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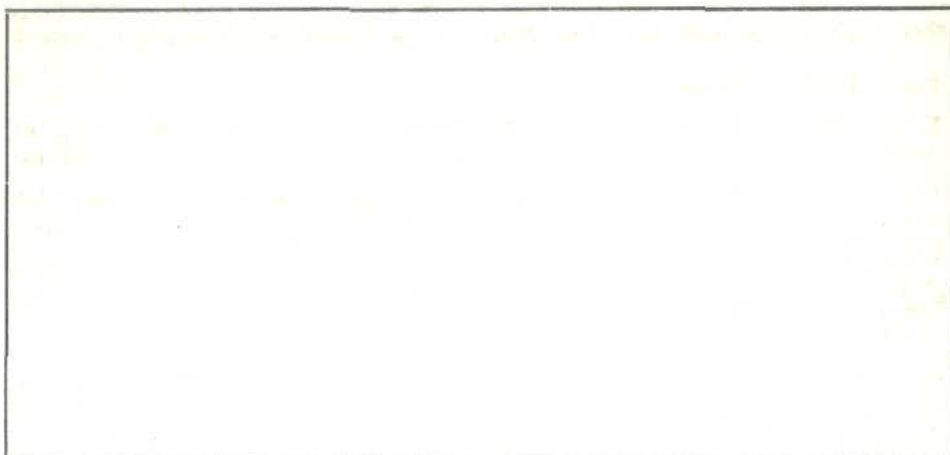
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**DETAILED MORPHOLOGICAL STUDIES ON THE H-ORGAN IN THE LARVAE
OF GALLEBIA MELLONELLA (PYRALIDAE, LEPIDOPTERA)
I. THE ANATOMY OF THE ORGAN**

Samir ABOU-HALAWA

Received June 23, 1986

Abstract. The anatomy of H-organ in *Galleria* larvae was described in detail. The studies indicated that the organ is rather complicated and may consist of two fused perisymphathetic organs; one belongs to the suboesophageal ganglion, attached at its rear, and the second one in the frontal region of the prothoracic ganglion. In the middle part of the H-organ, a new neurohaemal organ was found which is similar to the corpora cardiaca and lies in the ventral surface of the branching area. For this newly discovered paired organ the term "corpus prothoracale" is suggested. It receives the neurosecretory material from both the suboesophageal and prothoracic ganglia. No cyclical changes could be observed in the size of the anterior arm as well as in the transverse nerve of the H-organ during the development of penultimate and last larval instar. It has been suggested that such cyclical changes might exist only in the corpora prothoracalia and could also appear in some other parts of the neurohaemal area. In *Galleria*, the H-organ seems to be the first to degenerate during the metamorphosis, immediately after the movement of suboesophageal ganglion towards the brain. This may support the new hope for another development-stimulating center in the prothorax rather than the prothoracic glands.

INTRODUCTION

Since the discovery of the perisymphathetic organs (POs) by Raabe (1965), it has been generally accepted that their neurohaemal areas perform a similar function for the ventral nerve cord as the corpora cardiaca for the brain. Basically, they display a certain characteristic features; the most important one is their metameric distribution with their connection with each segmental ganglion (Raabe, 1984). An exception of all ventral ganglia was always the suboesophageal (SO) one, which in no case was found its PO. This holds true, not only in Lepidoptera (Provansal, 1972), but also in the other insect groups studied so far (Baudry, 1978; Raabe et al., 1971, 1974; Raabe, 1983, 1984; Thomas and Raabe, 1974; Grillet, 1976). Another exception was also found in the prothoracic ganglion (T₁G) of Hemimetabolous insects which (in contrary with SG) contains two POs; one in the front and another at its rear (Raabe, 1972; Thomas and Raabe, 1974; Grillet, 1983).

After the discovery of H-organ in various Lepidopterous larvae (Abou-Halawa and Sláma, 1986) it was shown that in *Pieris* larvae a large PO may be associated with the median nerve of the SG. Also, it has been found that the T₁G in Lepidoptera may have two POs as in Hemimetabolous insects. The present work provides some more details concerning anatomy of

the H-organ in an attempt to find (if present) the PO for SG and to understand (if possible) why two POs are associated with T₁G. Furthermore, it seems necessary to throw some more light on this newly discovered structure; i. e. the H-organ.

MATERIAL AND METHODS

Full grown penultimate (VIth) and last (VIIth) larval instars were used during the whole period of their development. Dissections of the thorax and the head were carried out in insect Ringer. A great care was paid during the dissections to the neck region to preserve the fine nerves between the SG to the H-organ. Thereafter, the choosen organs (SG, T₁G with POs) were transferred to the slide and stained with various vital stains as the methylene blue and neutral red and after fixation, with some other staining methods such as Giemsa, azocarmine and paraldehyde fuchsin. Dehydration in ascending concentration of ethanol, clearing in xylol and mounting in Canada balsam have been performed as the normal procedures. Measurements of the thickness of the anterior arm (Ha) and the transverse nerve (Tn) of H-organ were carried out by means of "Okular-Micrometer". The thickness of the first regular perisymphathetic organ (PO₁) and the first connective between SG and T₁G were also measured for comparison. These measurements were carried out daily during the last two days of the penultimate and during the whole period of the last larval instar which lasts for about 8 days. The total number of specimens used was 280 larvae in the rate of 12 — 25 insects for each stage.

List of abbreviations

adn = Anterio—dorsal nerve, amn = Anterio—medial nerve, cln = Cephalic nerve, cp = Corpus prothoracale, Ha = Anterior arm of the H-organ, Hp = Posterior arm of the H-organ, ISGn = Lateral suboesophageal nerve, m = Muscles, ncp I = Nerve of corpus prothoracale I, ncp II = Nerve of corpus prothoracale II, ns = Neurosecretion, nsc. Ha = Neurosecretory cells of the anterior arm, pdn = Postero—dorsal nerve, PO = Perisymphathetic organ, POs = Perisymphathetic organs, PO₁ = First metameric perisymphathetic organ, SG = Suboesophageal ganglion, T₁G = Prothoracic ganglion, Tn = Transverse nerve of the H-organ.

RESULTS

The results of anatomical investigations of the H-organ in *Galleria* larvae are presented in Figs. 1 & 2. The studies supported by histological research (see the second part) indicate that the perisymphathetic structure is rather complicated and differs completely in its appearance from the other regular POs. The most complicated part appears in its middle region, particularly from the lateroventral side (Fig. 1 b). In this branching area, inbetween the Ha, Tn and the posterior arm (Hp), a conspicuous organ was discovered. This organ looks like the corpus cardiacum which appears either spherical or ovoid with several nerves from both the SG and T₁G. Due to their topography of the prothorax, the name "corpus prothoracale" (cp) has been used for each of them.

In whole mount preparations (as well as in the histological sections), the cp did positively stain with the specific stains for the neurosecretion (ns) particularly with azocarmin. Each cp lies ventrally in the branching area and partly embedded in the posterior part of Ha. It is innervated by two nerves; (i) the nerve corporis prothoracalis I (ncp I) originates from the T₁G. This nerve appears rather thick and short with clusters of neurosecretory material, (ii) the second nerve coming from SG, appears thin and relatively long. This nerve (ncp II) contains fine ns-granules in axonal path-ways from a group

Table 1 Variation in the thickness (in μm) of Ha, Tn, PO₁ and connective (conn.) during the development of full grown penultimate (VIth) and last larval (VIIth) instars

