (10 specimens): Length of body of gravid specimens 1.58—4.22, maximum width 0.558—1.523. Cuticle spinose, dense spination being in anterior part of body: cuticle spines covering approximately two anterior thirds of body, their density gradually decreasing in posterior direction. Oral sucker subterminal, size 0.198—0.313 × 0.219—0.340; acetabulum less leveloped, situated at anterior part of body, size 0.090—0.245 × 0.105—0.245. Size ratio of both suckers 1 : 0.5—0.8. Prepharynx indistinct, muscular pharynx measuring 0.087—0.204 × 0.099—0.177; oesophagus 0.057—0.095 long. Pharyngeal glands present. Caeca by far not reaching posterior end of body. Genital pore median, just preacetabular. Testes almost spherical, size 0.218—0.449 × 0.218—0.435, symmetrical or slightly diagonal, in short distance below acetabulum. Cirrus sac well developed, usually partly overlapped by acetabulum; its length 0.180—0.517, width 0.075—0.163. Ovary spherical, measuring 0.150—0.367 × 0.159—0.394, situated immediately in front of left testis at acetabulum level. Uterus forming numerous coils filling in intercaecal field, reaching posteriorly almost to body end; anteriorly uterus passing between both testes. Vitellaria multifollicular, forming two lateral groups of follicles distributed laterally to caeca and partly overlapping them; vitellaria starting anteriorly at level of ovary

and posteriorly by far not reaching ends of caeca. Operculated eggs numerous, oval, yellow, size $0.027-0.033 \times 0.015-0.021$.

Host: *Rana rugulosa* Wiegmann (fam. Ranidae).

Localization: intestine.

Locality: Hanoi, North Vietnam (1984).

Comments: — The present material has consisted of 78 gravid specimens at different state of development. Their morphology corresponds on the whole to the original description of *G. staffordi* with the exception that the spination of cuticle does not reach up to the body end, the spines covering only some two anterior thirds of the body length. However, in our opinion this difference in the extent of cuticular spination should be considered an intraspecific variability. Also Odening (1968) considered congeneric specimens from the same host species from the vicinity of Hanoi to be *G. staffordi*.

This trematode species was originally described from *Rana vittigera* from the Philippines, later it was found as well in *R. rugulosa* in China (Canton) and *R. tigerina* in Taiwan (see Yamaguti 1971). From Vietnam from the surroundings of Hanoi this species has already been reported by Odening (1968) who recorded it from *Rana rugulosa* and *Occidozygia lima*.

Fam. Batrachotrematidae Dollfus et Williams, 1966

2. *Batrachotrema vietnamensis* sp. n. (Fig. 1 E)

Description (5 specimens; measurements of holotype in brackets): Body oval, 1.06–1.21 (1.09) long and 0.517–0.612 (0.517) wide. Anterior half of body covered with small, scale-like spines 0.006 (0.006) long. Oral sucker subterminal, size $0.081-0.123 \times 0.132-0.150$ (0.081×0.144). Acetabulum preequatorial, large, measuring $0.150-0.225 \times 0.150-0.165$ (0.225×0.165). Size ratio of both suckers 1 : 1.3–1.7 (1.7). Prepharynx indistinct. Oval muscular pharynx measuring $0.081-0.087 \times 0.057-0.081$ (0.081×0.081), oesophagus indistinct; caeca long, ending in front of testes; caecal bifurcation just preacetabular. Testes oval, symmetrical or somewhat diagonal, immediately postcaecal, size $0.147-0.216 \times 0.135-0.243$ ($0.204-0.216 \times 0.150-0.156$). Cirrus sac slender, $0.255-0.330$ (0.255) long and $0.042-0.063$ (0.042) wide, extending obliquely from acetabulum to marginal genital pore, crossing over right caecum, enclosing winding seminal vesicle and cirrus. Genital pore dextral, marginal, at level of pharynx. Ovary rounded, size $0.105-0.138 \times 0.135-0.174$ (0.126×0.135), situated between median line and left caecum below acetabulum. Seminal receptacle not present. Uterus winding in intracaecal space between acetabulum and testes, finally alongside cirrus sac. Vitellaria formed by numerous small follicles, filling up whole body width from caecal bifurcation mostly to anterior margins of testes except for uterine region; sometimes, vitelline follicles extending posteriorly up to posterior margins of testes. Anterior end of body filled up with numerous unstainable corpuscles resembling vitelline follicles in size. Eggs not numerous, elliptical, operculated, yellow-coloured, size $0.042-0.048 \times 0.018-0.021$ ($0.045-0.048 \times 0.018-0.021$). Excretory vesicle not well observable, probably Y-shaped.

Type host: *Rana kuhlii* Tschudi (fam. Ranidae).

Localization: intestine.

Type locality: Hanoi, North Vietnam (May-June 1984).

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype and paratypes — Cat. No. D-228); paratypes also in Department of Zoology, Agricultural University in Keszthely, Hungary, and Department of Vertebrate Zoology, Hanoi University, Vietnam. Etymology: The specific name of this species relates to the country of its origin.

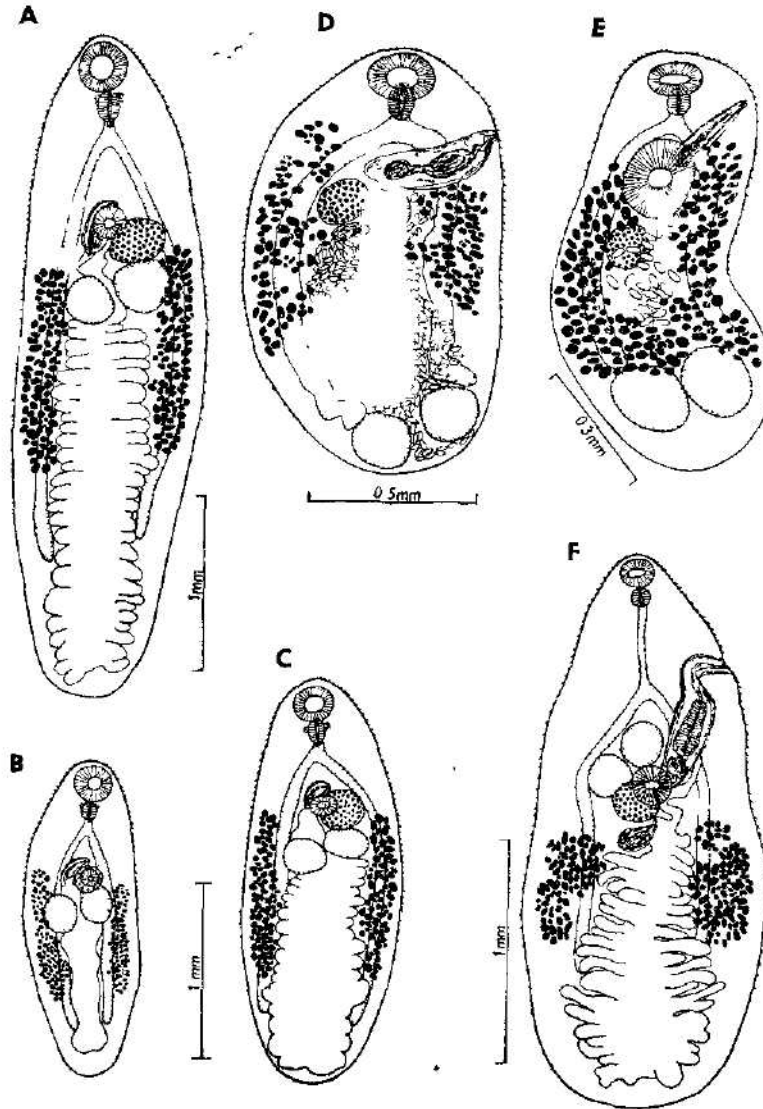


Fig. 1. Trematodes of frogs from Vietnam. A—C — *Glythelmins staffordi* Tuban-gui, 1928 (A — large specimen, B, C — smallest gravid specimens; same magnification); D — *Pleurogenes longivitellaris* sp. n.; E — *Batrachotrema vietnamensis* sp. n.; F — *Ganeo tigrinus* Mehra et Negi, 1928.

Comments: — At present the genus *Batrachotrema* Dollfus et Williams, 1966 includes three species: *B. petropedatis* Dollfus et Williams, 1966, *B. pseudobagri* Wang, 1981 and *B. yaanensis* Zhang et Sha, 1985 (see Zhang and Sha 1985). In possessing the spinose cuticle, testes situated near the posterior end of body and postacetabular situation of the ovary separated from testes by uterine coils, *B. vietnamensis* sp. n. resemble only *B. yaanensis*, described from *Rana phrynoides* from China (Sichan Prov.). However, it distinctly differs from the latter species in much shorter gut-caeca extending posteriorly only to anterior ends of testes (nearly to body end in *B. yaanensis*), less extensive vitellaria initiating anteriorly at level of caecal bifurcation (near anterior end of body in *B. yaanensis*), mostly symmetrical position of testes (testes diagonal or tandem in *B. yaanensis*) and smaller body measurements (body length 1.1–1.2 mm versus 1.7–2.4 mm in *B. vietnamensis* sp. n. and *B. yaanensis*, respectively) and larger eggs ($0.042\text{--}0.048 \times 0.018\text{--}0.021$ mm versus $0.035\text{--}0.038 \times 0.018\text{--}0.020$ mm). Moreover, the whole body of *B. yaanensis* is covered by spines, whereas only anterior half of body is spinose in *B. vietnamensis* sp. n.

B. vietnamensis sp. n. has been assigned to the genus *Batrachotrema* only provisionally, because in spite of the general similarity it differs from its type species, *B. petropedatis*, in some important morphological features (spinose cuticle, situation of testes, distribution of uterine coils, possibly the shape of excretory vesicle), showing certain affinities with some omphalometrid and plagiorchiid genera (e.g., *Sarumitrema*, *Manodistomum*). It may well be that subsequent studies will show it necessary to create a new genus to accommodate

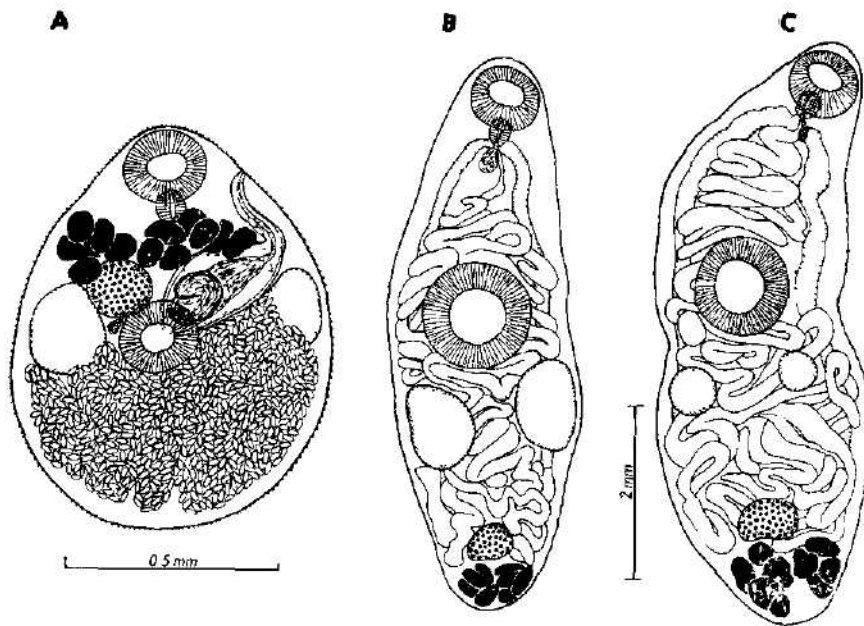


Fig 2 Trematodes of frogs from Vietnam. A — *Pleurogenoides sphaericus* (Klein, 1905); B, C — *Halipegus mehransis* Srivastava, 1933 (B — specimen with large testes, C — specimen with small testes).

the species *B. vietnamensis* sp. n. and probably also *B. yaanensis* Zhao et Sha, 1985.

Fam. Hemiuridae Luhe, 1901

3. *Halipegus mehransis* Srivastava, 1933 (Fig. 2 B, C)

Description (5 specimens): Body elongate. 7.26—9.59 long and 1.61—2.94 wide, cuticle unspined. Oral sucker subterminal, size $0.816-0.952 \times 0.911-1.061$. Acetabulum approximately at mid-length of body, measuring $1.36-1.46 \times 1.32-1.46$; size ratio of both suckers 1 : 1.4—1.6. Muscular oesophagus oval, size $0.340-0.408 \times 0.272-0.340$. Oesophagus indistinct. Caeca extending posteriorly up to body end. Genital pore near posterior end of pharynx. Size of seminal vesicle $0.435-0.554 \times 0.258-0.313$. Testes symmetrical, lateral, at short distance below acetabulum; testes spherical or of irregular shape, measuring $0.449-1.360 \times 0.517-1.550$. Ovary spherical to oval, median or submedian, situated in front of vitellaria, size $0.490-0.639 \times 0.625-0.816$. Vitellaria consisting of two groups of four to five large follicles each, situated at posterior end of body. Uterus winding mostly in intercaecal field, occupying space of body from intestinal bifurcation to ovary. Eggs numerous, $0.039-0.045 \times 0.015-0.018$, with a long filament (length 0.069—0.075).

Host: *Rana rugulosa* Wiegmann (fam. Ranidae).

Localization: intestine.

Locality: Hanoi, North Vietnam (1984).

Comments: — The morphology of all species of the genus *Halipegus* Looss, 1899 is very similar and many species have been described on the basis of features subjected to a considerable intraspecific variability; accordingly, the validity of some species is rather doubtful. We are assigning the specimens of the present material to *H. mehransis* on the basis of some morphological and biometrical features (e.g., situation of testes in relation to the acetabulum, absence of the oesophagus, length of caeca), localization in the host, geographical distribution and host types. In contrast to the original species description, our specimens are noted for the substantially greater measurements of the body and some organs, which can be considered as an intraspecific variability. It is confirmed by our specimens that, for example, the size of testes may be considerably different in this species (see Fig. 2 B, C).

According to Yamaguti (1971), this species is distributed in India, Sri Lanka and Burma; it has not hitherto been reported from Vietnam.

4. *Halipegus zweifeli* sp. n. (Fig. 3 A—C)

Description (5 specimens; measurements of holotype in brackets): Body elongate. 2.45—3.43 (3.08) long and 0.884—1.02 (1.02) wide, cuticle unspined. Oral sucker subterminal, size $0.449-0.530 \times 0.476-0.544$ (0.462×0.517). Acetabulum equatorial, large, measuring $0.680-0.748 \times 0.680-0.748$ (0.748×0.721); size ratio of both suckers 1 : 1.4—1.5 (1 : 1.5). Muscular pharynx oval, size $0.150-0.163 \times 0.122-0.150$ (0.150×0.150). Oesophagus indistinct. Caeca extending posteriorly up to body end. Genital pore median, nearly at mid-length of acetabulum. Size of seminal vesicle $0.165-0.219 \times 0.075-0.108$ (0.219×0.099). Testes lateral, symmetrical, immediately postacetabular; testes almost spherical or of irregular shape, measuring $0.435-0.612 \times 0.381-0.462$ ($0.517-$

—0.544 × 0.381—0.422). Ovary median, size 0.299—0.340 × 0.272—0.381 (0.340 × 0.272), immediately posttesticular, in front of vitellaria. Both testes and ovary usually partly overlapped by uterine coils. Vitellaria consisting of two groups of five large follicles each, situated at posterior end of body. Uterus winding mostly in intracaecal field, occupying space of body from pharynx to ovary. Eggs numerous, 0.036—0.042 × 0.015—0.018 (0.036—0.039 × 0.015), with a long filament measuring in holotype (0.051—0.066).

Type host: *Rana grunniens* Sonnini et Latreille (fam. Ranidae).

Localization: intestine.

Type locality: Ambunti, 50—150 m elevation, Sepik Prov., Papua New Guinea.

Occurrence: 5 *H. zweifeli* specimens in a single frog examined from the type locality.

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype and paratypes — Cat. No. D-235); paratypes also in Department of Zoology, Agricultural University, Keszthely, Hungary.

Etiymology: This species has been named in honour of Dr. Richard B. Zweifel of the Department of Herpetology, American Museum of Natural History, New York, who contributed greatly to the knowledge of the fauna of New Guinea frogs.

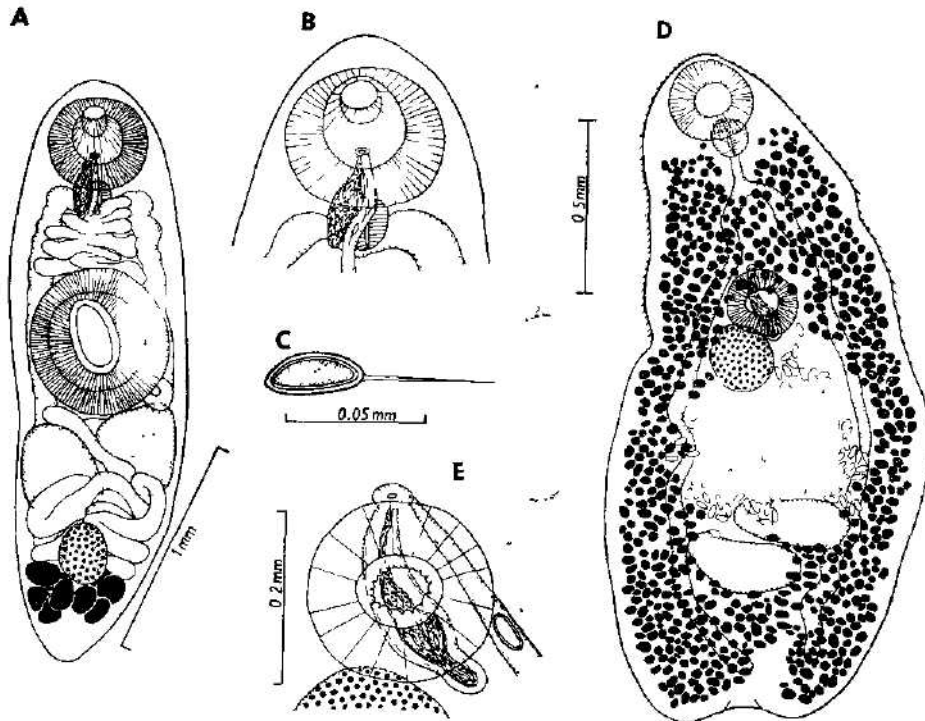


Fig. 3. Trematodes of frogs from Papua New Guinea. A—C — *Halipegus zweifeli* sp. n. (A — general view, B — situation of genital pore to oral sucker, C — egg); D, E — *Opisthioglyphe cophixali* sp. n. (D — general view, E — situation of cirrus sac to acetabulum).