Age in days	Ha			Tn			PO ₁			Conn.		
	min.	max.	mean \pm SD	min.	max.	mean \pm SD	min.	max.	mean \pm SD	min.	max.	mean \pm SD
VI/2	44.8	84.6	72.8 \pm 11.3	33.6	44.8	40.0 \pm 6.2	22.4	33.6	20.8 \pm 8.3	67.2	78.4	74.6 \pm 10.1
VI/3	56.0	89.6	72.8 \pm 9.7	44.8	56.0	46.8 \pm 8.1	22.4	44.8	32.6 \pm 12.2	67.2	78.4	75.3 \pm 8.6
VI/4*)	67.2	89.6	74.6 \pm 10.4	44.8	67.2	58.0 \pm 9.8	33.6	44.8	38.6 \pm 10.3	78.4	78.4	78.4 \pm 00
VII/0	56.0	89.0	72.8 \pm 11.5	56.0	56.0	56.0 \pm 00	22.4	44.8	38.8 \pm 8.2	78.4	78.4	78.0 \pm 00
VII/1	56.0	112.0	76.6 \pm 12.0	44.8	56.0	52.3 \pm 6.3	22.4	33.6	30.2 \pm 9.6	78.4	100.8	89.6 \pm 8.35
VII/2	56.0	112.0	81.5 \pm 16.6	44.8	67.2	51.5 \pm 9.0	22.4	44.8	30.8 \pm 9.7	89.6	100.8	92.3 \pm 7.8
VII/3	67.2	89.6	80.6 \pm 8.4	44.8	67.2	51.5 \pm 9.2	22.4	44.8	29.8 \pm 8.6	78.4	100.8	96.3 \pm 5.9
VII/4	67.2	112.0	87.4 \pm 14.9	44.8	56.0	49.3 \pm 5.5	22.4	48.8	32.6 \pm 8.2	89.6	100.8	96.1 \pm 8.2
VII/5	78.4	100.2	85.3 \pm 14.3	44.8	56.0	47.6 \pm 4.9	22.4	44.8	35.5 \pm 7.8	78.4	112.0	98.9 \pm 7.7
VII/6	56.0	89.6	85.1 \pm 5.5	44.8	44.8	44.8 \pm 00	22.4	44.8	38.3 \pm 10.2	89.6	100.8	96.5 \pm 6.5
VII/7	78.4	100.8	88.0 \pm 11.8	33.6	44.4	42.6 \pm 4.5	22.4	44.8	45.6 \pm 7.2	78.4	112.0	107.6 \pm 11.5
VII/8	56.0	112.0	93.8 \pm 20.1	33.6	44.8	38.0 \pm 5.5	22.4	56.0	45.2 \pm 10.6	100.8	134.4	117.6 \pm 12.5

*) About 12 hours before ecdysis
Conn.: The first connective between SG & T₁G

of neurosecretory cells (nsc) in the postero-ventral part of SG. These nerves are not seen in Fig. 2a due to their delicate appearance which could be easily cut during stretching the organs on a slide. They are clearly seen in histological sections particularly those in which the whole thoracic and neck regions were fixed and cut.

From the dorsal side, the Tn of the H-organ is innervated by six nerves (Fig. 1a, b): (i) The antero-medial nerve (amn) originates from SG, passes inbetween the two connectives and opens in the ventral surface of the Tn; (ii) The postero-median nerve (pmn) comes from the T₁G and innervates the dorsal part of Tn; (iii) Two lateral nerves rise from the posterior side of SG and are named antero-dorsal nerves (adn). These nerves are attached to the ventral surface of Tn near the branching area; (iv) The last two nerves lie also laterally, but from the dorsal side. They are the postero-dorsal nerves (pdn) which come from T₁G at the angle between the connectives and the lateral nerve of T₁G (lnP). They are the biggest nerves in comparison with the other 4 nerves mentioned above. They are nearly as thick as the posterior arm of H-organ and represent a conspicuous part of the branching area.

The Ha appears as a simple, rather thick tube. At its proximal part lies the cp at the ventral side of the branching area. At its distal (apical) part, another group of nsc (about 8 cells) lies just below its insertion with the muscles (Fig. 1a, b). These cells will be named the neurosecretory cells of Ha (nsc. Ha). It seems possible that some of these muscle fibres are entering the Ha; hence in the freshly dissected (unstained) specimens, a rhythmic movements of the Ha could be observed. These movements are of two types; longitudinally through the long axis which is followed by lateral vibrations. Two nerves are branched from this apical part of the Ha (Fig. 1). One is directed towards the head as a cephalic nerve (cln) and another one (P2) innervates the prothoracic glands. Both of them contain azanophilic ns-granules which may originate from nsc. Ha or/and cp. A third nerve appears very thin and delicate connecting the middle part of the Ha with the lateral edge of the SG. This nerve which could be named lateral suboesophageal nerve (LSGn) lies just below the cervical nerve and is covered by a very thin tracheal branch.

The Hp is the simplest arm which appears as a thin tube (its diameter is about 1/2 of Ha) and after crossing the lnP a large tracheal branch passes over it. This trachea divides into 3 small branches in the lateral sides of the Tn. At the point where the Hp crosses over the lnP, they are connected by a very narrow channel. This connection makes hard to separate them.

The diameter of the Ha and Tn was measured at different developmental periods of full grown penultimate and last larval instars. The results of these observations are included in Table 1. The table shows also the thickness of PO₁ and of the connectives between SG & T₁G. It is obvious from the table that no cyclical changes could be detected in both the components of the H-organ (i. e. the Ha & Tn). The same was observed in the PO₁ and the connective. In all of them there is, however, a slight and gradual increase in diameter until the time of pupation.

DISCUSSION

The present work indicates that the H-organ in *Galleria* larvae is a rather complicated structure and not as simple as it was described before (Abo -Halawa and Sláma, 1986). Several nerves from SG and T₁G are inner-

vating the organ, particularly its middle part (see the Results). The area is further complicated by the presence of cp at both of its lateral edges. These large and conspicuous neurohaemal organs were seen for the first time in histological sections. The difficulty to discover them during the intensive anatomical work could be summarized as follows: (i) Their existence was indeed unexpected; (ii) Their position in the lateral branching area which is the most complicated part of the organ; (iii) Their topography on the ventral surface of the H-organ being partly embedded inside the proximal part of the Ha.

The preliminary observations in the cp show that cyclical changes in its size occur at various stages of larval development. They appear hypertrophies round the moulting periods becoming small again and sometimes undetected during interecdysial periods. Detailed histological studies on these organs during the whole period of penultimate and last larval instars will be published elsewhere. Here it seems necessary just to mention that intrinsic azanophilic neurosecretory cells are found in the cp. These neurohaemal organs of the type of corpus cardiacum have never been described before (see reviews by Novák, 1966, 1975; Raabe, 1965, 1984; Wigglesworth, 1970; Raabe et al., 1974; Sláma et al., 1974; Grillo, 1976, 1983). In *Galleria*, the work by Provansal (1972) has described all the normal metameric POs throughout the whole ventral nerve ganglia except the H-organ with its cp which was completely overlooked until recently (Abou-Halawa and Sláma, 1986).

The H-organ seems on one hand to differ from the other regular POs and appears to be an unusual structure among the other metameric organs. On the other hand, however, such differences and abnormalities are difficult to be understood. A question arises why the H-organ differs from the all other regular POs and how did originate? According to the author's opinion the H-organ developed from two normal POs; one is attached in the front of T₁G and the second one represents the PO for SG placed at its rear (Fig. 3a, b). Due to the close position of SG and T₁G which appear to be the nearest ganglia, their POs are coalesced, thereafter completely fused particularly at their middle portion (Fig. 3c, d). However, the distal regions of these organs remain separate forming allatiform arms. The anterior arms are formed by the organ of T₁G, whereas the posterior ones are those from the SG. The fused middle part forms the most important neurohaemal area for both SG and T₁G. This hypothesis is supported by direct observations in some exopterygote insects in which the T₁G carries two POs; one in the front of the ganglion and the other at its posterior region (Raabe, 1972; Thomas and Raabe, 1974; Grillo, 1976, 1983). Furthermore, this hypothetical diagram follows the basic characteristic features for PO stated by Raabe (1984) as follows: (i) The POs are in a metameric distribution in each of the segments of the body, connected with the given ganglion; (ii) They are linked to the sympathetic nervous system. The same could be observed in the diagram represented in Fig. (3). This new hypothesis also replies the interrogation mark of Provansal (1972) concerns the PO for for SG. Her diagram which is represented in Fig. 4a could now completed and modified as it is shown in Fig. 4b.