Comments: — *H. zweifeli* sp. n. distinctly differs from all hitherto described *Halipegus* species in the situation of the genital pore; while in the new species the genital pore is located approximately in the mid-length of the oral sucker, in all other congeneric species it is shifted more posteriorly, not reaching to the oral sucker (usually it is situated at the level of caecal bifurcation or the pharynx). Otherwise the morphology of *H. zweifeli* sp. n. is rather similar to that of *H. japonicus* Yamaguti, 1936, especially as to the mutual localization of the acetabulum, the ovary and testes and the size ratio of both suckers, differing from it, however, in addition to the already above mentioned position of the genital pore, in smaller-sized eggs ($0.036-0.042 \times 0.015-0.018$ mm versus $0.045-0.048 \times 0.016-0.018$ mm) and a much shorter egg filament ($0.05-0.07$ mm versus 0.30 mm).

Fam. Lecithodendriidae (Lühe, 1901)

5. *Pleurogenes longiwitellaris* sp. n. (Fig. 1 D)

Description (4 specimens; measurements of holotype in brackets): Body elliptical, $0.93-1.41$ (1.41) long and $0.625-0.884$ (0.884) wide, covered by minute scale-like spines $0.006-0.012$ (0.012) long; 5 rows of spines present also on oral sucker; spines absent from posterior extremity. Oral sucker subterminal, size $0.126-0.165 \times 0.150-0.231$ (0.165×0.231). Acetabulum preequatorial, smaller than oral sucker, measuring $0.099-0.156 \times 0.120-0.171$ (0.156×0.171). Size ratio of both suckers $1:0.8$ ($1:0.8$). Oval muscular pharynx measuring $0.096-0.105 \times 0.081-0.087$ (0.102×0.087). Oesophagus indistinct; caeca extending posteriorly to testes level. Testes almost spherical, size $0.165-0.219 \times 0.180-0.240$ ($0.189-0.195 \times 0.195-0.225$), symmetrical, situated at body end. Cirrus sac well developed, $0.345-0.525$ (0.480) long and $0.108-0.150$ (0.150) wide, situated obliquely from anterior margin of acetabulum to marginal genital pore, crossing over caecum, enclosing seminal vesicle, prostatic complex and cirrus. Genital pore lateral, at level of posterior end of pharynx. Ovary almost spherical, size $0.099-0.201 \times 0.111-0.144$ (0.201×0.144), median or submedian, at acetabulum level. Seminal receptacle present. Vitellaria forming two lateral groups of follicles extending anteriorly to level of posterior end of pharynx and posteriorly to half distance between acetabulum and body end, overlapping partly caeca. Uterus winding mostly in hindbody in space between caeca, extending posteriorly to body end, overlapping partly testes. Eggs elliptical, yellow, size $0.027-0.033 \times 0.012-0.015$ ($0.027-0.030 \times 0.012-0.015$). Excretory vesicle Y-shaped.

Type host: *Rana kuhlii* Tschudi (fam. Ranidae).

Localization: intestine.

Type locality: Hanoi, North Vietnam (May — June 1984).

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype and paratypes — Cat. No. D-229); paratypes also in Department of Zoology, Agricultural University, Keszthely, Hungary, and Department of Vertebrate Zoology, Hanoi University, Vietnam.

Etymology: The specific name of this species relates to its characteristic feature, i.e. the considerable extent of vitellaria.

Comments: — This species distinctly differs from all presently known congeneric species in vitellaria extending posteriorly far below the acetabulum level (in other species vitellaria clustered in shoulder region), in markedly

long caeca and in the situation of testes at the posterior end of body. Characteristic of this species is also the absence of oesophagus; by this feature it resembles only *P. orientalis* Srivastava, 1934 for which Yamaguti (1971) erected an independent monotypic genus *Indopleurogenes*; but in contrast to *P. longivittellaris* sp. n., *P. orientalis* possesses markedly short caeca, its vitellaria are distributed in the anterior half of body, and testes are situated immediately below the acetabulum level.

6. *Pleurogenoides sphaericus* (Klein, 1905) (Fig. 2 A)

Description (10 specimens from *R. rugulosa*): Body of gravid specimens oval to elliptical, 0.48—1.28 long and 0.381—0.384 wide. Cuticle of whole body spinose. Both suckers mostly circular, approximately equal in size; oral sucker measuring 0.078—0.213 \times 0.099—0.213, acetabulum 0.093—0.204 \times 0.090—0.204; oral sucker subterminal, acetabulum in middle of body. Muscular pharynx oval, size 0.027—0.090 \times 0.027—0.084; oesophagus indistinct; caeca short, terminating at a preacetabular level, being mostly overlapped by ovary, cirrus sac and vitellaria. Testes symmetrical, lateral, at acetabulum level, their size being 0.132—0.300 \times 0.135—0.249. Ovary mostly spherical, somewhat smaller than testes, measuring 0.075—0.174 \times 0.066—0.210, situated submedially in front of acetabulum and right testis. Seminal receptacle present. Cirrus sac claviform, large follicles. Uterus winding, chiefly in hindbody. Excretory pore V-shaped, vesicle tubular, winding; prostatic complex well developed. Genital pore on left body margin at level of oral sucker. Vitellaria forming two, sometimes not well separated grape-like bunches in shoulder region, each consisting of 7—10 large follicles. Uterus winding, chiefly in hindbody. Excretory pore V-shaped. Eggs numerous, yellow, size 0.027—0.033 \times 0.015—0.018.

Hosts: *Rana rugulosa* Wiegmann and *R. kuhlii* Tschudi (fam. Ranidae).

Localization: intestine.

Locality: Hanoi, North Vietnam (May — June 1984).

Comments: — Altogether 118 specimens of *P. sphaericus* originating from *Rana rugulosa* and 5 specimens from *R. kuhlii* were studied. The morphology of our specimens has been identical to that described for this species by Odening (1968). We agree with the latter author that various congeneric species from the frogs of India, Malaysia, the Philippines and China are morphologically very similar to *P. sphaericus* and it may well be that they are only synonyms to *P. sphaericus*.

P. sphaericus was originally described from frogs in India. From Vietnam (Hanoi Prov.) it has already been reported as a frequent parasite of *Rana rugulosa* by Odening (1968). *Rana kuhlii* represents a new host record.

7. *Ganeo tigrinus* Mehra et Negi, 1928 (Fig. 1 F)

Description (10 specimens from *R. rugulosa*): Body elongate-oval, anterior end narrowed, posterior end rounded. Cuticle covered by scale-like spines, spination absent from posterior end of body; length of body 1.36—3.13; maximum width 0.734—1.39. Oral sucker subterminal, size 0.078—0.136 \times 0.087—0.204, followed by smaller oval muscular pharynx measuring 0.048—0.109 \times 0.045—0.109. Oesophagus 0.240—0.272 long. Caeca ending a considerable distance away from posterior extremity. Acetabulum small, preequatorial, size

0.093—0.218 × 0.033—0.231. Size ratio of both suckers 1 : 1.1—1.3. Testes almost spherical, diagonal, in anterior intercaecal field, posterior testis at level of acetabulum; size of testes 0.136—0.367 × 0.150—0.394. Cirrus sac elongate claviform, extending from acetabulum to genital pore, containing seminal vesicle turned back on itself and very strongly developed prostatic complex; its length 0.299—0.748, width 0.082—0.109. Genital pore lateral, at level of posterior half of oesophagus. Ovary immediately postero-lateral to acetabulum. size 0.095—0.299 × 0.122—0.340. Seminal receptacle present. Uterine coils confined to median field of hindbody, reaching posteriorly almost to body end. Vitellaria extending along posterior portion of caeca from behind ovary, leaving caecal ends free. Eggs oval, size 0.024—0.033 × 0.015—0.018.

Hosts: *Rana rugulosa* Wiegmann and *R. kuhlii* Tschudi (fam. Ranidae).

Localization: intestine.

Locality: Hanoi, North Vietnam.

Comments: — A total of 12 specimens from *Rana rugulosa* and 2 specimens from *R. kuhlii* were studied. According to Yamaguti (1971), this species has been reported from India, Burma and Sri Lanka; from North Vietnam it has been reported from *Rana rugulosa* by Odening (1968).

Fam. Omphalometridae Bittner et Sprehn, 1928

8. *Opisthioglyphe cophixali* sp. n. (Fig. 3 D, E)

Description (2 specimens; measurements of holotype in brackets): Body ovoid or pear-shaped, broader in posterior half; length of body 1.75—2.20 (2.20), maximum width 0.932—1.074 (1.074). Anterior half of body covered with minute spines, posterior half smooth. Oral sucker subterminal, size 0.252—0.264 × 0.264—0.279 (0.252 × 0.279). Acetabulum preequatorial, slightly smaller than oral sucker, measuring 0.201—0.225 × 0.210—0.255 (0.225 × 0.255), its inner edge being provided with a marked broad, cuticular margin with many folds. Size ratio of both suckers 1 : 0.8—0.9 (1 : 0.9). Prepharynx indistinct, size of muscular pharynx 0.135—0.147 × 0.150—0.153 (0.135 × 0.153). Oesophagus short, 0.075—0.081 (0.081) long, caeca extending posteriorly to body end. Genital pore median, situated near anterior margin of acetabulum. Cirrus sac weakly developed, median, size 0.189—0.360 × 0.060—0.081 (0.360 × 0.081), being mostly overlapped by acetabulum. Testes transversely elongate, diagonal, situated intercaecally closely to each other in posterior third of body; size of anterior testis 0.105—0.186 × 0.195—0.390 (0.186 × 0.390), of posterior one 0.093—0.189 × 0.240—0.390 (0.189 × 0.390). Ovary almost spherical, measuring 0.150—0.237 × 0.198—0.216 (0.237 × 0.216), submedian, on right side just below acetabulum. Uterine coils intercaecal or partly overlapping caeca, between anterior testis and acetabulum. Eggs yellow, size 0.054—0.060 × 0.021—0.030 (0.054—0.060 × 0.027—0.030). Vitellaria consisting of numerous small follicles disposed laterally, but also overlaying intestinal caeca, and extending from posterior margin of oral sucker to posterior end of body; behind testes and in front of acetabulum follicles confluent in median line.

Type host: *Cophixalus parkeri* Loveridge (fam. Microhylidae).

Localization: intestine.

Type locality: Kotuni, Mt. Otto, 2100—2400 m elevation, Papua New Guinea.

Occurrence: 2 specimens found in one of two *C. parkeri* examined.

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype — Cat. No. D-232); paratype in Department of Zoology, Agricultural University, Keszthely, Hungary.
Etymology: The specific name of this parasite is derived from the generic name of its host.

Comments: — In possessing a weakly developed cirrus sac containing a tubular seminal vesicle, the specimens of the present material can be assigned to the genus *Opisthioglyphe* Looss, 1899. Most species of this genus (like e.g. *O. ranae*) are noted, in contrast to *O. cophixali* sp. n., for the presence of the preacetabular cirrus sac and for the vitellaria forming in preacetabular region only two lateral stripes reaching anteriorly to the caecal bifurcation. On the other hand, the vitellaria in *O. cophixali* sp. n. extend anteriorly up to the pharynx level, the vitelline follicles being confluent in the median line in front of the acetabulum; by this feature *O. cophixali* sp. n. resembles only the species *O. rastellus* (Olsson, 1876) which is listed in the genus *Opisthioglyphe* by Yamaguti (1971), but in *Dolichosaccus* by other authors (e.g., Prudhoe 1970, Skryabin 1971, Ryzhikov et al. 1980). *O. rastellus* distinctly differs from *O. cophixali* sp. n. in the presence of a conspicuously large cirrus sac situated laterally to the acetabulum and posteriorly exceeding considerably the acetabulum (see e.g. Prudhoe 1970, Skryabin 1971, Ryzhikov et al. 1980).

In 1970, Prudhoe described from *Leiopelma* spp. (Anura: Leopelmatidae) from New Zealand a new species, *Dolichosaccus novaezealandiae*, that is very similar to *O. cophixali* sp. n.; the author assigned this species to *Dolichosaccus* practically only on the basis of the presence of the bipartite seminal vesicle in the cirrus sac; in our opinions, this feature is insufficient to distinction between the two genera. In addition to this feature, Yamaguti (1971) has used the size and the position of the cirrus sac as the main difference between both these genera. However, the cirrus sac of *D. novaezealandiae* is poorly developed, overlapped by the acetabulum, and by this feature it should belong to *Opisthioglyphe*. In spite of the opinions of some previous authors considering *Dolichosaccus* as only a synonym of *Opisthioglyphe*, in this paper we are taking both these genera as independent, considering as a principal differential feature between them the size and the position of the cirrus sac in relation to the acetabulum, and not the shape of the seminal vesicle; moreover, the latter is often badly observable which may lead to wrong conclusions. Consequently, it is necessary to transfer the New Zealand species to the genus *Opisthioglyphe* as *O. novaezealandiae* (Prudhoe, 1970) comb. n.

Despite a considerable similarity of *O. novaezealandiae* and *O. cophixali* sp. n., there are distinct morphological differences between them in the position of the genital pore (immediately in front of the anterior margin of acetabulum in *O. cophixali* versus nearly in mid-distance between the anterior margin of acetabulum and caecal bifurcation in *O. novaezealandiae*), in the length of caeca (nearly to the body end versus to about the hinder fifth of the body), length of the cirrus sac (slightly exceeding the posterior margin of acetabulum versus not reaching to the posterior margin of acetabulum), extent of the cuticle spination (only in the anterior half of body versus extending to the posterior region of body) and the size of eggs ($0.054-0.060 \times 0.021-0.030$ mm versus $0.024-0.047 \times 0.025-0.030$ mm). In addition, the inner edge of the acetabulum in *O. cophixali* sp. n. is provided with a conspicuous cuticular

margin that has not been mentioned in the original description of *O. novae-zealandiae*.

9. *Dolichosaccus grandiacetabularis* sp. n. (Fig. 4 A)

Description (2 specimens; measurements of holotype in brackets): Length of body 1.32—1.41 (1.41), maximum width 0.789 (0.789); maximum width of body slightly in front of acetabulum where in both specimens cuticle forms a wide transverse fold. Posterior part of body containing testes narrowed, posterior extremity blunt. Whole body covered by distinct spines up to 0.015 (0.012) long. Oral sucker subterminal, size 0.177—0.189 \times 0.210—0.219 (0.177 \times 0.219); acetabulum preequatorial, large, measuring 0.252—0.279 \times 0.279—0.285 (0.279 \times 0.285); size ratio of both suckers 1:1.3—1.4 (1:1.4). Prepharynx indistinct. Pharynx measuring 0.090—0.093 \times 0.090—0.096 (0.090 \times 0.090). Caeca extending posteriorly nearly to body end. Genital pore median, situated at level of caecal bifurcation. Cirrus sac well developed, size 0.345—0.369 \times 0.081—0.087 (0.369 \times 0.081), bent along right side of acetabulum, posteriorly not surpassing level of its posterior margin; it contains bipartite seminal vesicle, prostatic complex and cirrus. Testes diagonal or almost symmetrical, longitudinally elongated, size of left anterior testis 0.258—0.330 \times 0.174—0.180 (0.258 \times 0.174), that of right posterior one 0.315—0.375 \times 0.165 (0.315 \times 0.165), close to each other. Ovary oval, submedian, immediately post-acetabular, measuring 0.123—0.183 \times 0.174—0.195 (0.123 \times 0.174). Small circular seminal receptacle present below ovary. Uterine coils intercaecal, between

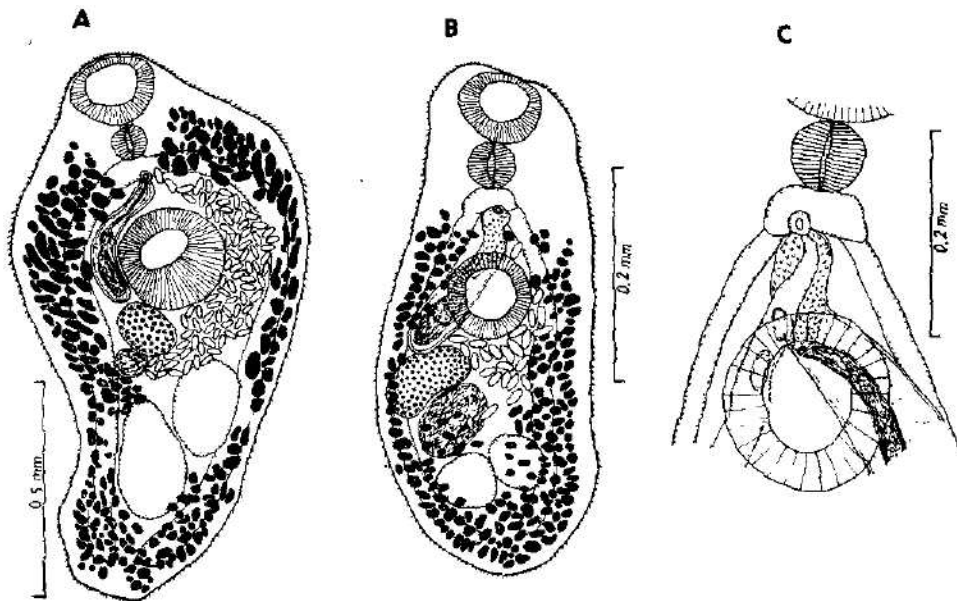


Fig. 4. Trematodes of frogs from Papua New Guinea. A — *Dolichosaccus grandiacetabularis* sp. n.; B, C — *Dolichosaccus longibursatus* sp. n. (B — general view, C — situation of genital pore to acetabulum).

anterior testis and intestinal bifurcation. Eggs yellow, size $0.042-0.048 \times 0.021-0.024$ ($0.045-0.048 \times 0.021-0.024$). Vitellaria consisting of numerous irregularly shaped follicles disposed laterally, but also overlying intestinal caeca dorsally and ventrally, and extending from posterior margin of oral sucker to posterior end of body; behind posterior testis and in paratype dorsally also in front of acetabulum follicles confluent in median line.