It seems possible that the middle part of the H-organ is the most important neurohaemal area throughout the whole ventral nerve cord for several reasons: 1. It is the main distributing center for the ns-material from two ganglia

(SG & T₁G); 2. It contains at either side the cp which contains intrinsic nsc; 3. It is situated in the narrowest area (the neck region) exposed to the strongest stream of the haemolymph; 4. The vibratory movements of the Ha is, without doubt, for increasing the rate of hormonal release from the gland.

As it was mentioned before (Abou-Halawa and Sláma, 1986) that the H-organ begins to shrink progressively after the last larval ecdysis and

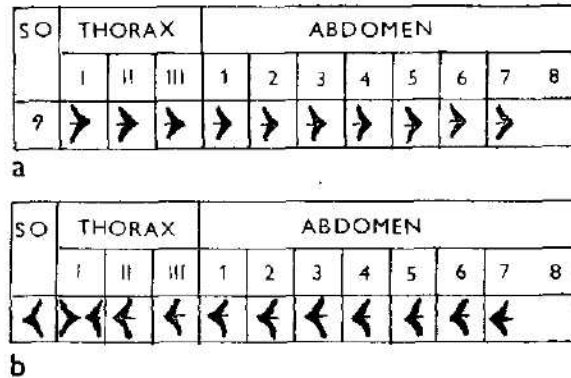


Fig. 4. a — the diagram of Provansal (1972) to show the distribution of the PO in the ventral nerve cord of *Galleria* larvae, b — the modified new diagram from the present author in the same insect.

disappears during the first day of pharate adult development. Such rapid degeneration of the H-organ may provide a new support for supposing the existence of another thoracic development — stimulating center beside (or rather than) the prothoracic glands. The function of these glands in moulting was put into question by the work of Sláma (1983).

One more point which calls for the discussion is the absence of any cyclical changes in the size of Ha and Tn. The same observations are in the normal metameric PO at the posterior part of T₁G. These results were indeed expected and simply indicate that the PO nerves (as the somatic ones) could hardly show any significant cyclical changes in their volumes (reference in Raabe, 1984). However, it seems possible that cyclical changes could only be found in the neurohaemal organs, particularly the cp of H-organ.

The last point is concerned with the unusually big size of Ha. The measurements indicate clearly that this arm is the thickest PO nerve throughout the whole ventral nerve cord. It reaches to about 2 — 3 times more thick than the normal metameric POs and in many of the cases it was as big as the connective. In this respect, the Ha seems to be different from the other regular PO nerves. The reason for this is still not clear.

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The figures 1—3 will be found at the end of this issue

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THE GROWTH OF THE ROACH (*RUTILUS RUTILUS*) IN THE ORLÍK RIVERINE LAKE IN 1981—82 (PISCES: CYPRINIDAE)

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Received August 12, 1986

Abstract. In the Orlík riverine lake the growth rate of the roach (*Rutilus rutilus*) was studied, using the scale method, on the base of samples from 1981 and 1982. Equations after Von Bertalanffy were calculated together with evaluation of the growth rate using the index of population growth rate. The weight-length relationship was expressed by Fulton's index (K). The growth rate of the roach from this locality is evaluated as an average one compared with other localities in Czechoslovakia and abroad.

INTRODUCTION

The roach, *Rutilus rutilus* (Linnaeus, 1758) belongs to the most common fish species of Czechoslovak rivers, artificial ponds and valley water reservoirs. Until now, it has not obtained any considerable economic value as the food fish, but it forms, nevertheless, an important part of the native ichthyofauna and bears the tendency to overfishing. Thus it can easily function as an important food competitor for other economically more important, fish species.

The growth of the roach in the large riverine lake Orlík was not yet studied. Long-term studies were performed in the Klíčava riverine lake, e. g. by Holčík (1967a, 1970), Pivnička (1974, 1975, 1982). In the Lipno riverine lake the growth of the roach was studied by Cabejšek and Frank (1968), Frank and Vostradovský (1961), in the Slapy reservoir by Frank (1959a) and Holčík (1961), in the Orava reservoir by Balon (1967), in the inundation backwater of the Danube in southern Slovakia by Chitradivělu (1974).

In the adjacent countries the growth of the roach was studied by Szczerbowski et al. (1976), Karpinska-Walus (1961), Penzak et al. (1976) in Poland; in the USSR by Rudenko (1971), Iljina (1960), Koževnikov et al. (1979), Strelnikov and Permitin (1983), Spivak et al. (1979); in Great Britain by Williams (1967).

MATERIAL AND METHODS

The material studied was obtained from the upper part of the riverine lake Orlík, in the upswelled part of the mouth of the river Otava, practically in the mouth of the Otava (the river km 4—7). For more exact data compare Závěta (1981). The fish were caught during the day and especially at night, in the course of May, June and October 1981 (387 sp.), and in September 1982 (128 sp.). The fishing was organized by the Czech Anglers Union, farm Štědronín, and it was performed by the staff and students of the Faculty of Science, Charles University, Prague, Department of Systematic Zoology. For netting seine nets were used, 50 m long, 4 and 6 m deep,

Table 1. Frequency of the roach in single age classes within years 1981 and 1982 in per cents of total catch

Year	n	I	II	III	IV	VI	VI	VII	VIII	IX
1981	348	0.6	43.4	15.2	2.6	7.6	8.3	11.8	7.2	3.4
1982	107	—	6.5	71.0	15.9	3.7	1.9	0.9	—	—

mesh size 2×2 cm and $0,8 \times 0,8$ cm, and 100 m long, 6 m deep, with meshes of 1×1 cm.

In all specimens of the roach the length of the body was measured (longitudo corporis, standard length, SL), in a part of the sample also the weight was determined. The age was determined on the basis of the scale structure by the use of the projecting apparatus Documator Lesegerät DL II, using the 17,5 times magnification. In all specimens the ventrodiagonal radius of the scale was measured. The Rosa Lee's method was used with the correction value of 22 mm. The back calculation of the weight was performed using the method following Rounsefell and Everhart (1960).

The length growth evaluation was made by the use of the index of the population growth rate, which can be calculated by averaging the growth characteristics (Balon, 1964).

RESULTS AND DISCUSSION

The roach material from the year 1981 was composed from 387 specimens, which belonged into 9 age groups. The most frequent was the IInd age class, which formed 43 % of the total material. The maximum body length of 250 mm

Table 2. Length growth of the roach in the Oriik reservoir in 1981

Age group	n	SL	Back calculated body lengths (SL) in mm								
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9
I	2	94	73								
II	151	87-100	50	98							
		92-150									
III	53	122	46	71	110						
		100-155									
IV	9	173	46	77	118	156					
		130-205									
V	26	182	43	67	99	135	171				
		150-230									
VI	29	199	44	66	94	133	162	190			
		165-235									
VII	41	212	41	60	86	115	147	175	203		
		190-240									
VIII	25	221	40	55	78	101	156	165	191	214	
		205-245									
IX	12	234	39	52	79	104	133	161	186	209	227
		210-250									
	348	average	47	69	95	124	164	173	193	212	227

Table 3. Length growth of the roach in the Orlik reservoir in 1982

Age group	n	SL	Back calculated body lengths (SL) in mm							
			l ₁	l ₂	l ₃	l ₄	l ₅	l ₆	l ₇	
II	7	119 100-185	51	97						
III	76	153 115-180	49	91	143					
IV	17	151 135-180	46	71	107	144				
V	4	173 170-175	39	57	92	131	170			
VI	2	180 175-185	40	56	82	116	147	173		
VII	1	175	44	67	93	99	134	153	169	
	107	average	45	73	103	123	150	163	169	

was found in a specimen of IXth age class, the smallest body length of 87 mm in a roach of the first age class. The most frequent length group was 111-115 mm, having 56 specimens.