Type host: *Rana grisea* van Kampen (fam. Ranidae).

Localization: intestine.

Type locality: Okasa, 900-1400 m elevation, E.H.P., Papua New Guinea.

Occurrence: 2 specimens found in a single host examined.

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype - Cat. No. D-233); paratype in Department of Zoology, Agricultural University, Keszthely, Hungary.

Etymology: The specific name of this species relates to its characteristic feature, i.e. a markedly large acetabulum.

Comments: — Only two of the hitherto known species of the genus *Dolichosaccus* Johnston, 1912, *D. amplicava* (Travassos, 1924) and *D. juvenilis* (Nicolle, 1918), are noted for the distinctly greater measurements of the acetabulum than those of the oral sucker (acetabulum is always smaller than oral sucker in all remaining species); the first species is known from amphibians from South America (Brazil), the latter species from Australia. *D. grandiacetabularis* sp. n. differs from the first named species mainly in the shape and size of the body (body length 1.32-1.41 mm versus 2.0-2.25 mm), situation of the ovary immediately below the acetabulum, absence of the oesophagus, size of eggs ($0.042-0.048 \times 0.021-0.024$ mm versus $0.060-0.064 \times 0.032-0.040$ mm), and also the geographical distribution (New Guinea versus Brazil) should be taken into account. From *D. juvenilis* it differs principally in possessing the spinose cuticle (the cuticle of *D. juvenilis* is smooth), in absence of the oesophagus, in the shape of body (body distinctly expanded at shoulder region and narrowed at its posterior third in *D. grandiacetabularis* sp. n. versus body elongate oval in *D. juvenilis*), and in the shorter cirrus sac (length 0.35-0.37 mm versus some 0.5 mm).

10. *Dolichosaccus longibursatus* sp. n. (Fig. 4 B, C)

Description (3 specimens; measurements of holotype in brackets): Body elongate-oval, length 0.87-1.03 (1.03), maximum width 0.449-0.598 (0.449). Whole body covered with distinct spines up to 0.009-0.012 (0.012) long. Oral sucker subterminal, size $0.136-0.159 \times 0.163-0.163$ (0.136×0.163); acetabulum equatorial, slightly larger than oral sucker, measuring $0.177-0.186 \times 0.190-0.195$ (0.177×0.190); size ratio of both suckers 1:1.1-1.2 (1:1.2). Prepharynx indistinct. Pharynx large, size $0.082-0.099 \times 0.082-0.117$ (0.082×0.082). Caeca extending posteriorly nearly to body end. Genital pore median, situated at level of intestinal bifurcation. Cirrus sac large, size $0.340-0.525 \times 0.078-0.095$ (0.340×0.095), extending posteriorly obliquely to anterior margin of ovary, containing bipartite seminal vesicle, prostatic complex and spined cirrus; distal part of sac containing cirrus $0.068-0.165$ (0.068) long and $0.041-0.060$ (0.041) wide. Testes spheroidal, almost symmetrical, size $0.102-0.122 \times 0.090-0.122$ ($0.109-0.122 \times 0.109-0.122$), close to each other. Ovary transversely elongate, size $0.084-0.105 \times 0.159-0.177$ (0.095×0.177), situated on right side immediately below acetabulum level. Large oval seminal receptacle present just

below ovary. Uterine coils intercaecal, between testes and caecal bifurcation. Eggs yellow, size $0.045-0.051 \times 0.021-0.024$ ($0.045-0.051 \times 0.021$). Vitellaria consisting of numerous follicles disposed laterally, but also overlaying intestinal caeca, and extending from caecal bifurcation to posterior end of body; follicles confluent in median line below testes.

Type host: *Rana grunniens* Sonnini et Latreille (fam. Ranidae).

Localization: intestine.

Type locality: Ambunti, 50—150 m elevation, Sepik Prov., Papua New Guinea.

Occurrence: 3 specimens found in a single frog examined.

Deposition of types: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice, Czechoslovakia (holotype and paratype — Cat. No. D-234); one paratype in Department of Zoology, Agricultural University, Keszthely, Hungary.

Ety m o l o g y: The specific name of this species relates to the characteristic feature of this species, i.e. a markedly long cirrus sac.

Comments: — By possessing vitellaria reaching anteriorly only to the caecal bifurcation and by having both suckers of approximately the same size (acetabulum slightly larger), the new species resembles only *D. anartus* Johnston, 1912 described from *Hyla arborea* and *Lymnodynastes peronii* from Australia. However, it markedly differs from the latter species in the position of the cirrus sac (considerably exceeding posterior margin of acetabulum versus not reaching to acetabulum), extent of the body spination (whole body spined versus only anterior part of body spined), situation of the ovary (immediately postacetabular versus in mid-distance between acetabulum and testes), length of the body (0.9—1.0 mm versus 3.3 mm), and other features. Approximately the same size of suckers is typical also of *D. schmidti* Fischthal et Kuntz, 1975, but the vitelline follicles of this species are commencing only about halfway between caecal bifurcation and acetabulum; it differs from *D. longibursatus* sp. n. as well in other features (situation of testes, shape of body, etc.).

A characteristic feature of *D. longibursatus* sp. n. is the presence of the relatively wide cirrus covered by numerous small, flat triangular spines; a spinose cirrus has not hitherto been reported for any congeneric species.

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**A CONTRIBUTION TO THE METHODOLOGY OF THE STUDY OF PREDATOR
FISHES FOOD**

Galerida PETROVA & Mladen ŽIVKOV

Institute of Zoology, Bulgarian Academy of Sciences, Bulv. Ruski 1,
Sofia, Bulgaria

Abstract. The method is based on the possibility of identifying species and estimating length and weight of prey by their bones found in the stomach of predators. With Cypriniformes we used the lower pharyngeal bone (os pharyngeum inferius), while with Perciformes it was the lower jaw (os dentale). Judging the length of these bones by means of nomograms, drawn up in advance, length and weight are estimated quickly, easily and simultaneously. The nomograms are based on a mathematical dependence between bone length (l), length (L), and weight (G) of the prey. These correlations provide statistically reliable population differences. In the solution of some practical problems, these nomograms can be used with satisfactory precision for other reservoirs. Nevertheless more fundamental studies are necessary for each species, working out separate equations of the relations between l, and L, and G for each reservoir. The paper discusses the advantages of the method.

INTRODUCTION

It is known that even a short time in the digestive tract of the predator, prey are considerably deformed and digestion begins. This hampers and frequently makes impossible not only the estimating of the length and weight of the prey, but also determining its species designation. The problem is even more complex, when studies are carried out during the summer or in cooling reservoirs, as in the case of the reservoirs studied — the cooling reservoir of the Maritsa Iztok 2 Thermo-electric Power Station.

Separate bones, parts of bones, scales and spines are preserved considerably longer in the stomach of the predator. Species characteristics of some spines are known and they could be used for determining prey species. Other, subject to morphological studies, can be determined at least to the degree of family (Skalkin, 1961, 1965). Most often the following bones are used: pharyngeal bones of Cypriniformes or lower jaws of Perciformes (Lišev, 1950; Fortunatova, 1951; Kovalev, 1959; Wasarheleyi, 1958; Horoszewiez, 1960; Fortunatova, Popova, 1973, 1974); vertebral column (Pichu, Pichu, 1970); otolithes (Skalkin, 1961, 1965; Schmid, 1977) opercular bones (Newsome, 1977).

Studies for estimating the length and weight of prey by means of these bones are very rare. Only a few authors have made use of preliminary established ratio between bone lengths and weight of the possible prey through the so-called transfer coefficients (Lišev, 1950), tables (Kovalev, 1958), empirical curves (Pichu, Pichu, 1970) and formulae (Newsome, 1977). As these relationships are specific for any population, species and reservoir have not been used by other authors, under other conditions. Besides, both the manner of estimating them and their application are frequently labour-consuming, cumbersome and not very precise.

This is why we had to solve the following problems: select and use the most suitable bones in order to estimate possible prey species in the Batak reservoir and the Ovčarica reservoir; establish the mathematical dependence between the length and weight of these bones and body length and weight of prey; on the basis of this relationship we had to build simultaneously, nomograms for each species, which allow quick and precise estimation of length and weight of prey judging by its bones in the stomach of the predator; to establish with the help of mathematical criteria the reliability of the population variability of the above relationship; on that basis to examine to what extent the suggested method could be used or applied for analogical studies on other reservoirs.

MATERIALS AND METHODS

The studies were carried out in two ecologically and morphologically different dams — the Ovčarica Dam and the Batak Dam. Data on fish published from the Volga river (Kovalev, 1958; Fortunatova, Popova, 1973), additionally processed mathematically, were used for comparison.

The Ovčarica Dam is a cooling reservoir of the Mariča — 2 Thermo-electric power Station of a lake or river type, with an area of 800 ha, mean depth 5—6 m, mean annual water temperature 16.2°C, mean January temperature — 6.3°C, and mean August temperature — 25.6°C. The reservoir is situated at an altitude of 170 m a.s.l. (for further details see Živkov, Grupčeva, 1987). The Batak Dam is the largest barrage in the systems of the Batak Hydroelectric Project, situated at an altitude of 1,100 m a.s.l. The waters of four other reservoirs situated higher up flow into it through canals. Its maximum area is 2,107 ha, maximum volume 309 million m³, mean depth 14—15 m, average January temperature 1°C, mean August temperature — 19.8°C, mean annual temperature — 10.3°C (further details v. Živkov, Petrova, 1984).

883 specimens with standard length from 20 to 200 mm were studied. Their distribution according to species in the Ovčarica and Batak Dam, respectively, was as follows: roach (*Rutilus rutilus*) — 55 and 40; carp (*Cyprinus carpio*) — 32 and 37; bleak (*Alburnus alburnus*) 64 and 51; perch (*Perca fluviatilis*) 20 and 38; chub (*Leuciscus cephalus*) — 0 and 16; rudd (*Scardinius erythrophthalmus*) — 12 and 0; bream (*Abramis brama*) — 43 and 0; gibel (*Carassius auratus gibelio*) — 8 and 5; pope or ruffe (*Acerina cernua*) — 68 and 0; American sunfish (*Lepomis gibbosus*) — 45 and 11. The standard length (L) of the each was measured with precision up to 1 mm and weight up to 1 g. Preparation of lower pharyngeal bones of Cypriniformes and lower jaws of Perciformes was done by boiling the heads of the fish. Bone length (l) was measured by means of a caliper-gauge with a precision up to 0.2 mm, as is shown in Figs. 2 and 3. The age of fish was determined by the scales. The correlation and regression analyses of dependence between l and L, and L and G have been made according to the conventional statistical methods (after Lakin, 1980). The reliability of differences between the one type equations describing these dependences for one species in different river basins (dam lakes was established by means of calculating t-criterion (after Rokickij, 1967). The reliability of a difference between coefficients b in L = a + bl type equations for two populations of one species from different river basins (dam lakes) was calculated via formula.

$$t = \frac{b_1 - b_2}{Sd_{(b_1 - b_2)}}$$

where b_1 and b_2 are the comparable regression coefficients, and $Sd_{(b_1 - b_2)}$ a statistical error of the difference between b_1 and b_2 . This error for the small samples (n 30) has been qualified by the use of the formula

$$Sd_{(b_1 - b_2)} = \sqrt{\frac{(n_1 - 2)S_1^2 + (n_2 - 2)S_2^2}{(n_1 - 2) + (n_2 - 2)} \cdot \left[\frac{1}{\Sigma(l_1 - l_1)^2} + \frac{1}{\Sigma(l_2 - l_2)^2} \right]}$$

and

$$Sd_{(b_1 - b_2)} = \sqrt{\frac{S_1^2}{\Sigma(l_1 - \bar{l}_1)^2} + \frac{S_2^2}{\Sigma(l_2 - \bar{l}_2)^2}}$$

for the bigger ones ($n > 30$) via the formula. In the latter formulae l_1 and l_2 are the lengths of the bones of fishes from the comparable populations, \bar{l} — a mean value of l , S_1 and S_2 — statistical errors of the comparable regression coefficients b . These errors were calculated by the use of a formula

$$S = \frac{\delta}{\sqrt{\Sigma(l - \bar{l})^2}}$$

in which δ (the rooted sum of squared deviations between the respective regression series) has been estimated via the formula

$$\delta = \sqrt{(\bar{L} - \hat{L})^2}$$

In the latter two formulae L marks the empirical values of body lengths and \hat{L} their theoretical values calculated by means of the formula $L = a + bl$ for the respective populations.

The values of t -criterion received in this way were compared with tables after estimating the degrees of freedom $\nu = n_1 + n_2 - 4$ and respective probability level n_1 and n_2 are the numbers of body length classes for grouped data or the numbers of individuals for ungrouped data of the comparable populations. The difference between comparable coefficients has been considered as statistically reliable in cases when $t > t_{\text{tabl}}$.

The calculations of all statistics were carried out on a personal computer Pravec (Apple II). A special program has been worked out with the indispensable help of engineer (Mrs) Ivanka Živkova.

RESULTS

Determining the Species of Prey fish

Cypriniformes prey from both dams were determined after the pharyngeal teeth, while predators by the lower jaws. Only 7 species of Cypriniformes, 3 species of Perciformes and the American sunfish (*Lepomis gibbosus*) (cf. Materials and methods) are practically important for the diet of predators in the Ovčarica dam. They constitute over 99% of the catch, both in numbers and in the quantity of biomass. The remaining 12 species (Živkov and Grupčeva, 1987) appear very rarely and are separate specimens. The situation at the Batak dam is similar. Potential prey is represented by 5 Cyprinid species, 2 Percid species, and the American sunfish (*Lepomis gibbosus*). The remaining 11 species (Živkov, 1981) are found very rarely.

Specific characteristics of pharyngeal teeth (numbers of lines and shape of the teeth) is well known and described in all monographs of the Cyprinidae family (i.e. Berg, 1949) and determining prey according to them is no problem. Nevertheless special studies on the specific features of lower jaw are absent. They required the search of certain major differential features on the bones of the species studied (pikeperch, perch, spined loach, American sunfish). All lower jaws are V-shaped. The upper part is covered with small teeth (Fig. 3). With pikeperch it is longer than the lower one with no apertures. The small teeth vary in size and are unevenly situated, the largest is in front, the larger ones are on the external side, while the smaller ones on the internal side. The lower part of the jaw has 4 small elongated apertures. The ratio between the

Table 1. Population variability of coefficients of $L = a + bl$ equation, describing dependence between length of os pharyngeum inferius with Cypriniformes or length of os dentale with Perciformes (l, mm) and body length (L, mm)

Species	Ovčarica Dam			RESERVOIRS Batak Dam			Volga River					
	a	b	r	No. of length classes	a	b	r	No. of length classes	a	b	r	No. of length classes
<i>Alburnus alburnus</i>	22.9703	12.8344	0.98	12	- 7.6622	17.6488	0.99	13	- 3.4481	16.9560	0.99	21
<i>Rutilus rutilus</i>	0.3201	13.0712	0.99	26	11.9340	11.6796	0.99	12	1.7951	12.3913	0.99	54
<i>Cyprinus carpio</i>	- 1.7885	6.7832	0.97	19	- 10.9066	7.8468	0.99	24	- 1.9913	7.7906	0.99	31
<i>Leuciscus cephalus</i>					5.6879	11.5700	0.98	12				
<i>Carassius auratus gibelio</i>	- 15.4781	9.7282	0.98	8	- 11.0020	9.3166	0.99	4				
<i>Abramis brama</i>	- 12.1286	14.8048	0.99	18					- 1.7884	13.8160	0.99	30
<i>Scardinius erythrophthalmus</i>	3.2564	11.8388	0.98	7								
<i>Stizostedion lucioperca</i>	- 8.3490	9.3158	0.99	24	- 24.2812	10.4406	0.99	28	- 13.9716	10.2369	0.99	47
<i>Percu fluviatilis</i>	5.2804	9.4615	0.99	18	- 39.0837	13.8745	0.99	17	- 0.0960	9.8339	0.99	30
<i>Lepomis gibbosus</i>	- 2.6344	12.1255	0.99	13	- 7.7374	11.7796	0.98	10				
<i>Acerina cernua</i>	- 6.2747	15.2421	0.98	16								

length of the bone and the width at the end is about 2 : 1. With perch both parts are of equal length. The upper one is with one elongated aperture, the wloer one with 4 (the first one is small, the remaining ones larger). The teeth are small, comparatively evenly distributed. The ratio between length and width of the bone is about 1.5 : 1. With spined loach the upper part is about 1/3 shorter than the lower part. The teeth are identical, evenly distributed in many rows. The lower part is quite wide, with 3 large founded apertures. The ratio between length and width is about 1.5 : 1. With American sunfish the parts are with equal length and the ratio between length and width of the bone is 1 : 1. The upper part has one oval opening with teeth of various sizes, distributed unevenly. The lower part has 4 openings (2 small apertures and 2 larger ones at the back).