The material from the year 1982 included 128 specimens, which belonged into the II-VIIth age class. The most frequent age class with 76 specimens was the IIIrd age class, which comprised 71% of the total material. The maxi-

Table 4 Weight growth of the roach in Orlik reservoir in the year 1981

Age group	n	W	Back calculated weight in grams								
			w ₁	w ₂	w ₃	w ₄	w ₅	w ₆	w ₇	w ₈	w ₉
I	2	13	7.0								
II	16	47 29-73	2.1	18							
III	4	46 38-52	1.6	6	26						
IV	1	128	2.1	8	33	80					
V	5	130 100-160	1.3	5	19	50	108				
VI	5	213 150-270	1.4	5	16	48	90	151			
VII	13	223 143-315	1.1	4	12	30	66	116	187		
VIII	10	276 220-340	1.0	3	9	20	80	96	153	221	
IX	7	311 235-380	0.9	6	18	22	48	89	141	205	268
	63	average	2.1	7	19	42	78	113	160	213	268

Table 5. Weight growth of the roach in Orlik reservoir in the year 1982

Age group	n	W	Back calculated weight in grams							
			w ₁	w ₂	w ₃	w ₄	w ₅	w ₆	w ₇	
II	7	35 20-90	2.8	19						
III	76	78 33-120	2.5	16	60					
IV	16	70 52-100	2.0	7	25	61				
V	4	106 100-115	1.2	4	16	46	100			
VI	2	115 105-125	1.3	4	11	32	65	106		
VII	1	125	1.8	6	17	20	49	73	99	
	105	average	1.9	9	26	40	71	90	99	

maximum body length of 185 mm had a specimen from the VIth age class, the smallest body length, 100 mm, a specimen from the IInd age class. The most frequent length group of 151-155 mm is represented by 22 specimens. The frequency distribution of the individual age classes from 1981 and 1982 is presented in Table 1.

The results of the length growth in individual years are presented in Table 2 and 3.

The length growth of the roach has the exponential mathematical form. The growth curve according to the growth model of Von Bertalanffy was constructed (after Ricker, 1975). The growth equations have the following form:

Orlik 1981

$$l_t = 530 (1 - e^{-0.0603 (t + 0.449)})$$

Orlik 1982

$$l_t = 231 (1 - e^{-0.194 (t + 0.068)})$$

In 1981 weight was determined in 69 specimens; the maximum weight of 380 g was found in a roach 245 mm long which belonged to the IXth age group. The smallest weight of 13 g was found in two specimens with the body length of 87 and 100 mm belonging to the ISt age group.

The weight-length relationship for the back calculation of the weight from the year 1981 has the following form:

$$\log w = -5.15304 + 3.21745 \log l$$

The correlation coefficient has a large value : 0.99413.

Results of the weight growth from 1981 are shown in Table 4.

From the sample of 1982 126 specimens were weighed. The maximum weight of 125 g was found in a roach 175 mm long from the VIIth year class. The minimum weight of 20 g was found in a specimen of 100 mm of the body length from the IInd age class.

Table 6. The comparison of the coefficient of the condition (K) in some localities

Locality – Reservoir	Age group								
	I	II	III	IV	V	VI	VII	VIII	IX
Orlík, 1981 – authors	1.57	2.14	2.05	1.89	2.31	2.24	2.28	2.36	2.40
Orlík, 1982 – authors	–	2.08	2.12	2.12	2.05	1.97	2.33	–	–
Lipno, 1959 – Cabejšek and Frank (1968)	1.61	2.42	2.25	2.14	2.25	2.32	2.45	2.51	2.50
Lipno, 1960 – Cabejšek and Frank (1968)	2.44	2.47	2.46	2.67	2.56	2.28	2.31	2.19	2.41
Lipno, 1961 – Cabejšek and Frank (1968)	1.70	2.14	2.25	2.18	1.98	2.05	2.04	2.09	2.13
Lipno, 1962 – Cabejšek and Frank (1968)	2.15	2.86	2.20	2.10	2.25	2.06	2.07	1.87	–
Orava, 1960–62 – Holčík (1967b)	2.29	2.26	2.20	2.05	2.06	2.07	2.00	2.03	1.93
Kachovsk, 1972 Males – Spivak et al. (1979)	–	–	2.08	1.77	1.98	2.00	2.07	1.98	1.98
Females	–	–	–	2.25	2.34	2.39	2.21	2.32	2.24
Kachovsk, 1973 Males – Spivak et al. (1979)	–	–	1.96	2.14	2.10	2.12	2.13	2.08	–
Females	–	–	2.10	2.43	2.28	2.35	2.35	2.31	2.10

The weight-length relationship from the year 1982 was

$$\log w = -4.64793 + 2.98144 \log l,$$

with the correlation coefficient 0.99771. Results of the weight growth from 1982 are summarized in Table 5.

In both years studied, the so-called Bank's start was determined also, which had the length of 40 mm in 1981 but in 1982 the body length of 36 mm corresponded to the body weight of 1 g (for details see Bank, 1940). The values of Bank's start in the roach from our territory range from 32 to 40 mm. The lowest value was found by Křížek (1977) – 32 mm, in the Kličava reservoir, Holčík (1967b) cited the value 34 mm from a roach from the Orava reservoir. Chitravadivelu (1972) found a 37 mm roach in the backwater of the Danube Žofin in southern Slovakia, while Balon (1955) found this value to be 40 mm in a roach from the backwater Poltruba (inundation area of the Labe in central Bohemia).

For the evaluation of the length and weight growth the Fulton's coefficient of condition (K) was calculated. In the specimens caught in 1981 its value range in dependence on the length groups, from 1.3 (average body length 100 mm) to 2.36 (average body length being 245 mm). In 1982 these values range from 1.9 (SL = 105 mm) to 2.07 (SL = 175 mm).

The relationship of K to the age classes is summarized in Table 6. The decrease of K in the IVth age class in 1981 is apparent. Similarly it can be observed in the VIth age class in 1982.

The coefficient of condition in the roach from the Orlík reservoir corresponds to the medium growth. Low values of K were recorded by Holčík (1967b) from the Orava reservoir. In the Kachov reservoir (the river Dniepr, USSR) Spivak et al. (1979) found different values in males and females. Since the specimens were caught in spring, the values ascertained were higher in females due to their being filled with eggs (Table 6).

Table 7. The survey of the index of the population growth rate for selected localities

Locality	Index of the population growth rate	
	1-5 year	1-9 year
Orlík, 1981 - authors	23.07	20.22
Orlík, 1982 - authors	22.39	-
Orava reservoir - Balon (1967)	12.73	12.92
Lipno reservoir 1964 - Vostradovský (1968)	30.86	-
Klíčava reservoir 1964 - Holčík (1970)	30.61	-
Slapy reservoir near Bučily - Frank (1959a)	21.25	19.14
Slapy reservoir near Cholin - Frank (1959a)	20.58	-
Pastviny reservoir - Frank (1959a)	30.18	-
Dunaj river - Žofin (arm) - Chitradivělu (1972)	17.19	-
Dyje river - Lelek (1965)	10.38	-
Dniestr river - Berg (1949) (USSR)	24.06	-
Volha river - Iljina (1960) (USSR)	18.14	-
Demencec lake - Rudenko (1971) (USSR)	9.45	12.64
22 Węgorzew lakes - Karpinska - Walus (1961) (Poland)	20.35	-
Sarkower lake - Bauch (1953)	19.67	17.15
Thames river - Williams (1967)	18.43	13.58
Siver lake (Latvian SSR) - Sloka (1959)	20.18	18.91
Dridzas lake (Latvian SSR) - Sloka (1959)	18.21	16.78

The length growth of the roach from the Orlík reservoir does not differ in 1981 and 1982. More substantial differences are evident in the 7th year of life. This is also evident from the index of the population growth rate (Table 7). When we are comparing the growth rate of the roach from the Czechoslovak territory according to the size of the increment in the first year of life, the growth rate is the slowest in the Pastviny valley water reservoir, in the Slapy reservoir near the village of Cholin (Frank, 1959a), and further, in the Poltruba backwater (Balon, 1955; Frank, 1959b). A medium growth rate was found in the Orava reservoir (Balon, 1967), in the side backwater of the Danube Žofin (Chitradivělu, 1972) as well as in the river Danube Vlčí Hrdlo and Rusovce (Krupka, 1972). A better growth rate was found in the artificial pond of Máchovo jezero (Cabejšek and Frank, 1968), in the Lipno reservoir (Vostradovský, 1968), in the Klíčava reservoir (Holčík, 1965; Pivnička, 1971, 1982). A very fast growth rate in the first year of life (84 mm) was cited by Lelek (1965), who analysed the spawning shoals of the roach from the river Dyje. The evaluation of the length growth cited does not correspond to the values of the index of the population growth rate (Table 7), where the most rapid growth rate within the first to fifth years of life is presented in the Pastviny reservoir (Frank, 1959a), because the growth rate of the length growth from this locality is reviewed to the fifth year of life (34, 71, 118, 163, 186 mm); note the remarkably large increment between the third and fourth years of life. A similar situation was found in the Lipno riverine lake (Vostradovský, 1968). The growth rate in the river Dyje appears to be slowest. In the fifth year of life the roach reaches the body length of 129 mm, but the length increment for the first five years of life is only 45 mm; this is reflected in the size of the index cited, which characterizes the length growth during the whole season more precisely.

A very rapid growth of the roach from the lower part of the river Dniestr was cited by Berg (1949). Iljina (1960) cited a slow growth from the river Volha up to the end of 1956. Very small increments were cited also by Rudenko (1971) from the lake Demenec. Similar situation from the Latvian lakes Siver and Dridzas was presented by Sloka (1959). Papadopol (1970) cited a rapid growth from the southern part of distribution in the Danube delta.

In the lake Plešćevo, according to Strelnikov and Permitin (1983), two different by growing populations of the roach can be found. In the litoral part of the lake the population more rapidly grows, feeds on the fund of the weeded part of the lake, partly also on benthic organisms and the plant food. Here the roach reaches up to the 13 years of age and the length of 215–220 mm. The other part of the population lives in the open part of the lake, the basis of its food being the zooplankton. In the litoral part of the lake roaches in the age of 5–8 years prevail, in the central part 4–7 year old specimens.

The largest weight in the roach was ascertained in the river Dniestr (Berg, 1949). The data from the Orlik riverine lake approach medium levels, very small weight increments were noted in the roach from the river Thames (Williams, 1967). Similarly a very small growth of the weight was found in the roach from the Poltruba backwater (Balon, 1955; Frank, 1959b), due to the large number of fish in this natural pond (Oliva, 1958).

According to the index which evaluates the growth rate it is evident that the growth of the roach in the Orlik reservoir belongs to the average ones. In this locality, the food conditions are apparently sufficient. The number of carnivorous fishes is apparently not sufficient to limit the size of its population here, but it is not evident, its mass overfishing and slowing of the growth.

SUMMARY

In 1981 and 1982 the length and weight growth of the roach (*Rutilus rutilus*) in the Orlik riverine lake was studied, using the scale method, in 387, and 128, respectively specimens. The roach studied belonged to I–IXth age class and to II–VIIth age class.

The length growth was expressed by Bertalanffy's equation, which presented exponential mathematical form with coefficients:

Orlik 1981	$L_{\infty} = 530$	$K = 0.0603$	$t = -0.449$
Orlik 1982	$L_{\infty} = 231$	$K = 0.194$	$t = -0.068$

For the evaluation of the growth relative indexes were also used: the index of the population growth rate and Fulton's coefficient.

On the basis of the growth rate the roach in the Orlik riverine lake is defined as medium growing in comparison with other localities. The local fishing industry does not influence this species substantially and, therefore, further exploitation can be recommended.

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**HARVESTABLE SIZE OF TWO INDIAN MAJOR CARPS
(PISCES: CYPRINIDAE)**

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Abstract. Age-wise growth data obtained from the scales of 2283 specimens of *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) have been employed for the determination of minimum theoretical harvestable size, which has been calculated from the interception of the length increment in the percentage of the first growth season and the length in percentage of the final growth season. The plotting of these two percentages along Y axis and age classes along X axis gives the point of intersection which is considered as the harvestable size. Based on the present investigations, it is suggested that the present legal limit or 30 cm total length be increased to 48.50 cm and 63.00 cm total length in *Labeo rohita* and *Catla catla* respectively.

INTRODUCTION

To get a sustained yield year after of a species, it is essential to calculate the harvestable size so that enough is left for recruitment. In Indian major carps, so far no attempt has been made to calculate the harvestable size based on scientific calculations. However, a legal limit of 30.00 cm total length in these carps and the commercial fishes is in practice for commercial fishing in northern India (Jhingran, 1982). Some fishery workers from India and abroad such as Chitravadivelu (1972), Holčík (1974), Tandon and Oliva (1977) and Singh (1978) have used growth data of different fishes for the calculation of harvestable size, which appears to be logical, considering the biology of these fishes. While going through the literature, it has been found that the legal limit of 30.00 cm is based on the attainment of first maturity. Different ages and sizes for first maturity have been described in these Indian major carps (Khan and Jhingran, 1975; Jhingran, 1982) from different water bodies. Considering this lacuna, a method for the calculation of minimum harvestable size of two Indian major carps viz., *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) based on the growth studies has been described. The present investigations and the observations of the earlier workers on the size/age attained at the first maturity clearly indicate that the legal limit of 30.00 cm total length needs modification.

MATERIAL AND METHODS

The specimens of *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) were collected from Gobindsagar, Himachal Pradesh (longitude 76°20'E; latitude 31°10'N), end point of the river Ghagger at Rang Mahal, Rajasthan (longitude 73°54'E; latitude 29°18'N) and the confluence of the rivers Beas and Sutlej at Harike, Punjab (longitude 74°57'E; latitude 31°10'15'N) and treated as described earlier by Johal and Tandon (1985). The back-calculated lengths were used for the calculation of

Table 1. Back-calculated lengths, (cm) of *Labes rohita* and *Catla catla* from different localities

Locality	N	r	C	Back-calculated lengths (cm) in different age classes							
				1	2	3	4	5	6	7	8
Gobindsagar	246	0.9965	10	23.96	40.43	53.37	63.81	<i>Labes rohita</i>			
				23.96	16.47	12.94	10.44	70.23	76.20	78.39	
				100.00	96.00	54.00	44.00	27.00	21.00	13.00	
Rang Mahal	691	0.9995	14	31.00	52.00	68.00	81.00				
				43.13	54.96	64.90	75.46	79.80	83.01	85.38	
				28.00	15.13	11.83	9.54	10.56	4.34	3.21	2.37
Harike	244	0.9981	16	100.00	54.00	42.00	36.00				
				33.00	61.00	64.00	76.00	88.00	93.00	97.00	100.00
				31.78	49.56	64.08	70.66	74.58	79.91	83.40	87.45
Gobindsagar	229	0.9997	16	100.00	56.00	46.00	21.00				
				36.00	57.00	73.00	81.00	85.00	91.00	95.00	100.00
				31.76	17.80	14.52	6.58	3.92	5.33	3.49	4.06
Rang Mahal	650	0.9414	21	26.00	46.00	61.00	79.00	<i>Catla catla</i>			
				62.11	65.56	77.16	85.77	90.49	96.16	99.31	
				31.58	20.53	13.45	11.59	8.62	6.20	3.61	3.16
Harike	223	0.9996	20	100.00	66.00	43.00	37.00				
				33.00	55.00	69.00	81.00	90.00	96.00	100.00	
				29.85	48.77	64.73	74.34	82.44	88.85	94.67	94.67
				29.85	18.9	16.96	9.61				
				100.00	63.00	53.00	32.00	27.00	21.00	23.00	
				32.00	52.00	68.00	79.00	87.00	94.00	100.00	100.00

N = number of specimens; C = correction factor in mm; h = annual increment in cm; A = length increment in percentage of the length of first growth season; B = length in percentage of the length of the final growth season; r = correlation coefficient between total length (cm) and lateral scale radius (cm).

harvestable size. The minimum theoretical harvestable size of these carps has been determined from the intercept of the length increment in percentage of the length of the first growth season and the length in percentage of the final growth season. The plotting of these two lengths (in percentages) along Y axis and age classes along X axis, is considered as the minimum theoretical harvestable size of a species.