Work on fish species identification os considerably facilitated if a small collection of pharyngeal teeth and lower jaws of the species is made in advance for the expected prey in the studied dam. These species are comparatively few and comparing the bone in the stomach of the predator with the collection it is easy to identify the species of the prey.

Relationship between Bone Length and the Fish Length

The principal schema of the idea of estimating the length of the prey through the length of bone (l) found in the stomach of predators is illustrated in Fig. 1. Nevertheless, for that purpose we have to establish the precise mathe-

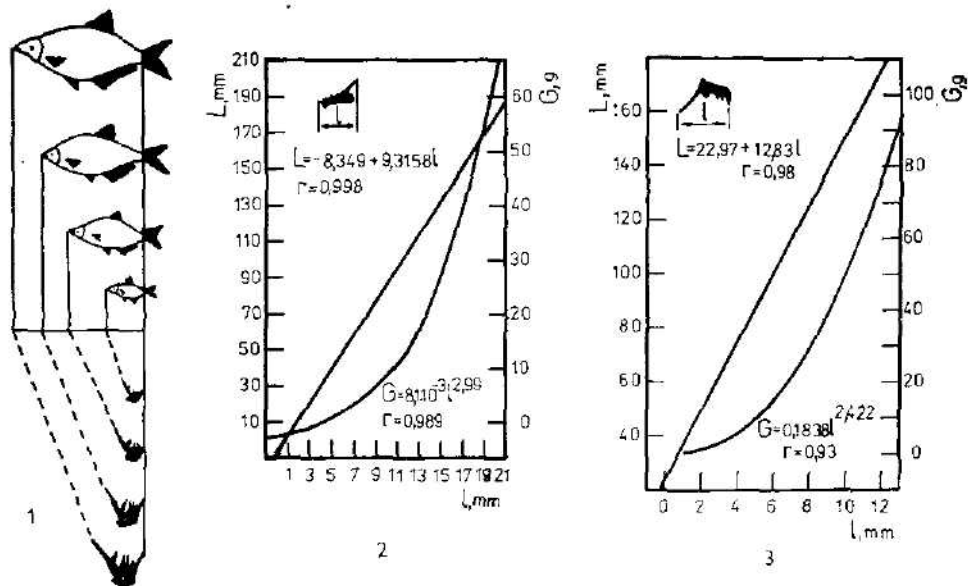


Fig. 1. Principal scheme for estimating the length of prey by their bones (os pharyngeum inferius) found in the stomach of predators.

Fig. 2. Relationship between length of os pharyngeum inferius (l) and length (L) and weight (G) of bleak from the Ovčarica Dam.

Fig. 3. Relationship between length of os dentale (l) and length (L) and weight (G) of pikeperch from the Ovčarica Dam.

mathematical dependence between l and L . The correlation — regression analysis shows that it is described by the linear equation $L = a + bl$ (Figs. 2 and 3). Its coefficients (a and b) with different species and dams, as well as the coefficients of correlation (r) between l and L are given in Table 1. For comparison, the same table gives the results of our analogous studies (after empirical data of Kovalev, 1958; Fortunatova and Popova, 1973) for these species from the Volga, which appear in the Ovčarica Dam and the Batak Dam. The reliability of differences of the coefficient b with one and the same species, however, in different dams is given through the values of t — the criterion in Table 2.

Relationship between Bone Length and Fish Weight

In order to estimate the weight of prey (G) via the length of its bone (l), found in the stomach of the predator, we established in advance the type of the mathematical dependence between l and G . It was established that the growth of fish weight as related to length of studied bones is described best by the equation of the function — $G = al^b$ (Figs. 2 and 3). The values of the coefficients of correlation (r) between l and G are given in Table 3.

Nomograms for Reading Length and Weight of Prey

A nomogram was devised for each species from each dam in 4 scales (Figs. 4 and 5) in order to estimate length (L) and weight (G) directly and simultaneously judging by bone length of prey (l). First a scale was selected at random in building the two inner, absolutely identical scales for the bone length (1 mm). In order to build the scale of the fish length (L , mm) and the weight (G , g) we made use of the dependences between l and L , respectively L and G for

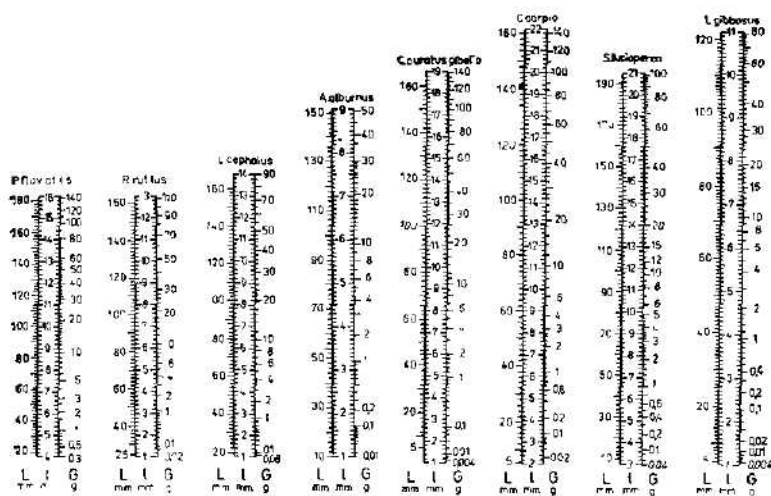


Fig. 4. Nomograms for estimating length (l) and weight (G) of various prey species at the Batak Dam by length of their bones found in predator stomachs. l — length of lower pharyngeal bone (os pharyngeum inferius) with Cypriniformes or length of lower jaws (os dentale) with Perciformes.

each species and dam. We determined the scale of lengths (L) choosing at random two values of L (i.e. 1 and 10 mm), substituting them in the equation $L = a + bl$, and computing the respective values of l . This exactly opposite the obtained values of l , to the left we placed their respective values of L (1 and 10 mm). The distance between them was divided into 10 or 5 even parts, each of which corresponds to 1 or 2 mm. In an analogous way we built the scale of weight, making use of the equation $G = al^b$. However, as this dependence is curvilinear in character (Figs. 2 and 3), such calculations should be done for all values of G noting the weights on the scale (G , mm).

Mode of operating with the nomograms: if for example in the stomach of a predator from the Batak dam we find a pharyngeal bone of a roach with a length $l = 6$ mm, immediately, following the nomogram for the roach on Fig. 4, we establish, that the prey's length was $L = 81$ mm and it weighed $G = 9$ g.

DISCUSSION

The suggested method has considerable advantages before the currently employed method of analysis of components of diet of predators. Above all the estimation of prey length and weight by means of our nomograms is positively quicker, easier, performed directly on the spot and simultaneously. The methods which make use of transfer coefficients (Lišev, 1950), tables (Kovalev, 1958), or empirical curves (Pichu, Pichu, 1970) are more difficult, more cumbersome, less precise and much more time-consuming. For instance Kovalev (1958), had to process 15,000 specimens of 17 species in the course of 8 years, i.e. about 900 specimens per species, in order to compile tables of dependences between L and l in the 5 mm classes of fish from the Volga. Our results show that 30–50 specimens per species are sufficient to

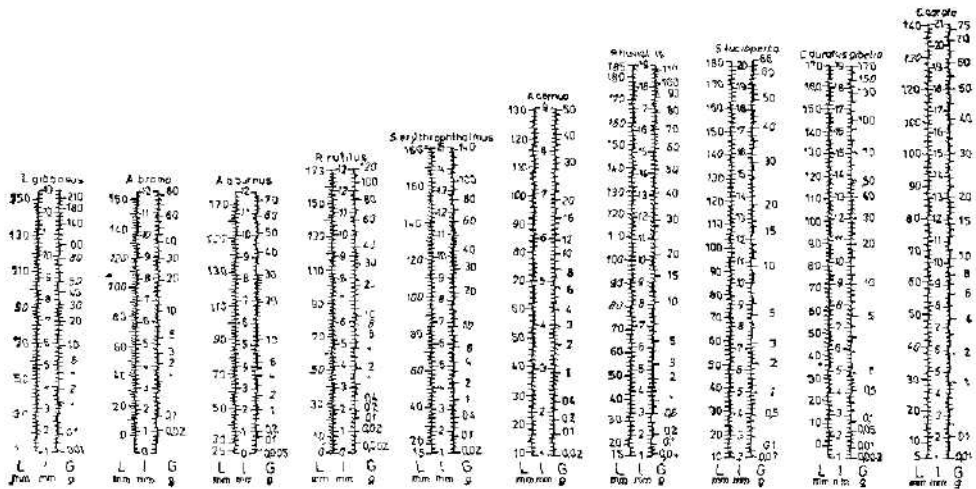


Fig. 5. Nomograms for estimating length (l) and weight (G) of various prey species at the Ovčarica Dam by length of their bones found in predator stomachs. l — length of lower pharyngeal bone (os pharyngeum inferius) with Cypriniformes or length of lower jaws (os dentale) with Perciformes.

draw a mathematical dependence between l and L and G . As is evident from Fig. 2 and 3 and Table 1 and 3, that the degree of freedom between l and L and between l and G with all species is exceptionally high, almost functional. The values of the coefficients of correlation (r) are most frequently around 0.99, even if the number of studied specimens is considerably smaller than the above figures.

The values of t -criteria (Table 2) show that the difference in all cases of regression coefficients (b) between l and L is statistically reliable. Only the American sunfish is an exception, where $t < t_{\text{tabl}}$ however the differences in the coefficients a (-2.6 and -7.7 , Table 1) are evident. Sometimes these differences are small, however reliable, owing to the rather high coefficients of correlation between l and L . For instance, with one and the same value of l (10 mm) with one and the same species (roach), respective mean values of L in the Batak Dam, the Ovčarica Dam and the Volga are 128.7 mm, 131 mm, and 125.7 mm, while those of G , respectively 47.9 g, 48.2 g, and 41.8 g. With the same value of l in the same reservoirs the values of l for pikeperch are, correspondingly, 80.1 mm, 84.8 mm, and 88.4 mm, and for G , respectively, 5.2 g, 7.9 g, and 7.4 g. Moreover, we should bear in mind that the compared reservoirs are quite varied morphologically, geographically and ecologically. This fact explains larger differences in the values of G . For example at $l = 5$ mm, the values of l of bleak at the Batak Dam, the Ovčarica Dam and the Volga are, respectively, 80.6 mm, 87.1 mm and 81.3 mm, while the values of G are, accordingly, 5.5 g, 9.1 g, and 6.9 g. With perch these differences are even larger. At $l = 5$ mm the corresponding values of L are 30.3 mm, 52.6 mm, and 49.1 mm, while those of G 0.8 g, 2.6 g, and 2.4 g. The range of these differences varies according to the different values of l . For example if such comparisons are carried out for bream from the Ovčarica Dam and the Volga at $l = 5$ mm, we obtain l of, respectively, 61.9 mm, and 78.3 mm, while values of G are, respectively, 3.98 g, and 5.3 g; however, with $l = 10$ mm the differences are insignificant (135.9 and 136.4 mm).

Therefore in carrying out fundamental scientific research it is necessary to work out a separate equation for these dependences or to compile a separate nomogram. The calculation of the weight of prey can also be done by using the equation of the dependence $L - G$ (instead of the $l - G$ dependence), as it is drawn up for any biological population study.

Nevertheless, our nomograms and formulae for the respective species can be used for the solution of a number of practical tasks with satisfactory precision. As they refer to three reservoirs, it is advisable to use the formulae of the reservoir closest, ecologically, to the reservoir studied.

Acknowledgements

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BIRDS IN THE CENTRE OF PRAGUE

Petr POKORNÝ

Institute of Hygiene and Epidemiology, Šrobárova 48, 100 42 Praha 10,
Czechoslovakia

Abstract. The avifauna of the centre of Prague, a densely built-up area, was investigated quantitatively. The study was carried out during the nesting period of the birds on an area of 36.9 ha using a mapping method. Twelve bird species have been identified of which *Columba livia* f. *domestica*, *Passer domesticus* and *Apus apus* were dominant. Total density of the avifauna was 128.3 pairs/10 ha. Values of diversity and species evenness ($H' = 1.42$, $J' = 0.57$) were influenced by the vegetation of the area studied. The majority of bird species were nesting on buildings. Characteristic of the area was an absence of species nesting either on, or slightly above, the ground.

INTRODUCTION

Recent decades have seen a detailed consideration of quantitative studies. In ornithology, increased attention has been given to various types of anthropocoenoses of cities and towns, and also town centres, which represent the climax stage of succession in urban development. A number of authors evaluated bird populations of the centres of towns, both qualitatively and quantitatively (e.g. Graczyk, 1962; Erz, 1964; Tomialojć, 1970; Saemann, 1970a, 1973; Grimm & Theis, 1972; Grimm, 1973; Eggers, 1975; Hudec, 1976; Chrabrij, 1981; Bezzel, 1982). Baruš & Weismann (1981) described the synurbanization process of vertebrates.

MATERIAL AND METHODS

Our project was carried out in the very centre of Prague on 36.9 ha. Most of the houses of this densely built-up area are 4- and 5-storeyed and date back to the beginning of this century, a minimum of houses are of a more recent date. The buildings form large blocks, often enclosing small yards and, sometimes, dispersed greenery. Of the 20 and more tree species growing in the area studied, the dominant species are *Tilia* sp., *Robinia pseudacacia*, *Aesculus hippocastanum*. City green (0.6 ha) is provided by Františkánská zahrada (Franciscan garden), also inside a block of houses, by trees, flower beds and ornate shrubs in Václavské náměstí (Wenceslaus Square) forming the axis of the area studied.

Bird counts were made during the nesting season of 1985 (between April and June), using a modified mapping method (IBCC 1970, Štastný 1974), which had to be adjusted to specific conditions of the centre of an urban agglomeration. In addition, the variegated type of sampling sites and, sometimes, an impeded view (mostly by roofs) required specific methods for a determination of the state of several bird species. *Columba livia* f. *domestica* and *Passer domesticus*, both apparently, the most abundant species in the area studied, had to be monitored separately. The individual specimens were counted over three mornings in April, the results were related to pairs and averaged. The density of *Apus apus* was determined on the basis of an average of nine observations made in one half of the area studied, during the evening hours of the last decade of June, and then related to whole area.

Table 1. Bird species, their dominance and density in the town centre

Species	Number of pairs	Dominance	Density (pairs/10 ha)
<i>Columba livia f. domestica</i>	211.0	44.6	57.2
<i>Passer domesticus</i>	161.0	34.0	43.6
<i>Apus apus</i>	39.5	8.4	10.7
<i>Turdus merula</i>	19.5 (2.0)*	4.1	5.3
<i>Delichon urbica</i>	18.0	3.8	4.9
<i>Streptopelia decaocto</i>	10.5 (2.0)	2.2	2.8
<i>Phoenicurus ochruros</i>	5.5	1.2	1.5
<i>Fringilla coelebs</i>	2.5	0.5	0.7
<i>Parus major</i>	2.0 (1.0)	0.4	0.5
<i>Falco tinnunculus</i>	2.0	0.4	0.5
<i>Corvus monedula</i>	1.0	0.2	0.3
<i>Carduelis chloris</i>	1.0	0.2	0.3
Total	473.5	100.0	128.3

* In brackets are informations of Franciscan garden

The remaining bird species were monitored in regular intervals six times in the morning and twice in the evening. Each time, a check-up was made of the plot including the spaces inside the blocks of house, the entire investigation requiring often up to 5 hours.

We entered our data in maps, scale 1 : 1 000, from which we evaluated the number of pairs, determined the dominance of species and its grade (Palmgren, 1930) including density expressed in pairs/10 ha. In addition, we calculated the values of diversity (H') and species evenness (J') as suggested by Hudec (1976), and determined the proportional representation (in %) of species nesting on buildings (Tomialojć, 1970).

RESULTS

We identified a total of 12 bird species, permanently inhabiting the centre of the town (Table 1). All these species were typical of this type of urban environment, and were nesting there. Once or twice, during checking, we encountered specimens of 6 other bird species, the presence of which in the centre of Prague was exceptional. These were *Anas platyrhynchos*, *Accipiter nisus*, *Hirundo rustica*, *Serinus serinus*, *Sturnus vulgaris*, *Corvus frugilegus*.

The three dominant species (*Columba livia f. domestica*, *Passer domesticus*, *Apus apus*) participated with 87% in the avifauna. Three species (*Turdus merula*, *Delichon urbica*, *Streptopelia decaocto*) were influent, six species (*Phoenicurus ochruros*, *Fringilla coelebs*, *Parus major*, *Falco tinnunculus*, *Corvus monedula*, *Carduelis chloris*) were accessory species.

The three dominant species participated with 111.5 pairs in the relatively high total density (128.3 pairs/10 ha), while both influent and accessory species participated in it only with 16.8 pairs/10 ha.

The species nesting in the study area were represented mainly by species nesting on buildings. Seven species with a total density of 118.7 pairs/10 ha (92.6%) nested exclusively on houses. Among the species which nested partly on buildings and partly on trees were *Turdus merula* and *Streptopelia decaocto* and, in the absence of natural hollows in trees and nest boxes, perhaps also

Parus major. The species nesting exclusively on trees (*Fringilla coelebs*, *Carduelis chloris*) fed solely on the vegetation of yards in their immediate vicinity, they were never encountered in the trees lining the squares. The value of diversity was 1.42, that of species evenness 0.57.

DISCUSSION

The dominant species of the centre of Prague were largely identical to those reported by Bezzel (1982) for town centres of Central Europe. Equally, the total number of identified species did not differ greatly from the data obtained from town and city centres (particularly those with old buildings) of Central Europe (e.g. Erz, 1964, Saemann, 1970a, Eggers, 1975, Hudec, 1976).

Most interesting was the position of the two dominant species, i.e., *Columba livia* f. *domestica* and *Passer domesticus* — in that the first species was more abundant even if we considered a possible error arising, e.g., from an absence of the feral pigeon population when searching for food outside the study area. Thus, the relatively high total density of an ornithocoenosis in the centre of a town seems to be underestimated rather than overestimated (Table 1). The presence of larger green spaces in the study area increased the value both of diversity (1.42) and species evenness (0.57).