OBSERVATIONS AND DISCUSSION

The scales of 1181 specimens of *Labeo rohita* (Hamilton) and 1102 of *Catla catla* (Hamilton) were studied for the back-calculations and minimum theoretical harvestable size. As the collections were made at three months interval, the annuli formed during the months of April to July in these two species have been considered valid for age determination and back-calculated lengths. Linear relationship and high degree of correlation (Table 1) have been observed between total length and lateral scale radius. Different values of correction factor (C) have been observed in the same species from different water bodies and for different species from the same waterbody (Table 1). The correction factor has been given due weightage in the back-calculated lengths to get accurate results.

In Table 1, the back-calculated lengths (cm) in different age classes, the annual increment (h), length increment in percentage of the first growth season (A) and the length in percentage of the length of the final growth season (B) are given. The point of intersection in *Labeo rohita* (Hamilton) falls between age classes 2 & 3 (Fig. 1) from Gobindsagar and Rang Mahal and on the age class 2 from Harike. The harvestable size has been found to be 50.78, 44.90 and 49.56 cm from Gobindsagar, Rang Mahal and Harike respectively. In *Catla catla* (Hamilton) the point lies between the age classes 2 & 3 (Fig. 1) and the harvestable size has been found to be 59.21, 59.90 and 63.13 cm from Gobindsagar, Rang Mahal and Harike respectively.

In Indian freshwaters, it is suggested that the fish should be harvested after first maturity. Different size/age groups in these carps have been described from different waterbodies, hence an alternate method to calculate the harvestable size has been described for the first time in these carps.

In *Labeo rohita* (Hamilton), the first maturity is attained in the second year of life (Alikunhi, 1957; Khan, 1972). Khan and Jhingran (1975) described first maturity in the second year of life when the fish attained the average size of 46.20 cm. *Catla catla* (Hamilton) attained the first maturity in the second year of life (Chacko and Kuriyan, 1948; 1950; Alikunhi 1957). Alikunhi (1957) and Natarajan and Jhingran (1963) observed the first maturity in *Catla catla* (Hamilton) between 44.16–55.88 cm.

From the observations of the earlier workers it is clear that the age and size at first maturity are different in different species from various water bodies of India depends upon the ecological conditions. If the basic criterion for the determination of legal limit of 30.00 cm total length was the first maturity, then this limit needs modification in order to keep the optimum level of yield.

The present approach of calculating the minimum theoretical harvestable size is based on the growth data obtained from large number of samples collected over two and half years. It is clear that these carps should be harvested in the second or third year of life, when their size is definitely more than 30.00 cm in total length. It has also been observed that in those populat-

ions, where the growth rate is slow the harvestable size shifts to higher age groups.

It is not possible to generalize the harvestable size of Indian carps because of changing ecological conditions. It is suggested that the harvestable size of *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) be increased to 48.50 and 63.00 cm respectively in the waters of Northern India. It is further opined that the harvestable size of other commercial fishes from different sources be determined on the basis of growth studies for their optimum exploitation. It has been recommended in the seminar on 'Status of Wildlife in Punjab' that in order to preserve native fish species separate policies should be evolved for the optimum exploitation of fishery resources (Anon, 1983).

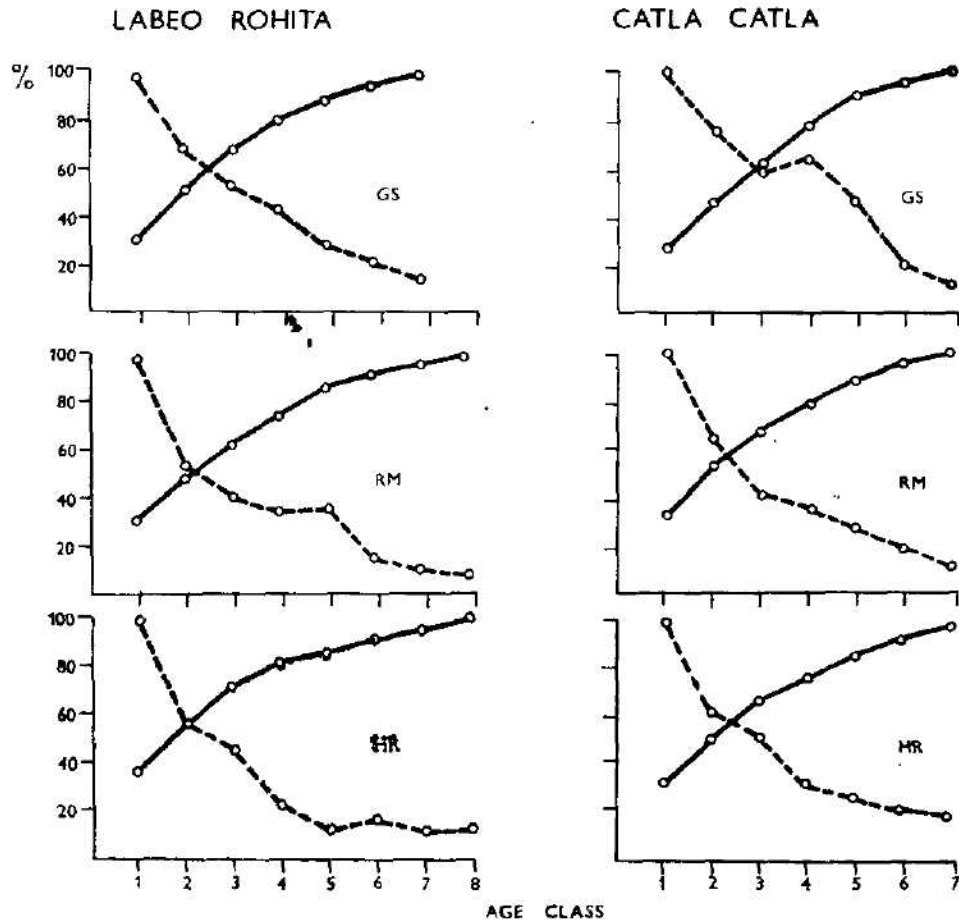


Fig. 1. Harvestable size of *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) from Gobindsagar (GS), Rang Mahal (RM) and Harike (HR). Dotted lines = Length increment in percentage of the length of the first growth season. Solid lines = Length in percentage of the length of the final growth season. Age classes along abscissa and percentages along ordinate.

The present observations have also indicated that excessive netting of Indian major carps of 30.00 cm and above (but below their minimum harvestable size) has led to the depletion of their stocks (Tandon and Johal, 1982). However, the competition with exotic carps cannot be ruled out.

SUMMARY

The age-wise growth data of *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) from Gobindsagar, Himachal Pradesh (longitude 76°20'E; latitude 31°10'N), end point of the river Ghagger at Rang Mahal, Rajasthan (longitude 73°54'E; latitude 29°18'N) and the confluence of the rivers Beas and Sutlej and Harike, Punjab (longitude 74°57'E; latitude 31°10'15"N) has been employed for the calculation of minimum theoretical harvestable size. Harvestable size has been calculated from the interception of the length increment in the percentage of the first growth season and the length in percentage of the final growth season. The plotting of these two percentages along Y axis and age classes along X axis gives a point of intersection has been obtained which is considered as the harvestable size. In *Labeo rohita* (Hamilton) the harvestable size has been found to be 50.78, 44.90 and 49.56 cm and in *Catla catla* (Hamilton) 59.21, 59.90 and 63.13 cm from Gobindsagar, Rang Mahal and Harike respectively. On the basis of present investigations it has been suggested that the present legal limit of 30.00 cm total length should be modified to 48.50 and 63.00 cm in *Labeo rohita* (Hamilton) and *Catla catla* (Hamilton) respectively from the waterbodies of Northern India. In order to avoid over exploitation of the commercial fishes, it is suggested that the harvestable size should be calculated.

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**THE GROWTH OF THE BLEAK (*ALBURNUS ALBURNUS*, PISCES:
CYPRINIDAE) IN SOME CZECH LOCALITIES**

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Abstract. The growth of 361 specimens of the bleak (*Alburnus alburnus*) from three localities (the riverine lake Orlík and two natural backwaters of the river Labe in central Bohemia) was studied using the scale method. In the riverine lake Orlík the growth rate was slower than in the backwaters, apparently due to the overfishing in the latter localities.