CONCLUSIONS

1) The avifauna of the town centre consisted of 12 constant species (*Falco tinnunculus*, *Columba livia* f. *domestica*, *Streptopelia decaocto*, *Apus apus*, *Turdus merula*, *Phoenicurus ochruros*, *Parus major*, *Delichon urbica*, *Carduelis chloris*, *Fringilla coelebs*, *Passer domesticus*, *Corvus monedula*).

2) Total density assessed in the area studied was 128.3 pairs/10 ha. The tree dominant species participating in bird density were *Columba livia* f. *domestica*, *Passer domesticus*, *Apus apus*. The species nesting on buildings participated with minimally 92.6% in total density.

3) Species diversity (1.42) and species evenness (0.57) were both relatively low, their value was influenced favourably by larger spaces of urban green in several parts of the town centre.

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**NEW DATA ON KARYOTYPE VARIATION IN THE PINE VOLE,
PITYMYS SUBTERRANEUS (RODENTIA, ARVICOLIDAE)**

O. V. SABLINA¹, J. ZIMA², S. I. RADJABLI¹, B. KRYŠTUFEK³,
F. N. GOLENIŠEV⁴

¹Institute of Cytology and Genetics, Siberian Branch, Academy of Sciences USSR, 630090 Novosibirsk, USSR; ²Institute of Systematic and Ecological Biology, CSAS, Květná 8, 603 65 Brno, Czechoslovakia; ³Natural History Museum of Slovenia, Prešernova 20, 61001 Ljubljana, Yugoslavia; ⁴Institute of Zoology, Academy of Sciences USSR, Universitetskaja nab. 1, 199034 Leningrad B-39, USSR

Abstract. 39 specimens of the pine vole (*Pitymys subterraneus*) from 17 localities in central and north-eastern Europe were karyotypically studied. 54-chromosome form was found in the Leningrad region in the USSR. New data concerning the autosomal inversion polymorphism, and Y chromosome length variations are presented. Possible systematic implications of the karyotypic data are discussed.

According to its karyotype variation pattern the pine vole, *Pitymys subterraneus* (de Selys Longchamps, 1836) is a polytypic and polymorphous species. Two karyotypic forms possessing different chromosome numbers. $2n = 52$ or 54 , occur in the distribution range of this species (Meylan 1970, Kratochvíl and Král 1974, Niethammer 1982). The 54-chromosome form has so far been found in France, Belgium, the Federal Republic of Germany, Switzerland, and Poland. In the other parts of the European area of its distribution, karyotypes containing 52 chromosomes have been ascertained.

Variations in the length of Y chromosome have been observed in karyotype banding studies enabling the exact identification of all chromosomes in the set. A markedly longer Y chromosome was described in the karyotypes of specimens originating from the Austrian Alps (Gampert et al. 1982), a little shorter Y chromosome was reported from males from the Tatras in Czechoslovakia (Zima 1984).

Autosomal polymorphism caused by pericentric inversion in a large subtelocentric chromosome was described in several populations of the 52-chromosome form. Polymorphous populations were reported from various localities in central and south-eastern Europe (Král and Zima 1978, Zima 1986, Zagorodňuk 1988).

In this paper, some new data on the character of the geographical and population karyotypic variations in the pine vole are presented.

MATERIAL AND METHODS

39 specimens of the pine vole were examined. The specimens were captured in 17 localities of Czechoslovakia, Yugoslavia, Poland, Rumania, and the Soviet Union during the period of 1977—1988. Beside the animals captured in free-living populations, the karyotypes of two hybrids between a female from Polish Tatras and a male from Soviet Carpathians were studied.

Karyotype examination followed the standard method of the direct treatment of bone marrow cells. The G- and C-banding techniques, slightly modified after the suggestions of Seabright (1971), Sumner (1972), and Radjabli and Krukova (1973), were used in the karyotype examination of certain specimens.

RESULTS

Synopsis of karyotypes found in the localities examined

Specimens with karyotypes containing 52 chromosomes were found in 16 localities. The 54-chromosome form was ascertained in one locality. The following karyotypes have been revealed in individual localities:

Czechoslovakia

- Klíny, Krušné hory Mts., 1 specimen, $2n = 52$, normal karyotype.
Šerlich, Orlické hory Mts., 2 specimens, $2n = 52$, normal karyotype.
Karlova Studánka, Jeseníky Mts., 4 specimens, $2n = 52$, normal karyotype.
Vratkov, Dražanská vrchovina Highlands, 3 specimens, $2n = 52$, normal karyotype.
Skalní mlýn, Moravian Karst, 4 specimens, $2n = 52$, two specimens with normal karyotype, two species with a heterozygous inversion in the largest autosome.
Sedlec, southern Moravia, 1 specimen, $2n = 52$, normal karyotype.
Jánská dolina Valley, Nízké Tatry Mts., 1 specimen, $2n = 52$, normal karyotype.
Dumbier, Nízké Tatry Mts., 1 specimen, $2n = 52$, normal karyotype.
Muráň, Slovenské Rudohorie Mts., 1 specimen, $2n = 52$, normal karyotype.
Predné Meďodoly Valley, Belianské Tatry Mts., 3 specimens, $2n = 52$, normal karyotype.
Silická Brezová, Slovakian Karst, 5 specimens, $2n = 52$, normal karyotype.

Yugoslavia

- Sava River springs, Kranjska Gora, 3 km W — 1 km N, Julian Alps, 1 specimen, $2n = 52$, normal karyotype. The Y sex chromosome rather small, about 2/3 of the length of the longer arm of the X chromosome.
Prekmurje, Murska Sobota, 8 km W — 3 km S, Pannonian Lowlands, 2 specimens, $2n = 52$, normal karyotype.

Rumania

- Curmatura, Pietra Craiului Mts., 1 specimen, $2n = 52$, normal karyotype.

Poland

- High Tatra Mts, 1 specimen, $2n = 52$, normal karyotype.

The Soviet Union

- Boksitogorsk, Leningrad region, 2 specimens, $2n = 54$, normal karyotype.
Soviet Carpathians, Ukraine, 1 specimen, $2n = 52$, normal karyotype.

The banded karyotype of the 54-chromosome form

The karyotype and the G- and C- banding pattern of the chromosomes of a specimen from Boksitogorsk in the Leningrad region are illustrated in Plate 1*. The amount of C- heterochromatin in the karyotype is rather small. The whole Y chromosome and centromeric regions of several autosomes were C-positively stained. The centromeric blocks of C- heterochromatin were very distinct especially in the small metacentric autosomal pair.

The analysis of banded chromosomes in two hybrids of 52-chromosome form has indicated the identity of parental karyotypes. The comparison of the 52- and 54-chromosome karyotypes has shown the similarity of the G-banding patterns in all autosomal arms. The size and morphology of the sex chromosomes seems to be identical in both forms too. The differences in the diploid number is apparently caused by single tandem fusion of two autosomal pairs. The distinct block of C-positive heterochromatin was observed in centromeric region of the fused autosome. This centromeric block of heterochromatin may be considered as a consequence of the tandem fusion event.

DISCUSSION

The distribution of the 52- and 54- chromosome forms of the pine vole in Europe is summarized in Figure 1*. The finding of a 54- chromosome form in the Leningrad region confirms the assumption that populations with this karyotype occur primarily in the northern parts of the distribution area of the pine vole. The only exception is represented by the finding of Meylan (1970) from Valais in Switzerland. We must admit that the northern part of the distribution area of the 54- chromosome form can be discontinuous, and may consist of two isolated parts in the west and in the east. This consideration is supported by the fact that in the environs of Frankfurt am Oder (GDR), 52- chromosome form was described (Král and Zima 1978). This area represents the northern edge of the distribution range of the pine vole according to Niethammer (1982). The new distributional data from the GDR and Poland (Pucek and Raczynski 1983, Erfurt and Stubbe 1986) indicate, however, that the northern boundary of the range of the pine vole is situated in central Europe much farther to the north than suggested in the map by Niethammer (1982). It is probable that the occurrence of the pine vole extends, at least locally, to the coast of the North and/or Baltic Seas. The examination of the karyotype of such marginal populations is necessary for solving the problem of the continuity of the distribution area of the 54- chromosome form.

The interpretation of the evolutionary history of the origin of the contemporary distribution pattern of the two chromosome forms is difficult without further basic distributional data. It is obvious that neither the 52- nor the 54- chromosome form can be unequivocally identified with any of the nominal subspecies. In terra typica of *Pitymys subterraneus* (Wareme, Liège, Belgium), the presence of the 54- chromosome form was confirmed (Meylan 1974). The only other subspecies described inside the considered range of the 54- chromosome form is *transvolgensis* Schaposchnikov et Schanev, 1958. The type localities of all other subspecies of the pine vole probably lie inside the distribution area of the 52- chromosome form. It would be important to ascertain the karyotypic status of the isolated populations from central France assigned to separate subspecies *capucinus*, as well as of the populations from central and southern Poland, because terra typica of the local subspecies *atratus* is situated in the region of the probable contact zone of both chromosome forms. The oldest named subspecies occurring in the known distribution range of the 52- chromosome form is *dacius*, described by Miller at the foot of the Rumanian Carpathians. In the distribution area of the eastern-

*Plate 1 and Fig. 1 will be found at the end of this issue

most subspecies *ukrainicus*, populations with 52-chromosomes were found (Zagorodník 1988).

The chromosome banding patterns are very similar in the karyotypes of both forms. The amount and the pattern of C- heterochromatin distribution are almost identical in the karyotypes of the 52- and 54- chromosome forms. In the specimens of the 54- chromosome form examined, only the size of centromeric heterochromatin regions in small metacentric autosomes seems to be larger than in the previously studied 52- chromosome karyotypes. The G-banding pattern on individual chromosome arms is also very similar in both forms. The difference between the 52- and 54- chromosome karyotype is apparently due to single autosomal tandem fusion. It confirms the close phyletic relationship of the chromosome forms of the pine vole.

The distribution of both chromosome forms of the pine vole can be characterized as allopatric or parapatric, and this karyotype variability seems to indicate the course of intraspecific phyletic differentiation. On the other hand, the occurrence of polymorphous populations containing pericentric inversion is clearly mosaic, without allocation to any particular part of the range. Furthermore, the inversion has not been found in the homozygous state, and this absence of homozygotes also suggests that the rearrangement is not included in a divergent karyotype change, but is more likely to represent an adaptive populational mechanism. However, the nature of an adaptive meaning of the inversion is not known (cf., Zima 1986).

Gamperl et al. (1982) described a relatively large Y chromosome in males from the Austrian Alps. In the males examined by us smaller Y chromosome was found, corresponding by its length to the previous findings from the Tatras (Zima 1984). The results obtained by Gamperl et al. (1982) may thus be interpreted as a specific feature of the local population studied. It has to be noted that the size differences between populations in Y chromosome length are rather slight, and we cannot exclude that they are conditioned by the varying degree of spiralization of chromosomes in individual preparations. It can therefore be concluded that for evaluating the evolutionary relationships between populations the importance of the length variations in Y chromosome is disputable.

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**A STUDY OF DISPERSAL PHORETIC ASSOCIATION BETWEEN SPHAERIUM
(MUSCULINUM) TASMANICUM (HETERODONTA, SPHAERIIDAE) AND SIGARA
(TROPOCORIXA) TRUNCATIPALA (HETEROPTERA, CORIXIDAE)**

Tomáš SOLDÁN¹, Ian C. CAMPBELL² and Miroslav PAPÁČEK³

¹Institute of Entomology, Czechoslovak Academy of Sciences, Branišovská 31, 370 05 Czechoslovakia; ²Water Studies Centre, Chisholm Institute of Technology, Caulfield East, Victoria, Australia; ³Department of Biology, Pedagogical Faculty, České Budějovice, Czechoslovakia

Abstract: Details concerning a peculiar association between corixids and immature mussels firmly attached to claws of their middle legs by means of constricted shells are presented for the first time from a forest billabong locality in Victoria, Australia. Attached immature mussel stages belonging to a well defined size category exhibit very high attachment to a host species specificity, only a single incidental occurrence on nymph of *Austrolestes cingulatus* (Odonata) was observed. Infestation rate (13.82%), possible mechanism of infestation, infestation sites of both corixids and mussels and other potential host species are discussed in detail. The association is considered as a mussel dispersal adaptation realized through fixed migratory habits of corixids.

INTRODUCTION

When collecting aquatic insects at some localities of *Eucalyptus regnans* forests in the Great Dividing Range in Victoria, Australia one of us (T. Soldán) noticed a young mussel firmly attached to the leg of an aquatic bug. Close examination of this locality showed this phenomenon to be very common representing a very peculiar type of mussel-insect association. Although our knowledge on biology of freshwater sphaeriid mussels is relatively extensive (see e.g. summary of earlier data by Wesenberg-Lund, 1943 or bibliography by Herrington, 1962) their temporary associations of most likely dispersal character with other organisms have not been studied in detail so far and remained quite unknown from Australia. As to possible transmission of mussels of this type some authors (e.g. McMichael, 1967; Clarke, 1973; Smith and Kershaw, 1979 and others) stated that ".... the species are easily dispersed by insects, birds and wind storms". Moreover, the problem has completely escaped the attention of entomologists, although the corixids were studied extensively (e.g. Lansbury, 1970, 1981, 1984) in Australia.

The objective of this study is (1) to describe the morphological background of this association, (2) to study site and host preference of attached mussels and (3) to discuss the significance of the association and its role in reproduction and dispersal of sphaeriids.

MATERIAL AND METHODS

Altogether more than a thousand specimens of benthic macroinvertebrates were taken from three localities (one with common occurrence of associated animals, one with incidental occurrence of it and one "control" locality, see below) situated near Marysville, Victoria, Australia. Usual hydrobiological techniques, mostly long-handled metal cup with a screen bottom, were used to collect the specimens. Since the equal attention was paid to all habitats the samples could be regarded as quantitative or at least semiquantitative ones. Sampling was carried out from February 18 —

February 24, 1987, material was fixed with 75% alcohol, some associated specimens with Bouin fixative.

After sorting to species, the material was determined to a specific level in mussels, Heteroptera and Odonata according to existing keys (Brooks, 1951; McMichael and Hiscock, 1958; Smith and Kershaw, 1979; Lansbury, 1968, 1970, 1975, 1978, 1981, 1984; Lundblad, 1934; Hawkins, 1986; Polhemus, 1984 and Sweeney, 1965). Accompanying invertebrates (mostly insects) were determined at generic or familial level due to incomplete detailed knowledge of Australian freshwater fauna (cf. Williams, 1980). Morphometric characteristics of free-living as well as attached mussels collected were taken by a projective micrometer (magnification $\times 100$) and respective indices (BMI, MHI, BHI — see Table 1) were calculated according to McMichael and Hiscock (1958). Photographs were taken by a Reichert automatic camera, electronmicrographs by a scanning electron microscope Tesla BS 300. Bouin-fixed specimens, gold-coated by sputtering and dehydrated by a critical point drying methods were used for the electronmicroscopic study of surface structures.

All the material examined is deposited in the collections of Water Studies Centre, Chisholm Institute of Technology, and Institute of Entomology, Czechoslovak Academy of Sciences.

Description of study area

Three localities studied are situated near Marysville about 100 km N.E. of Melbourne, Victoria. Two of them with sporadic or none occurrence of the association described below represent artificial biotopes: "Lake" (in fact a shallow reservoir with inflow from the Steavenson riv.) (No. 3) in Marysville and a dam reservoir near the junction of the Steavenson and Taggerty river about 4 km. N. of Marysville (No. 2). These small reservoirs (about 30—50 m across) shows a large spectrum of biotopes with well developed littoral submerged flora and they are settled with fish. Both reservoirs possess predominantly sandy bottom with fine organic sediments.

The locality studied in detail (No. 1 in Table 2) lies at the end of Marysville golf course near Buxton Road about 3.5 km from Marysville near the junction of the Steavenson and Taggerty rivers and the locality No. 2. It is situated at the edge of *Eucalyptus regnans* forest about 20—30 m from the Taggerty riv. It is formed like a pool of oval and bent shape about 20 m long and 3—5 m wide. There is no in- or outflows; the water level is subjected to underground water level and probably also to floods of the river nearby. The pool is maximally 100—120 cm deep, average depth could be estimated from 30—50 cm. There are nearly no emergent vegetation on its banks. The water is clear, transparent to the bottom, neutral or slightly alkaline when measured by indicator paper. Its temperature during the study period varies from 14.4—17.8 °C being evidently much higher than that in the Taggerty river. No fish were observed, the locality is occasionally invited by ducks and herons. Judging from the character of bottom and growth of aquatic weeds the locality never dry possessing rich and permanent water supply.

Bottom is predominantly muddy or clayey covered with a relatively deep layer of organic sediment and debris since the locality receives a large amount of *Eucalyptus* leaf litter. Numerous tree branches and remnants of roots can be found as well. The bottom is mostly free, aquatic weeds are concentrated near the banks and only scattered in the middle of pool. Non-vascular plants are very rare as well as phyto- and zooplankton in general. Since there is evidently no more organic enrichment (contrary to similar localities lying on pastures nearby) the pool can be regarded as oligotrophic. The water is apparently well oxygenated. Consequently it differs in many respects from a typical Australian "billabongs" (cf. e.g. Hillman, 1986) showing some common feature with mountain pools or peat-bog aquatic habitats despite its relatively low altitude (400—500 m a.s.l.).

RESULTS

Mussels and their size and shape

The proper determination of specimens studied seems to be rather complicated since the systematic position of individual Australian species is unclear and a detailed revision of pea-mussels is still urgently needed. The species

Table 1. Morphometrical analysis of shells of *Sphaerium (Musculinum) tasmanicum* specimens from the locality studied

Morphological characteristics	Mussels of fully grown specimens	Mussels of free living immature specimens	Mussels of immature specimens attached to corixids
No. of specimens measured	29	47	26
Beak height (mm)	5.25 ± 0.29	3.52 ± 1.21	1.41 ± 0.15
Maximal height (mm)	4.32 ± 0.31	2.30 ± 0.91	1.01 ± 0.13
Beak length (mm)	3.08 ± 0.12	1.71 ± 0.85	0.84 ± 0.17
Maximal length (mm)	6.35 ± 0.38	4.00 ± 1.09	1.79 ± 0.11
Maximal width (mm)	3.10 ± 0.11	1.90 ± 0.69	0.68 ± 0.09
BLI index (mean and range)	0.50 (0.47–0.51)	0.42 (0.39–0.40)	0.47 (0.46–0.50)
MHI index (mean and range)	0.66 (0.58–0.68)	0.55 (0.45–0.58)	0.57 (0.55–0.57)
BHI index (mean and range)	0.83 (0.78–0.86)	0.78 (0.69–0.84)	0.78 (0.76–0.80)

BLI (beak length index) = max. beak length/max. length;
 MHI (maximum height index) = max. height/max. length;
 BHI (beak height index) = beak height/max. height

studied belongs to the genus *Sphaerium* (subgenus *Musculinum*) of the family Sphaeriidae (Heterodonta, Pelecypoda). However, although about 14 Australian species of this family have been recorded (Gabriel, 1939; McMichael and Hiscock, 1958; McMichael and Iredale, 1959; McMichael, 1967; Williams, 1980 and others) and a number of generic and species names largely based on minute differences of shell shapes and on distribution have been proposed for the Australian forms particularly by Iredale (1943, 1944) possibly only a few widespread species of sphaeriids exist here (Smith and Kershaw, 1979). According to the existing keys (McMichael and Hiscock, 1958) the species studied represents *Sphaerium (Musculinum) tasmanicum* (Tenison-Woods, 1867) a species widely distributed throughout S. E. Australia mainland and Tasmania in habitats with soft mud and weed growth including ponds, billabongs and some dams (Smith and Kershaw, 1979). To facilitate the future revision of this species-determination the measurements of alcohol-preserved specimens are given in Table 1. Although not proved with histological evidence, the gut of attached mussels conserved in alcohol or its remnants seem to be empty not containing any food contrary to free-living immature stages where gut content can be easily found by simple dissection.

Of the 102 specimens studied 76 mussels were collected free-living, most of them from submerged aquatic weeds, they were very rare on the surface of fine mud. Of these, 29 are supposed to represent mature individuals with well developed but weak hinge teeth and well apparent prominent umbos. Their size varies from about 5.00–6.5 mm in length (see Table 1). Shell valves are

Table 2. Percentage and sex ratio (males/females) of aquatic Heteroptera (Nepomorpha) at the locality No. 1

Family and species	Adults (%)			Nymphs (%) Instar 5	Younger nymphs (%)	Total No. of specimens
	Males	Females	Sex ratio			
Corixidae						
<i>Sigara truncatipala</i>	29	38	0.76	22	11	386
<i>Micronecta</i> spp.	38	41	0.92	11	10	188
Notonectidae						
<i>Enithares woodwardi</i>	33	44	0.75	13	10	402
<i>Anisops thienemanni</i>	36	40	0.90	15	9	516
Naucoridae						
<i>Naucoris congrex</i>	34	37	0.93	21	9	109

inflated, structured with minute but well distinguishable growth lines and darker (transparent brownish yellow) colour.

Most specimens collected belong to immature stages of various sizes (Table 1) with less apparent beak teeth and less prominent umbos but well developed beak and retractor) adductor muscles scars. The shell symmetry is very similar to that of adults but its colour is much paler, usually transparently dark yellowish. The least free-living specimens measured round 3.85—3.90 mm (maximal length) smaller specimens were not collected.

The measurements of attached immature specimens are apparent from Table 1 as well. Their size (round 1.8 mm of maximal length) is relatively uniform with low standard deviations and narrow range of the BLI, MHI and BHI indices. The shall shape generally resembles that of other (larger) immature stages but hinge teeth are nearly absent and only very slightly indicated and umbos are not prominent at all. Otherwise the symmetry of shells is well distinguished: wing, disc and both anterior and posterior margins are well developed. Anterior and posterior adductor muscle scar and posterior retractor muscle scar are well apparent, pedal retractor muscle scar is distinguishable but weak; beak muscles scars are not superficially discernable in any specimens observed. In comparison with free immature stadia the palial line seems to be shifted more marginally (in alcohol-fixed material). Growth lines are hardly distinguishable but apparently present. Colour of shells of attached stadia is conspicuously pale always lighter than that of free-living mussels, pale yellowish or whitish; shells are less transparent, slightly milky. Colour of all specimens studied were uniform, there were no variability as in free-living specimens. Although not proved with histological evidence, the gut of attached mussels conserved in alcohol or its remnants seem to be empty not containing any food contrary to free-living immature stages where gut content can be easily found by simple dissection.

Occurrence of association, host specificity, and potential hosts

Immature stages of *Sphaerium (Musculinum) tasmanicum* were found to be attached only on *Sigara (Tropocorixa) truncatipala* the only exception is mentioned below. During a close investigation of the locality studied altogether 152 adults of both sexes and 57 nymphs of the ultimate (last, 5th) instar were

found. Of the adults, 21 specimens were found to carry one or two mussels on their leg, i.e. the frequency of this phoresis is relatively high (13.82%) in adults. On the other hand, nymphs seem to be free of infestation. Only a single specimen (1.75%) carrying a single mussel was collected but the mussel was broken out from its middle leg during fixation.

The same host species (*T. truncatipala*) occurs at two nearest localities (dam near junction of the Steavenson and Taggerty river — No. 2 and lake in Marysville — No. 3). Freshwater mussels are very rare at the former locality and they are probably missing at the latter. Although many specimens of *Sigara truncatipala* were collected at these localities (52 and 81 respectively) among the aquatic weeds only a single case of phoresis between adult female of *Tropocorixa* and immature *Sphaerium* was found at the locality of dam which lies about 300 m from the place of relatively highly occurrence of corixid-mussel phoreses.

All three localities studied are inhabited with very similar fauna of aquatic Heteroptera although the quantitative presentation is rather different. Species and quantitative presentation of the Nepomorpha (semiaquatic species or Gerromorpha living mostly on water surface are omitted) is apparent from Table 2. Dominant species is *Anisops thienemanni* but neither it nor subdominant *Enithares woodwardi* were found to be infested with immature muscle. However, 3 specimens of *Anisops* (adults) and 5 specimens of *Enithares* (nymphs of instar 4 and 5) possess broken middle or fore leg claws which can indicate earlier infestation (see Preference of infestation sites). Approximately the same composition of aquatic Heteroptera fauna was found at the locality of dam (No. 2) but no *Enithares* and *Plea* were collected. The locality No. 3 (lake in Marysville) shows quite different quantitative composition of the community (*Naucoris congrex* and *Micronecta* spp. prevailing, representing more than 80% of specimens collected).

As to the other potential hosts the following taxa of aquatic animals were found at the locality No. 1: Ephemeroptera: *Cloeon* sp., *Atalophlebia* cf. *australis*; Odonata: *Austrolestes cingulatus*, *Ischnura aurora*, *Austroaeschna* sp. Coleoptera: larvae and adults of *Cybister* and *Sphaerius* sp.; Diptera: Tipulidae-Tipulinae gen. sp. (larvae), Tipulidae-Limoniinae gen. sp., Empididae gen. sp. (larvae), Chironomidae-Chironominae gen. sp. and numerous eruciform larvae of Trichoptera (indeterminable). None of the above species was not infested although many of them (Ephemeroptera, Odonata, Coleoptera and some Trichoptera) live among the aquatic weeds at the same place where *Tropocorixa*, *Enithares* and *Anisops* rest.

The only exception host species is *Austrolestes cingulatus* (Burmeister) (Odonata, Anizoptera) which is very common at the locality studied. We found a single nymph of the last instar carrying one mussel on the claws of metathoracic leg (Fig. 4)*. No other infestations except *Tropocorixa* were observed, broken claws were not found in several hundreds of insect larvae examined.

Attachment sites and locomotion of infested specimens

With the exception of evidently incidental finding of mussels attached to claws of right hind leg of *Austrolestes cingulatus*, all cases found concerned exclusively middle legs of *Sigara truncatipala* females. Of the 21 cases analysed

*Figs 1—4 will be found at the end of this issue.

mussels one leg were observed in 16 association (9 on the right and 7 on the left one) and mussels on both legs of the same species were found in 5 cases. The specimens with two mussels attached (Fig. 1) moved in the same way and speed as those with the only mussel.

Similarly, there is probably no determined position of mussel and/or bug leg site of attachment. Of the 26 cases analysed, 9 mussels were attached to the outer (ventral) (Fig. 2)* claw of middle leg, 11 mussels to the inner (dorsal) claw and in 6 cases, the mussel shells were attached to both claws of respective middle leg. As to the position on the claws itself 2 mussels were attached clearly to basal (proximal) part of claw or claws (Fig. 3)*, 8 mussels were attached approximately in the middle of claw and 7 mussels were attached to apical (distal) part of claws. In 9 cases the mussels were attached nearly terminally at the very apex of claw; in cases of attachment to both of the respective leg claws their attachment sites were the same or nearly the same differing only very slightly. However, other tarsal structures like arolium pretarsus were never constricted by mussel shells. In one case only, pretarsal apex was constricted.

Mussels were always attached by their disc or more precisely by its ventral margin, no attachment position near beak was observed. In 6 cases, the attachment position was shifted to anterior margin, in 13 cases slightly or moderately to the posterior one. In remaining 7 cases the attached claws follows the transversal symmetry axis of a mussel body. Shells of mussel were always very firmly adducted constricting the chitinous cuticle of *Sigara*'s claws very strongly. Constricted part of claws nearly always reached deeply behind the palial line of mussel (Figs 2, 3). No morphological evidence of either bug or mussel secretion were found near the attachment sites.

Close examination of claws on not infested material shows their injury or mutilation to be relatively very frequent. Normally, the claws of *Sigara truncatipala* measure 0.415—1.150 mm being always slightly dissimilar although the difference between claws of the same leg reached at most 0.315 mm (30 specimens measured) being equal to that between claws of the same specimen. However, differences of even 0.650—0.750 mm were often found in the middle claws of the same specimen. Microscopic investigation of these specimens always showed that they had been broken at least at the very tip. Moreover there were specimens with evidently broken claws at their bases. Of the 30 incidentally selected specimens of *S. truncatipala*, broken claws were found (at least a single claws of one middle leg) in 9 cases. Similarly in *Enithares woodwardi*, where claws of middle leg measure 0.285—0.390 mm, specimens with mutilated claws reached 10% in 60 specimens measured and in *Anisops thienemanni* where claws normally measure 0.150—0.270 mm about 15% specimens with broken claws occurred. Claws were found to be mutilated also on the fore legs in the latter two species from the family Notonectidae (no claws present in *Sigara*, Corixidae) but their incidence is much lower, restricted only to several cases. Comparison with the material of the respective species (always 3 specimens examined) from the localities Nos 2 and 3 showed that broken claws are very rare here reaching about 1—3% of specimens investigated.

Although only very limited observations of living associated specimens have been conducted so far the locomotion (swimming) ability of corixids bearing mussels is not restricted. perhaps it is a little slower especially in specimens

with two mussels. When swimming mussels are towed at the ends of slightly stretched and relaxed middle legs of corixid and they apparently show wave-like sinusoidal trajectories in water. No differences to unattached specimens were found as to their food uptake (animal uses mussels instead of claws when sitting on the surface of bottom and plants) or respiration (the buoyancy seems to be same). Examination of flight apparatus showed no changes or degenerative resorption of flight muscles and no pterygopolymorphism of *Sigara truncatipala* at any locality studied. Weighing of alcohol-preserved (wet-weight) specimens indicates that mussel attached reach about 10% or 20%, respectively of the host weight. Specimens of host species weigh 10.3–14.5 mg, mussels 0.9–1.1 mg (30 corixids and 7 mussels weighed).

DISCUSSION AND CONCLUSIONS

Taking into account the results of this limited, short-term study the following conclusions emerge: (i) the above described association is not definitively incidental at least at the locality studied and must be considered as an integral part of mussel life cycle. Attached mussels seem to show some degree of "anabiosis" — a resting stadium with firmly adducted shells and most probably not receiving any food for a relatively long period during summer season; (ii) the associated mussels most probably does not cause any injury or any harmful effects to their hosts being at least passively towed by their swimming although it has escaped the attention of both malacologists and entomologists for a long time; (iii) mussels seem to show a strictly defined host species and attachment specificity being found nearly exclusively on middle legs of *Sigara truncatipala*; (iv) the phenomenon seems to be limited to some localities only and (v) although its real biological background remains unknown it is most likely connected with reproductive/dispersal cycle of the mussel.

Discussing the phenomenon described above it is necessary to find answers to the following questions: (1) which factors determine the attachment position of mussels; (2) why corixids are preferred to other freshwater insect or other invertebrates; (3) what is the general profit for immature mussel stadia to attach the insects and to maintain this phoretic associations for such a long time and (4) what adaptations of mussels play a role to survive unfavourable conditions during attachment period.

The first question (1) seems to be relatively simple to be answered considering the morphological and ecological aspects of corixid life cycle. Prothoracic and metathoracic legs of *Sigara truncatipala* and of all other corixid genera in general possess very reduced or lacking claws contrary to mesothoracic leg which are provided with double and well developed long claws. Moreover, when resting the corixids (both adults and nymphs) use solely the mesothoracic legs which anchor the animal to substrates (mainly submerged weeds). First leg pair (prothoracic) is very short assisting largely to food uptake and cleaning of mouthparts and hind leg pair (metathoracic) serve mainly for swimming. Considering the motility of *Sphaerium* mussels — adults and immature stages solely benthic with slow creeping movements on the substrate surface by means of muscled foot — the attachment of mussels just to metathoracic legs can be explained easily. On the other hand, the mechanism of attaching itself — most probably sudden contraction of shell adductors

induced immediately after touch of corixid's claws to some part of soft mussel body (mantel) — remains unknown. However, judging from clearly incidental place of attachment both host claws and mussel disc the process of attachment takes place probably very quickly.

(2) There is no doubt that the phoretic association between mussels and corixids is characterized by relatively strong host specificity. If we take into account a purely dispersal adaptive function of this phenomenon (for details see paragraph 3) then the following requirements should be fulfilled (a) immature stages of insects and other invertebrates are not suitable because of very probable loss of immature mussels during metamorphosis in both exo- and especially endopterygote insects with a pupal stage. Moreover, there are several to many moultings before reaching more vagile adult stage and a danger of loss of mussels with the old cuticle would decrease. From the above reason most insect groups except for Heteroptera and Coleoptera, the specimens of which live in the aquatic environment in the adult stage as well, can be excluded.

(b) Mature insects or other invertebrates once attached by immature mussels should have an extremely high vagility to spread the mussels more effectively. That means to be a very good fliers and to regularly exhibit the migratory or even invasive population movements to other biotopes of the same type or even of similar types. Although some aquatic insects different show the migratory patterns (e.g. Odonata and Diptera) there are only two insect groups fitting this requirements — the Heteroptera and Coleoptera again. Invertebrates other than insects with their relatively lower vagility do not represent suitable hosts at all.

(c) External morphological body arrangement should be sufficient for phoresis i.e. with some suitable appendages and the potential host should be so large and powerful to carry relatively large mussels attached to them. This requirements are neither met by most oligopode larvae (Trichoptera) and even apode larvae (Diptera) nor by the most of invertebrates other than insects. Moreover, some aquatic Heteroptera such as *Plea* or *Micronecta* or aquatic beetles (e.g. Sphaeriinae of Hydrobiidae and other families) do not meet these requirements — their final body size is much smaller than that of immature mussels.

(d) The potential host should not possess any predatory or strong defence habits in order to easily tolerate a phoretic organism especially when attached to a long body appendage. There is no doubt that many of predaceous forms, especially those feeding regularly on some aquatic snails and other molluscs (e.g. dytiscid beetles), can easily utilize the attaching mussels as their prey. The same could be applied to the water bug family Notonectidae the nymphs and adult of which feed on aquatic invertebrates sucking their body tissues.

(e) The potential host should regularly visit the places of the easiest attachment the mussels regularly occurs — open surface of fine mud sediments or aquatic weeds. This requirement clearly excludes all burrowing forms and forms living in plant tissues and on the water surface.

To conclude, the potential host should meet these requirements: stout and strong body with suitable attachment size, herbivorous habits, very good flying ability with regularly migrating habits; aquatic adults often visiting bottom and plant habitats. According to our opinion, the only species meeting all the above demands is *Sigara truncatipala* since at least one of these pre-

mises are not met in every other organism in question. Although nobody actually observed the process of attachment of mussel to the corixid's leg some facts can be calculate if considering the following facts: immature stages of mussel probably actively search for resting sites of corixids; infestation at other place is excluded owing to considerably different motility and differences in exclusively benthic behaviour of mussels and benthic/pelagic behavior of hosts (breathing, food uptake etc.).

The unique finding of a single mussel on the leg of *Austrolestes cingulatus* is most likely only incidental since at least a thousand nymphs of this species observed there were obviously not infestsated, similarly to all other species of dragonflies and larvae of other aquatic insects. This rare occurrence means at least less than 1⁰/₁₀₀ incidental infestation in this particular species. Taking into account a relatively very high incidence of broken claws in *Enithares* and *Anisops*, these species seem to be attached equally to *Tropocorixa* since it is comparable or even higher to that of this "obligatory" species. Moreover, in *Enithares* and *Anisops* which possess distinct claws on the first (prothoracic) legs as well some specimens were mutilated also at this place. However, no mussels were found to be actually attached to specimens of these two genera — this might be explained by predatory habits of hosts resulting in active removing the mussels out of their legs.