INTRODUCTION

The bleak, *Alburnus alburnus* (Linnaeus, 1758), inhabits slowly running waters or stagnant water bodies and frequently occurs also in riverine lakes, backwaters and in inundation areas of rivers. As regards riverine lakes designated for the tap water, it is not suitable fish species because it feeds on zooplankton and thus reduces, indirectly, its filtering activity. The growth rate has not been studied frequently. In the Slapy riverine lake the growth was examined by Oliva and Frank (1959) and Čihař (1961), in the Lipno riverine lake by Vostradovský (1963), in the Orava lake by Balon (1967). The growth rate in other types of the so-called open waters was studied by Oliva (1963) and Chitradiveliu (1971), in the water bodies of the inundation areas by Oliva (1963), Chitradiveliu (1972) and Krupka (1972). We have no information on the growth of the bleak in the Orlík riverine lake. In the neighbouring countries the growth was investigated by Vasnecov (1934), Bauch (1953), Papadopol (1970), Strelnikov and Permitin (1983).

MATERIAL AND METHODS

The bleak was collected in 1981—1982 in the upper part of the Orlík riverine lake in the mouth of the river Otava near the castle of Zvíkov between the 3rd and 7th river km of the Otava. Seine nets were used; their length was 50 and 100 m, depth 6 m, meshes 1 × 1 and 2 × 2 cm. In the specimens caught the length of the body (SL) and the total weight were ascertained. A part of the material studied was collected in the natural ponds of the inundation area of the river Labe in Central Bohemia near Čelákovice (ponds Poltruba and Řehákova bouda). The seine net measured 70 m, depth 6 m, meshes 1 × 1 cm; a certain part of the bleaks from the pond Řehákova bouda was obtained by angling. About these localities see, e. g., Oliva (1957), Závěta (1981).

The scale material was studied using the method of R. Lee with the corrections of 23 mm (Orlík) or 16 mm (natural ponds mentioned above); the ventrodiagonal radius was measured.

The length growth was evaluated using following indexes (Balon, 1964): G — instantaneous growth rate, C_{1t} — growth characteristics, C_1 — specific rate of length

growth, which was calculated as the absolute increment related to the average growth value during the period studied (l_n and l_0), φC_{1h} — index of the population growth rate, φC_1 — index of the population linear growth intensity. The weight growth was ascertained by the method cited in Rounsefell and Everhart (1953).

RESULTS AND DISCUSSION

In 1981, 193 specimens of the bleak were captured in the Orlík riverine lake, but 16 specimens had damaged and regenerated scales and were excluded. The length groups kept within 105–185 mm. The length group of 120 mm with 41 specimens was the most frequent. From the age classes the most frequent was the 3rd with 93 specimens. The longest specimen measured 185 mm and belonged to the 6th age class. The oldest bleak from the 7th age class measured 180 mm. The length growth from 1981 is summarized in Table 1.

In 1982 the growth was studied in 66 specimens whose length was between 145–180 mm. The most frequent was the length class of 165 mm (19 sp.). The most frequent age class was the 3rd with 40 specimens. The smallest specimen measured 145 mm and belonged to the 2nd age class, the largest 180 mm (the 3rd and 4th age class). The oldest specimen from the 5th age class measured 175 mm. For the length growth see Table 2.

From the natural pond Poltruba 58 bleaks were obtained in 1980, measuring 90–125 mm. The most frequent were the length groups of 120 mm (21 sp.) and 115 mm (19 sp.). The most frequently represented age class was the 5th (24 sp.). The smallest specimen (90 mm) belonged to the 2nd age class, the largest (125 mm) to the 6th age class. The length growth is summarized in Table 3.

From the natural pond Řehákova bouda 60 specimens were obtained in 1982, having 105–145 mm in length. The most frequent was the length group of 125 mm (19 sp.). The smallest fish (105 mm) belonged to the 4th age class, the largest (145 mm) to the 7th age class. The youngest specimen from the 3rd age class measured 120 mm. As regards the age classes, the most frequent was the 5th. The length growth is summarized in Table 4. The sample contained 24 males and 33 females. The youngest male was in the 3rd age class and measured 120 mm, but the smallest (110 mm) belonged to the 4th age class. The longest and oldest male measured 145 mm and belonged to the 6th age class. The 5th age class with 10 specimens was the most frequent. The smallest

Table 1. Length growth of the bleak in the riverine lake Orlík in the year 1981

Age group	n	Lc	Back calculated body lengths in mm					
			l_1	l_2	l_3	l_4	l_5	l_6
II	18	122	70					
III	93	121	64	115				
IV	33	160	64	112	150			
V	18	169	60	97	133	158		
VI	12	174	60	87	118	150	165	
VII	3	180	54	74	111	134	157	172
	177	average	62	97	128	147	161	172

Table 2. Length growth of the bleak in the riverine lake Orlik in the year 1982

Age groups	n	Lc	Back calculated body lengths in mm				
			l ₁	l ₂	l ₃	l ₄	l ₅
II	5	157	86	133			
III	40	180	64	112	142		
IV	20	59	60	92	123	145	
V	1	175	59	83	124	151	163
	66	average	67	105	130	148	163

and youngest female (120 mm) belonged to the 4th age class, the longest and oldest (145 mm) was in the 7th age class. The most frequent was the 5th age class with 14 specimens. The summary of the length growth of both sexes separately is given in Table 5 and 6.

Exponential characteristics of the length growth of the bleak was calculated and expressed on the base of Bertalanffy mathematical model of the growth (after Ricker, 1975). The growth equations for single localities are as follows:

$$\begin{aligned} \text{Orlik 1981} & : l_t = 204 (1 - e^{-0.298(t + 0.225)}) \\ \text{Orlik 1982} & : l_t = 196 (1 - e^{-0.338(t + 0.239)}) \\ \text{Poltruba 1980} & : l_t = 131 (1 - e^{-0.325(t + 0.754)}) \\ \text{Řehákova bouda} & : l_t = 171 (1 - e^{-0.235(t + 0.436)}) \end{aligned}$$

The weight growth

The weight of the bleak inhabiting the Orlik riverine lake was determined only in 34 specimens in 1982. The heaviest specimen (77 g) was 3 years old and measured 180 mm, the smallest weight (45 g) was found in the bleak of 150 mm from the 4th age class. The weight growth is summarized in Table 7.

From the natural pond Poltruba 58 specimens were weighed. The heaviest (27 g) was from the 5th age class and measured 125 mm. The smallest (8 g) measured 90 mm and was from the 2nd age class. For details see Table 8.

From the natural pond Řehákova bouda 60 specimens were weighed. The largest weight was 40.5 g in a specimen of 145 mm from the 6th age class.

Table 3. Length growth of the bleak in the backwater Poltruba in the year 1980

Age group	n	Lc	Back calculated body lengths in mm				
			l ₁	l ₂	l ₃	l ₄	l ₅
II	2	93	73				
III	9	115	60	99			
IV	22	116	55	79	100		
V	24	117	49	67	88	104	
VI	1	125	50	73	86	99	112
	58	average	57	80	91	102	112

Table 4. Length growth of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	Lc	Back calculated body lengths in mm					l ₅
			l ₁	l ₂	l ₃	l ₄	l ₅	
III	3	119	53	92				
IV	21	123	54	83	107			
V	24	131	49	76	98	117		
VI	11	139	49	71	90	111	126	
VII	1	146	39	58	80	104	120	134
	60	average	49	76	94	111	123	134

The smallest weight (14 g) was found in a specimen of 107 mm of length from the 4th age class. The weight of males and females was determined separately. The weight growth is summarized in Table 9, 10 and 11.