(3) There is no doubt that there must be some profit to mussels resulting from this association which is probably connected with some of key life function. Parasitism is most likely excluded owing to the position of mussels attached. True parasitic form on corixids feeding either on soft tissues or hemolymph living inside the body select quite different attachment position as seen e.g. in parasitic aquatic mites (Hydracarina) (cf. Crisp, 1959; Rush, 1973). Improvement of oxygen and/or food uptake by mussels seem to be not probable since the shells are firmly closed. Strong contraction of respective muscles at least partially prevents filtering of water.

According to our opinion this association is connected with reproduction/dispersal processes of mussels. In freshwater mussels in general, the trochophore stage is suppressed and the veliger stage is represented by some larval form. The commonest is glochidium, the two other forms are lasidium (e.g. *Anodontites*, South America) and hastoria larvae (e.g. *Mutela*, Africa). All these types of larvae undergo parasitic phase in fishes. However, species of the family Sphaeriidae are viviparous retaining the larvae within the ctenidia throughout their development. Also the fertilization, which is never internal in other families, takes part in suprabranchial cavities in the Sphaeriidae. The retention of developing larvae is most common in the cases where it is difficult to find a suitable habitat for the young. This is the case of most freshwater mussels (see e.g. McMichael, 1967; Clarke, 1963) and those like shipworm (Teredinidae) living in a specialized, particular type of substrates (wood etc.).

Non-parasitic, viviparous reproduction means much higher requirements on the possibilities of dispersal since some freshwater mussels cannot be spread in glochidial stage encapsuled in fish gill epithelium. The possibilities of dispersal by drift of running water are nearly totally restricted in lakes and in higher depths (some populations of *Sphaerium* live at depth of 15—25 m, Wesenberg-Lund, 1943). Perhaps the migrations of corixids (and/or other aquatic insects) enable colonization of new biotopes by young *Sphaerium*

individuals replacing parasitic associations with fishes in other freshwater mussels. The probability of transfer of young *Sphaerium* by migrating corixids is undoubtedly much higher than that of dispersal of glochidia.

However, the *Sigara-Sphaerium* phoretic association can be influenced by some other biotic factor as well. Since it was observed only at a single, relatively small aquatic habitat densely populated by both *Sphaerium* and water insects its incidence would be density-dependent. The absence of attached mussels at the larger aquatic biotopes where both species are less numerous can decrease a probability of their meeting. Also inter- or intra-specific concurrence can influence needs to disperse. Dr. A. Jansson of University of Helsinki kindly informed us (pers. comm.) that he had observed cases of *Sigara-Sphaerium* association only in rock-pools near Tvärmine, south Finland, while it had been absent in lakes. Rock-pools undoubtedly represent an astatic biotope with very high pressure on dispersion (high temperatures, water level fluctuation etc.).

The last question (4) concerning the survival of attached mussels cannot be answered without some experimental results. Probably firmly constricted shells of young specimens enable to conserve the moisture needed for respiration when transported on flying corixid legs. These mechanisms are probably similar to those enabling many freshwater mussels to survive partial or short-term total drought caused e.g. by water manipulation in reservoirs etc. Moreover, the exposition to "terrestrial" conditions is relatively short since corixids, although flying for long distances, never spend long time outside the water.

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**THE GROWTH OF THE FRY OF THE BREAM (*ABRAMIS BRAMA*) AND THE
PIKE-PERCH (*STIZOSTEDION LUCIOPERCA*) IN THE ORLÍK VALLEY WATER
RESERVOIR IN 1983**

Josef ZÁVĚTA & Milan VELEBNÝ

Department of Zoology, Faculty of Sciences, Charles University, Viničná 7,
128 44 Praha 2, Czechoslovakia

Abstract. In the Orlick valley water reservoir the growth and age composition of the bream (*Abramis brama*, 350 sp.) and the pike-perch (*Stizostedion lucioperca*, 125 sp.) was examined. In each species the length and weight growths were ascertained together with the coefficient of condition (*K*). The relation between the total length and the standard length is 1.28 in the bream and 1.18 in the pike-perch. The most numerous species is the roach (78 %), then follows the bream, 10 %, the bleak (5 %) and, finally, the pike-perch (almost 4 %). The most frequent were the length groups of 60 mm in the bream and 65 mm in the pike-perch.

INTRODUCTION

In the Orlick valley water reservoir the growth and length composition of the fry of the bream, *Abramis brama* (Linnaeus, 1758) and pike-perch, *Stizostedion lucioperca* (Linnaeus, 1758) was studied. The first data concerning the growth of the fry of the pike-perch in the riverine lake Orlick are presented. The bream and the roach are the most frequent species in this reservoir covered by the seining operation. The basic knowledge of the population dynamics in fishes includes also the length and age composition of their fry.

The problems of the fish fry were studied by Balon (1971), Černý (1977), Peňáz and Gajdůšek (1979). As regards foreign authors, papers by Dmitrieva (1960), Laganovskaja and Sloka (1963), Lesnikova and Charitonova (1979), Ševcova (1983), Bernatowicz (1967), Steffens (1960), should be mentioned.

MATERIAL AND METHODS

The two species of the fry caught were obtained in the Orlick water reservoir, situated on the river Vltava. The riverine lake occupies the square area of almost 2,400 ha. The fry was caught by the help of seine nets in the upper part of the reservoir near the village of Stědronín in the estuarine mouth of the river Otava into the river Vltava in June 1983. The seine nets were 50 m in length with meshes of 0.8 × 0.8 mm, the depth was 3 m; one tulle net with meshes of only 1 mm was also used.

The collected material was conserved right on the spot in a 4% solution of the formaldehyde. In all fishes the body length (longitudo corporis, SL) and in a part of the material also the total length (longitudo totalis, TL), were measured.

Fishes were weighed with the accuracy of 0.5 g. For the age determination and the back calculation of the growth the scale method was used with the correction towards the scale formation according to Rosa Lee's method. The weight was determined by the method published by Rounsefell and Everhart (1960). Owing to the influence of conservation it was necessary to use the correction factor according to Steffens (1960), and Lusk and Pokorný (1964). In the bream 8 % of the weight were subtracted, in the pike-perch only 7 %.

RESULTS AND DISCUSSION

The bream

The value of the correction for the start of the scale formation in the bream found through the study of the fry in the Orlík reservoir is 12 mm. Peňáz and Gajdůšek (1979) state that scales are formed with the length of 13–16 mm. This, however, does not correspond with the values found by Oliva (1958), who studied the bream in the natural pond Poltruba and found the correction value of 21 mm. Poupě (1971) presents this value as 14 mm (bream from the Danube), 21 mm (bream from the Lipno riverine lake), but Vostradovský (1964) found this value to be 32 mm for the same reservoir.

Naiksata (1974) gives 30 mm for the Orlík reservoir, Matěnova (1975) only 19 mm. Závěta (1981) 25 mm for the same locality.

The length growth of the fry of the bream from the Orlík reservoir was determined in 98 specimens. In the sample, age classes 0–II were represented, the most numerous being age class I (74^{0/0}); length groups were within the range of 50–80 mm, the most numerous being the length group of 60 mm (32^{0/0}). The length growth is summarized in Table 1.

Also with the fry of the bream the average value for the ratio TL/SL was found to be 1.28. Závěta (1987) gives 1.33 for the length class 45 mm and 1.24 for the length of the bream 90 mm.

This value is well known also from other localities, where larger specimens were examined (Skořepa, 1966). Again we can see here a decrease of this value in proportion with the increase in the body length (Table 2). For the bream from the natural pond Poltruba, Skořepa (1966) cited the value of 1.33 with the body length of 50 mm; 1.31 with the body length of 160 mm and 1.28 with the length of 200 mm. For the bream from the Mostiště reservoir Gajdůšek (1981) cited the value of 1.32 with the body length of 130–190 mm; 1.30 with the body length of 191–240 mm and 1.28 with the length of 241–320 mm.

The weight of the fry was examined in 132 specimens. The smallest bream weighed 0.9 g and measured 50 mm. The length-weight ratio is expressed as follows:

$$\log W = -6.186 + 3.7365 \log SL,$$

the correlation coefficient of this relation being $r = 0.9617$. The average weight of the bream fry in age class 0 at the time of the capture was 1.5 g, in age class I 2.6 g, in II 7.8 g.

Table 1. The length growth of the fry of the bream

Age class	No.	Body length at the time of capture in mm		Back calculated body lengths in mm	
		average	ranges	l_1	l_2
0	24	56	55–80	—	—
I	72	66	55–80	36	—
				46–67	—
II	2	75	70–80	49	66
				43–54	60–72
				52	66
	98		average	43–67	60–72

Table 2. The relationship between the total length and the body length (TL/SL) of the fry of the bream and the pike-perch

Body length in mm	The bream TL/SL	The pike-perch TL/SL
45		1.16
50	1.30	1.18
55	1.30	1.22
60	1.30	1.20
65	1.29	1.20
70	1.27	1.18
75	1.25	1.17
80	1.26	1.16
85	1.27	—
110	—	1.20
115	—	1.16
120	—	1.20
125	—	1.14
AVERAGE	1.28	1.18

The back-calculated weight was 2.2 g in age class I and 4.1 g in age class II.

When we evaluate the length growth of the fry according to the back-calculated values, it is evident that in age class II there is very small increment of the length in this life period. This is caused, apparently, by the small number of specimens examined in age class II and, at the same time, those specimens could represent some extremely slow-growing individuals. When we compare the body length of the bream with the data from other localities according to the length of the body in the first year of life with regard to back-calculated lengths, the value of 53 seems to be the average one. From the Orlik reservoir the length of 41 mm was found in 1974 (Závěta, 1981), Matěnová (1975) gives 54 mm for 1973. Naiksatam (1974) 57 mm, Závěta (1981) 59 mm for 1976, Závěta (1987) 53 mm for 1982 (fry of the bream) and 55 mm for 1983.

Comparable values were published also by Oliva (1958) from the natural pond Poltruba (55 mm); in another natural pond, Řeháková bouda, situated not far from this region, he found 56 mm. The same author presented also values from the river Labe near the village Sedlčánky — 59 mm, and from the Vltava in Prague — 62 mm. Poupě (1971) found the length of the body in the first year of life to be 72 mm in the Danube bream near Medvedovo.

In the Lípno riverine lake the bream reach 76 mm at the end of the first year (Poupě, 1971), in the Slapy reservoir it was 81 mm (Čiháň and Oliva, 1959), in the Jesenice reservoir 56 mm (Vostradovský, 1964), in the Svihov reservoir, before the construction of the lake, 79 mm; afterwards it was 126 mm (Leontovyč, 1974).

Berg (1949) reported the value of 65 mm (Lake Ilmen), but 73 mm from the Caspian Sea and 95 mm from lake Aral Nikolskij (1954) has found 84 mm in the last mentioned locality. Mamontov (1977) 74 mm in the Bratsk reservoir. All these values relate to the first year of the life of the bream.

According to Bauch (1953) the average value from 36 North German lakes is only 46 mm; Karpińska-Walus (1961) gives a slightly higher

Table 3. The values of weight for the individual length groups and the values of K of the bream

Length groups in mm	No.	Average weight in g	Min — max weight in g	K
50	5	1.5	0.9—1.8	1.178
55	11	1.9	1.8—2.8	1.181
60	40	2.9	1.8—4.6	1.342
65	37	4.1	2.8—5.5	1.485
70	22	5.1	3.7—7.4	1.487
75	6	6.4	5.5—8.3	1.527
80	5	8.8	8.3—10.1	1.725
85	1	10.1	10.1	1.648

value of 48 mm from 14 Polish lakes. The smallest value of 34 mm is given by *Segerstrale* (1933) from the locality Haika Fjörd Borga in Finland. Similarly, only 35 mm are reported by *Nikolskij* (1954) from the Finnish lake Tuusula. Apparently, this extremely slow growth is influenced by the climatic condition at the northern border of the area of distribution of the bream.

Very high values are published by *Papadopol* (1970) from the Danube delta (112 mm), *Solovov* (1970) found as much as 147 mm in the upper part of the Ob in Siberia.

The weight growth of the bream was also compared with the back-calculated data from other localities.

The value of 1.7 g determined by us is comparable only with *Leontovyč* (1974), reservoir Švihov, 1971, 1.9 g. *Závěta* (1981) found 3.2 g in the Orlík reservoir in 1974, 4.7 g in 1976. *Matěnová* (1975) also found 4.7 g in the Orlík reservoir, *Naiksata m* (1973) 4.9 g from the river Danube-Žofín.

A high value of the weight growth of the bream in the first year of life is reported by *Solovov* (1970) from the upper part of the river Ob (12 g); *Mamontov* (1977) found 7.2 g in the Bratsk reservoir; *Djatlov* (1982) in the Ladoga lake — 9 g. *Biró* and *Garádi* (1974) 7.8 g in lake Balaton, *Papadopol* (1970) 12 g in the delta of the Danube.

The coefficient of condition of the fry of the bream in the Orlík reservoir is expressed by *Fulton's* coefficient (K), whose values increase with the increasing of the body length. The smallest value in the length group of 50 mm is 1.178, the maximum value of 1.725 was found in the length group of 80 mm. A survey of the values of K according to the length groups is summarized in Table 3.

Table 4. The length growth of the fry of the pike-perch

Age class	No.	Body length at the time of capture in mm		Back calculated body length in mm l_1
		Average	Ranges	
0	59	63	55—75	—
1	11	91	75—125	63
	70		average	57—72

In age class 0 Fulton's coefficient in the bream from the Orlík reservoir is 0.85, from the Danube — Vlčí hrdlo 1.89 (Pořípě, 1971). In age class I the present authors found 0.91, but Závěta (1981) found a higher value of 2.0 for Orlík in 1976. Leontovyč (1974) found the value of 1.74 in the Švihov reservoir in 1971, and a higher value of 1.82 for the year 1972 after the filling of the reservoir. Naiksatam (1973) found the value of 2.68 for the bream of age class I in the Danube-Žofín.

The pike-perch

The correction value for the time of scale formation calculated for the fry of the pike-perch in the Orlík reservoir is 20 mm. Dmitrieva (1960 b) reports the body length to be 20.5—35.0 mm at the time of the scale formation, Sedlár (1971 b) 45 mm. Bastl (1965) 34 mm.

In the Orlík reservoir the length growth of the fry of the pike-perch was studied in 70 specimens. In the sample age classes 0 and I were represented, length groups were within the range of 55—125 mm, but specimens from the length groups of 85—105 mm were missing. The most numerous was the length group of 65 mm (34%). The length growth of the fry of the pike-perch is summarized in Table 4.

The average value of TL/SL is 1.18. The values quoted vacillate considerable in dependence on the body length. It is true that the smallest value was found in the largest specimens, but the highest values were not found in the smallest specimens. The survey of the dependence is presented in Table 2.

For the pike-perch from Poland, Nagieć (1961) gives the value of this relation for the length groups of 45—99 mm as 1.19, for the length groups of 100—149 mm as 1.176.

For the Canadian species *Stizostedion canadense canadense*, Carlander (1950 a) reports the ration TL/SL = 1.159.

In the Orlík valley water reservoir the weight growth of the pike-perch was calculated on the basis of the sample consisting of 99 specimens. The smallest fish weighed 0.5 g and measured 50 mm. The length-weight ration had the following form:

$$\log W = -7.2045 + 4.1228 \log SL$$

Again the correlation coefficient shows a high dependence of the values studied and can be expressed as $r = 0.9913$.

The average weight of the pike-perch fry at the time of capture was 2.2 g in age class 0, 7.4 g in age class I. The back-calculated weight was 1.6 g in age class I.

The length growth of the pike-perch was evaluated on the basis of the body lengths at the time of capture. In the first year of life the pike-perch in the Orlík reservoir reaches 91 mm, Balon (1966) found 120 mm in the reservoir Orava.

The first data about the successful spawning of the pike-perch in the artificial pond Blaník near Lomnice nad Lužnicí in 1881 were published by Šusta (1884). Until autumn, the fry kept together with the carp, reached 80—120 mm of the length (the total length).

When we compare the length growth of the pike-perch in the first year of life with other data obtained from Czechoslovakia, the best growth rate (150 mm) was found by Čihař (1961) in the Slapy valley water reservoir

Oliva and Frank (1959) found in the same locality only 128 mm. Bastl (1965) studied the growth in Orava reservoir, separate by in males and in females, but he did not find any considerable differences in their growth. The males reached the length of 125 mm in the first year of life, the females 119 mm. Sedlár (1971 a) studied the growth from the Danubian backwater ("lake") Lion, which is situated outside the inundation area of the Danube, and reported the length of 130 mm for the first year of life. The same value back-calculated for the first year of life was found by Sedlár (1971 b) in the reservoir Nováky, 115 mm in the reservoir Virt and the channel of the same name in southern Slovakia, 102 mm in the Danubian backwater near the town Medvedovo, 63 mm only in the reservoir Rudno.

Data excerpted from foreign localities are higher in most cases. E.g., Nagieć (1964) gives the value of 308 mm from the Visla, back-calculating the body length at the end of the first year of life as 188 mm. From the Polish territory Nagieć (1961) presented many data about the growth of the pike-perch. For the river Wda she calculated the length for the first year of life as 131 mm, for the lake Wdzydze 142 mm in 1956, 135 mm in 1957, for lake Dlugie 148 mm, for lake Jamno 124 mm, for lake Turawa 156 mm.

In lake Dgal Maly Bernatowicz (1967) found the total length of 157 mm (0+) (standard length is 133 mm), range of 103—157 mm SL (127—185 mm TL); for the age 1+ the average length 262 mm (SL = 222 mm), range of 228—310 mm (193—263 mm SL).

Berg (1949) reports 206 mm from the river Volga, 169 mm from the river Don, 152 mm from Aral lake.

From the river Kama Soloveva and Zinovev (1971) reported the length of 124 mm at the end of the first year, from the Kama reservoir 138 mm, from Votkinsk reservoir 127 mm.

Bauch (1953) reports the average of 106 mm from 27 North German lakes, from Sarkower lake — 123 mm.

Wunds ch (1973) quotes the data of Mohr from 1916, according to which the Elbe river pike-perch reached 80 mm in the first year of life; in the locality of Obereider the same length was 50 mm, in lake Müggelsee (according to P a p l 1938), cited by Wunds ch (1973) this length was 144 mm.

The growth of the pike-perch from the localities outside Czechoslovakia is sometimes given in the total lengths of the body. We have transferred these data into standard lengths, using the coefficient 1.18. Thus Unger (1931) found 200 mm TL (169 mm SL) in the first year of life (Lake Balaton), S a k o w i c z (1928) 80 mm TL (68 mm SL) for the same period (the river Labe) and for the Obereider 120 mm TL (102 mm SL). Quoting literary data he also presented the lengths in the first year of life for the following localities: Lake Toften, Sweden, 83 mm TL (70 mm SL), lake Vänern 81 mm TL (68 mm SL), Hjälmaren 82 mm TL (69 mm SL), Tuusula, Finland, 113 mm TL (96 mm SL), Ladoga, USSR, 116 mm TL (98 mm SL). Tesch (1956) gives, as the maximal year increment for the pike-perch of age group 0, the length of 175 mm TL (148 mm SL), lake Müggel See.

Steffens (1960) studied the growth of the pike-perch in artificial ponds and also the increments during the first year of life in single months. E.g., in the pond Luschtz the length of the fry in June was 39 mm (at the age of one month only), in July 46 mm, in September 55 mm, in October 57 mm.

For comparison we also present the data published by Carlander (1950 a),

Table 5. The values of weight for the individual length groups and the values of K of the pike-perch

Length groups in mm	No.	Average weight in g	Min - Max weight in g	K
50	1	0.5	0.5	0.377
55	9	0.8	0.5 - 1.4	0.471
60	32	1.6	0.9 - 2.8	0.760
65	33	2.2	1.9 - 2.8	0.807
70	8	2.9	1.9 - 4.7	0.831
75	8	3.7	2.8 - 5.6	0.868
80	3	5.1	4.2 - 5.6	0.999
110	2	16.3	14.9 - 17.7	1.223
115	1	18.6	18.6	1.223
120	1	23.3	23.3	1.346
125	1	22.3	22.3	1.142

who studied the fry of the sauger (*Stizostedion canadense canadense*) from the Lake of Woods. Specimens of age class 0 measured 86 mm, the same of age group I 144 mm on the average (SL). The back-calculated value for the body length in the first year of life was 97 mm. The relation between standard, fork and total lengths were so nearly rectilinear that, single conversion factors could be used on all sizes of saugers, as follows: Fork length = 1.102 standard lengths and Total length = 1.159 standard lengths. These coefficients were based upon measurements of 1,888 and 645 Lake of Woods saugers, respectively, ranging in standard length from 50 to 375 millimeters (Carlander, 1950 a).

The first year growth of the walley, *Stizostedion vitreum vitreum*, was studied from 4,544 specimens collected during the first summer of life in the Red Lakes in six seasons by Smith and Pycha (1960). For comparison we can quote, e.g. the growth of age class 0 from the sample of 1956, when the walley reached the length 47 mm TL (40 mm SL) (July 1st), 59 mm TL, 51 mm SL (July 10), 71 mm TL, 61 mm SL (July 20), 85 mm TL, 73 mm SL (July 30), 95 mm TL, 81 mm SL (August 10), 104 mm TL, 89 mm SL (August 20), 111 mm TL, 95 mm SL (August 30). The first annulus appeared with the total length of 124 mm (SL = 106 mm). During 17 year of the study of the fry in Red Lakes the first annulus appeared within the range of the total length of 106—150 mm (SL = 91—128 mm) with the average value of 137 mm TL (SL = 117 mm) (Smith and Pycha, 1960). The relation between total and standard lengths is $TL/SL = 1.168$ (Carlander, 1950 b).

Comparing the values of the weight growth of the pike-perch, Sedlár (1971 a) found the weight 33 g for the first year of life (lake Lion, southern Slovakia). According to values of the weight-length ration given by Bastl (1965), we calculated the weight-length ration using the equation:

$$\log W = -5.16058 + 3.10676 \log SL$$

For the pike-perch from the Orava reservoir the weight was calculated in the following way: in the first year of life, males 19.4 g, females 19.4 g.

For the pike-perch from the reservoir Nováky, Sedlár (1971 b) found in the first year of life the weight of 23 g, for the reservoir Virt 22 g, for the channel Virt also 22 g, for the reservoir Rudno only 3.1 g, for the backwater of the Danube at Medvedovo 14 g.

The weight growth of the pike-perch was compared on the basis of the data registered during the time of capture. The present authors give 7.4 g. Very large values of 26 g were found by Gajgalas and Gjarulajtis (1974) in the drainage of the river Kuršju-Mares; Solovov (1971) presents the data of other authors from the river Don and Južnoj Bug — 80 g.

Sakowicz (1928) gives the following values: for the river Labe 5 g in the first year of life; for the river Obereiedr 13 g. Unger (1931) found a considerably larger value of 100 g for the pike-perch from the lake Balaton.

Bernatowicz (1967) presents the following values: age class 0+, ave. 37.5 g (range of 25—60), age class 1+ ave. 147 g (range of 90—200 g).

For the pond Luschitz, Steffens (1930) gives the weight of 0.4 g of the pike-perch at the age one month (caught in June); in July the weight was 0.6 g, in September 1.1 g, in October 1.2 g.

For the fry of the sauger (*Stizostedion canadense canadense*) from the Lake of Woods Carlander (1950 a) presented this length-weight ratio: $\log W = -5.03387 + 3.05800 \log SL$. In the time of the capture, the weight of the sauger was 57 g in age group I, the back-calculated values for the first year of life being 18 g.

The length and the weight growths of the pike-perch are expressed in K coefficient. The increase of the K value in the pike-perch was observed also in the bream. In the Orlik reservoir the smallest value found was 0.3777, and it was within the length group of 50 mm, the maximum value of 1.346 was found within the length group of 120 mm. The review of the values and results according to the increasing length groups is given in Table 5.

K value for the Orlik reservoir pike-perch in age class I is 0.99; higher value is presented by Solovov (1977) for the lake Balkhas (1.90).

CONCLUSIONS

The fry of the bream and pike-perch was studied in the course of 1983 in the Orlik reservoir with regard to the length and weight composition.

The length growth of the bream was estimated for age classes 0, I and II and for the pike-perch for 0 and I classes. The back calculated lengths were reconstructed using the correction for the length at the beginning of the scale formation as 12 mm at the bream and 20 mm at the pike-perch.

The weight growth was studied on the basis of the research of individual length groups and also by the back calculation using the length-weight ratio. The length and weight growths were compared with local and foreign localities and can be evaluated on the average, as rapid in comparison with domestic localities but slow in comparison with foreign localities.

The length and weight growths were also evaluated by means of the coefficient and condition (Fulton's index, K) in relation to the length and weight groups. In the bream and pike-perch the values of K are increasing with the length increase. In both species the relation of the total length to the body length (TL/SL) was calculated. In the bream this ratio is 1.28, in the pike-perch 1.18.

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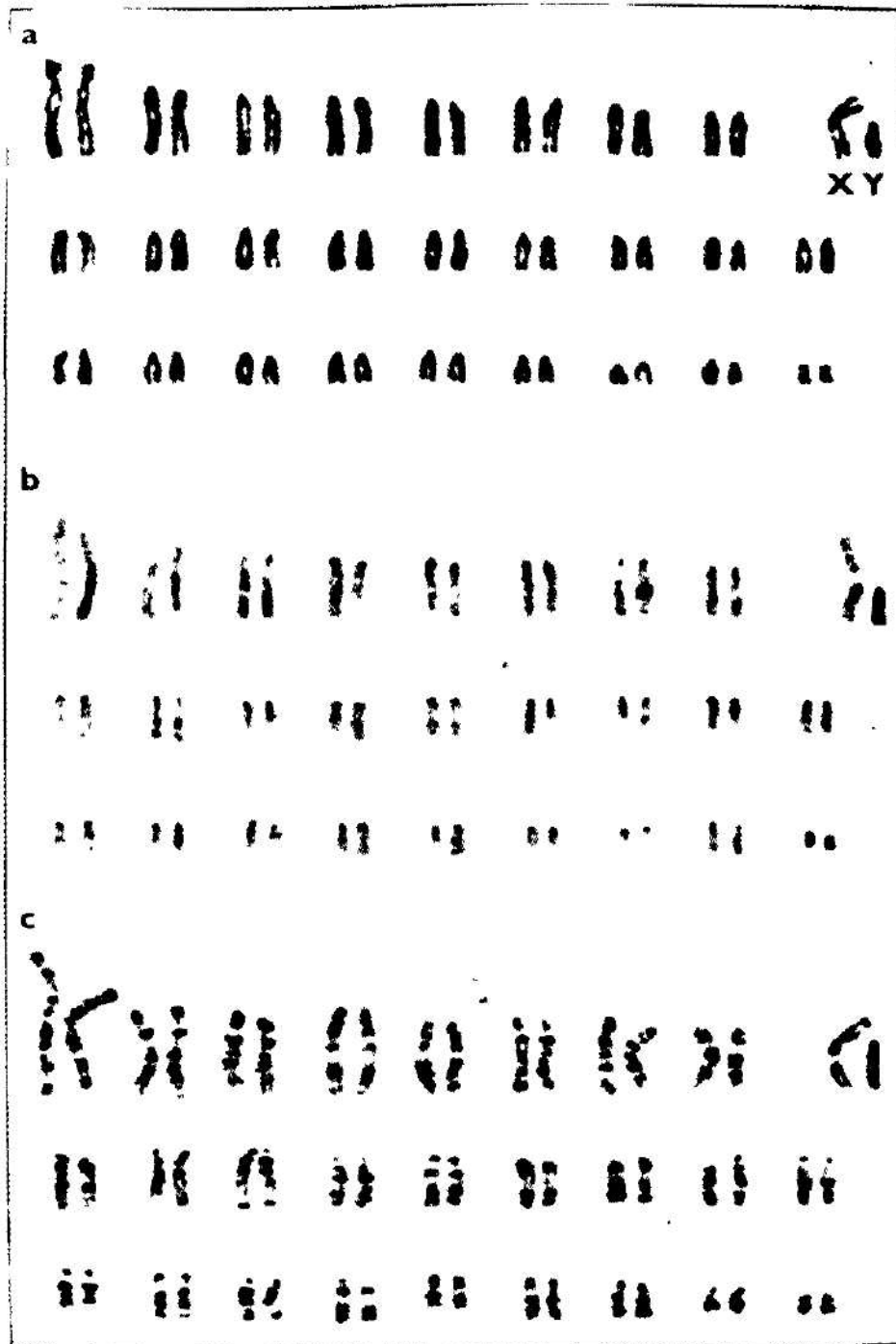


Plate 1. Karyotype of a male *Pitomys subterraneus* from Boksitogorsk, the USSR
a — conventional staining, b — C-banding, c — G-banding.

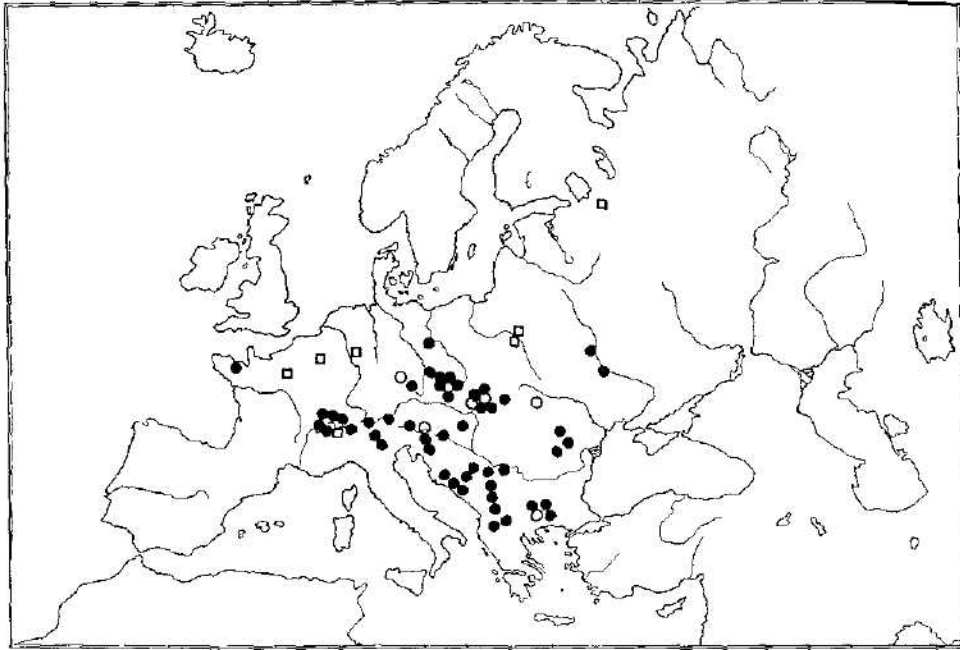


Fig. 1 Distribution of the 52-, and 54-chromosome forms of *Pitymys subterraneus*. Squares — finds of 54-chromosome populations, closed rings — finds of 52-chromosome populations, open rings — find of 52-chromosome populations containing the autosomal pericentric inversion.

Soldán T., Campbell I. C., Papáček M.: A study of dispersal phoretic association between *Sphaerium* (*Musculinum*) *tasmanicum* and *Sigara* (*Tropocorixa*) *truncatipala*

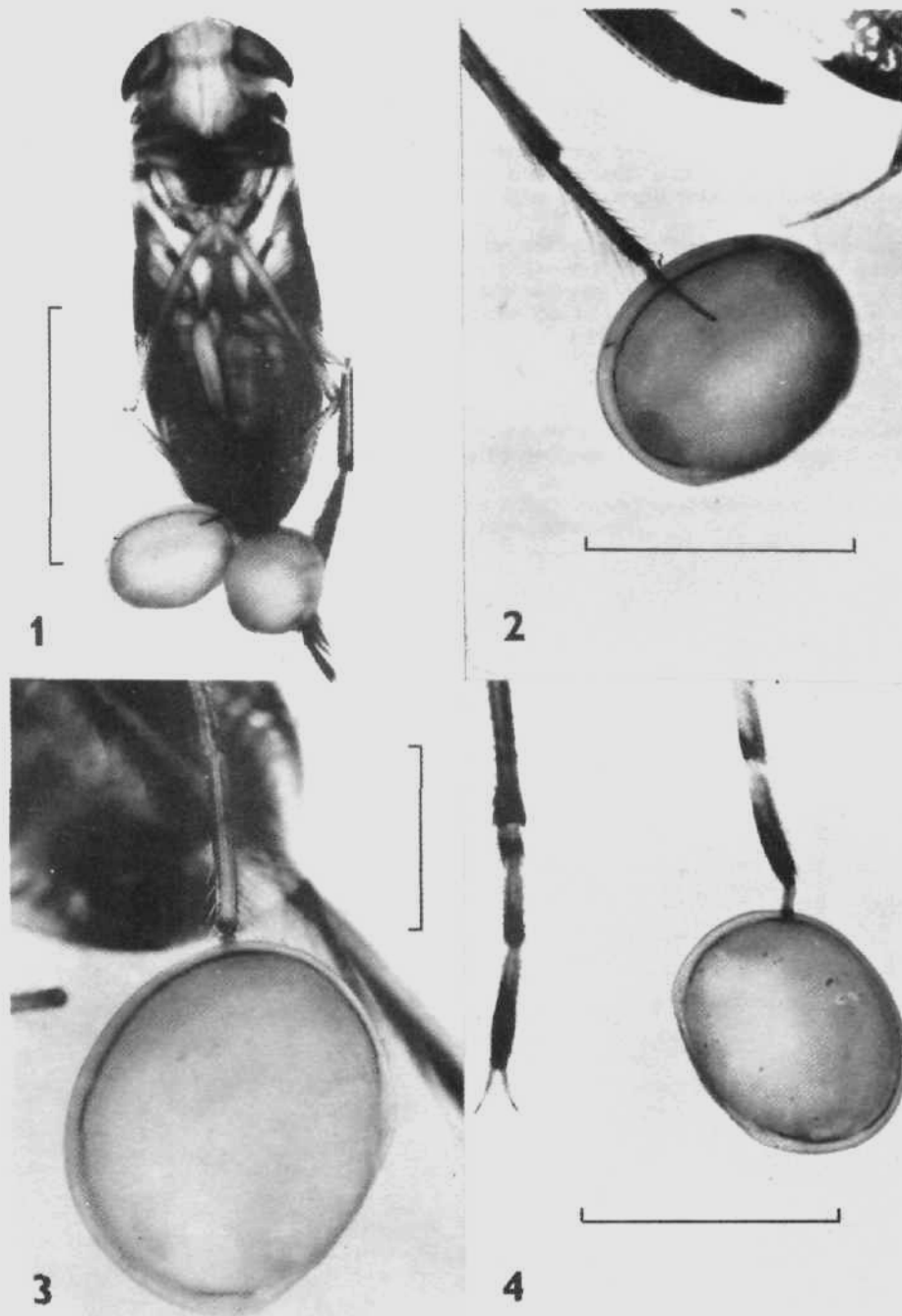


Fig. 1. Adult of *Sigara* (*Tropocorixa*) *truncatipala* bearing two young *Sphaerium* (*Musculinum*) *tasmanicum* on its middle legs; ventral view, scale 3.2 mm. Fig. 2. The same, young mussel attached to inner (dorsal) claw of middle leg, ventral view, scale 1.80 mm. Fig. 3. The same, young mussel attached to both claws of middle leg. Attachment site of mussel moderately shifted to the posterior margin of disc. Ventral view, scale 0.85 mm. Fig. 4. Young mussel attached to claws of middle leg of larva of *Austrolestes cingulatus*. Opposite middle leg at left; dorsal view, scale 1.80 mm.