The weight growth was calculated according to the following equations:

Orlík 1982	: $\log W = -3.7237 + 2.4848 \log L$ correlation coefficient $r = 0.98624$
Poltruba 1980	: $\log W = -6.1274 + 3.6143 \log L$ correlation coefficient $r = 0.97776$
Řehákova bouda	: $\log W = -4.5156 + 2.3192 \log L$ correlation coefficient $r = 0.97902$

In the Orlík riverine lake the growth rate does not vary considerably in individual years; the indices $\varphi C_{lh 1-3}$ (representing the period of the 1st to 3rd year of life) and $\varphi C_{lh 1-5}$ (representing the values from the 1st to the 5th year of life) do not differ very much. The values represented in the index of the population linear growth intensity φC_1 offer a similar picture.

In the natural pond Poltruba the growth rate is considerably smaller owing to the well-known fact that the large number of fish here gets into a strong food competition and the biomass reaches the values of up to 1 000 kg . ha⁻¹ (Oliva, 1957).

The pond Řehákova bouda lies also in the area of the inundation waters of the Labe; from Table 12 it is evident that the growth of males is slightly faster than that of females. This is also documented by the growth indices in Table 14.

Table 5. Length growth of the males of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	Lc	Back calculated body lengths in mm				
			l ₁	l ₂	l ₃	l ₄	l ₅
III	2	120	49	89			
IV	9	120	52	79	105		
V	10	130	48	75	99	116	
VI	3	142	51	76	94	115	131
	24	average	50	80	99	116	131

Table 6. Length growth of the females of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	Lc	Back calculated body lengths in mm					
			l ₁	l ₂	l ₃	l ₄	l ₅	
IV	10	127	54	87	108			
V	14	131	50	77	97	117		
VI	8	137	48	69	89	109	124	
VII	1	145	39	58	80	104	120	134
	33	average	48	73	94	110	122	134

From the results of the study of the weight growth, which, of course, is dependent on the length growth, it is evident that the growth rate in the pond Řehákova bouda is faster than in the pond Poltruba; the differences in the growth rate between males and females are also evident (see Table 14).

When we compare the length growth of the bleak in the examined localities with the data from other localities, we can see that the growth in the Orlík

Table 7. Weight growth of the bleak in the riverine lake Orlík in the year 1982

Age group	n	W	Back calculated body weights in g				
			w ₁	w ₂	w ₃	w ₄	w ₅
II	3	51	11.7	35			
III	20	62	5.6	21	41		
IV	6	54	4.9	12	26	43	
V	1	70	4.5	11	29	48	58
	30	average	6.7	20	32	46	58

riverine lake is one of the slowest out of all riverine lakes cited, the differences in the first year of life being 10–20 mm. The very fast growth rate in the Lipno riverine lake in the first year of life is not registered in the indices evaluating the growth, which are even numerically lower. Comparing the growth rate in the riverine lakes Slapy, Lipno, Vranov and Orlík in the first

Table 8. Weight growth of the bleak in the backwater Poltruba in the year 1980

Age group	n	W	Back calculated body weight in g				
			w ₁	w ₂	w ₃	w ₄	w ₅
II	2	9	4				
III	9	21	2	12			
IV	22	21	1.4	5	13		
V	24	22	1	3	8	14	
VI	1	26	1	4	7	12	19
	58	average	1.9	6	9	13	19

Table 9. Weight growth of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	W	Back calculated body weight in g					
			w ₁	w ₂	w ₃	w ₄	w ₅	w ₆
III	3	21	2.2	10				
IV	21	24	2.3	8	16			
V	24	29	1.7	6	12	20		
VI	11	34	1.7	5	10	18	25	
VII	1	36	0.9	3	7	15	22	30
	60	average	1.8	6	11	18	24	30

three years of life, it becomes evident that the quickest start of the growth is in Lipno. In the first year of life the Lipno bleak attains up to 93 mm of length. The shortest length in this period was attained in Orlik in 1981 (62 mm). The largest length in the third year of life is attained in Slapy and Lipno (148 mm), the smallest in Orlik again (in 1981 128 mm). The values of the

Table 10. Weight growth of the females of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	W	Back calculated body weights in g					
			w ₁	w ₂	w ₃	w ₄	w ₅	w ₆
IV	10	26	2.3	9	16			
V	14	28	1.8	6	12	20		
VI	8	32	1.6	5	9	17	24	
	1	36	0.9	3	7	15	22	30
VII	33	average	1.7	6	11	17	23	30

index φC_{lh} in the 1st to the 3rd year, however, do not always document precisely the increment of the length of the body. The largest value is given for the Slapy riverine lake - $\varphi C_{lh 1-3} = 30.12$; the smallest, $\varphi C_{lh 1-3} = 23.84$, surprisingly, for Lipno where, on the contrary, the fastest growth rate in the first year of life was found and also the largest increment in the third year of life. The slowest growth in Orlik is not expressed by the given index.

Table 11. Weight growth of the males of the bleak in the backwater Řehákova bouda in the year 1982

Age group	n	W	Back calculated body weights in g					
			w ₁	w ₂	w ₃	w ₄	w ₅	
III	2	22	1.7	9				
IV	9	23	2.1	7	15			
V	10	28	1.6	6	13	20		
VI	3	35	1.9	6	11	19		28
	24	average	1.8	7	13	20		

Table 12. Survey of the length growth of the bleak in some localities

Locality	n	l ₁	l ₂	l ₃	l ₄	l ₅	l ₆	l ₇
Orlík 1981 – authors	177	62	97	128	147	161	172	
Orlík 1982 – authors	66	67	105	130	148	163		
Poitruba 1980 – authors	58	57	80	91	102	112		
Řehákova bouda 1982 – authors	60	49	76	94	111	123	134	
Males	24	50	80	99	116	131		
Females	33	48	73	94	110	122	134	
Riverine lakes								
Slapy – Oliva and Frank (1959)	46	75	121	148	163	154		
Slapy – Oliva (1979)	55	74	121	142	153	159	168	
Lipno – Vostradovský (1963)	159	93	132	148				
Vranov – Oliva (1963)	21	70	118	140	147	147		
Orava – Balon (1967)	2497	75	109	115	133	139	149	
Rivers								
Vltava by Prague – Chitradivělu (1971)	21	54	87	110				
Ohře – Chitradivělu (1971)	43	50	83					
Labe by Děčín – Chitradivělu (1971)	108	48	75	96	115	128	142	161
Dunaj-arm Žofín – Chitradivělu (1971)	565	60	81	99	111	125	138	
Dunaj-delta Somova – Papadopol (1970)	134	68	78	91	105			
Thames – Williams (1967)	4009	39	70	92	111	121	130	138
Tuusula lake – Vasnecov (1934)	–	41	72	106	125			

The growth rate is not evaluated satisfactorily by the index of population linear growth intensity, either. The largest values ($pC_{1-3} = 35.79$) are attained by the material from Orlík, although the growth is the slowest there. On the other hand, this index shows well the rate of increments, the size of increments being evidently the greatest there. Therefore this index seems to be more suitable for the evaluation of the amount of increments than for the evaluation of the growth rate from various localities (Table 14).

The slow growth rate of the bleak from the ponds Poitruba and Řehákova bouda is comparable rather with the growth rate in rivers, where the water temperature and food supply are not stable, being obviously lower than in the stagnant waters and riverine lakes. Remarkable is the very slow growth rate in the river Thames; the slow growth rate in the lake Tuusula can be influenced by the climatic conditions of Finland (Tables 12 and 14).

The weight growth found in the Orlík riverine lake was faster, followed by the riverine lake Orava; unfortunately, the number of localities with all the data needed is very small. A relatively faster weight growth is evident from the southern areas of the distribution of the bleak (the Danube delta, the Danube arm Žofín). In rivers the weight is comparable with the data obtained from the Labe backwaters, which is also documented by the indices evaluating the weight growth. Extremely slow is the weight growth rate in the river Thames, obtained by the study of numerous materials (Williams, 1967; Table 13 and 15).

Table 13. Survey of the weight growth of the bleak in some localities

Locality	n	w ₁	w ₂	w ₃	w ₄	w ₅	w ₆	w ₇
Orlík 1982 — authors	30	6.7	20	32	46	58		
Poltruba 1980 — authors	58	2	6	9	13	19		
Řeháková bouda 1982 — authors	60	2	6	11	18	24	30	
Males	24	2	7	13	20	28		
Females	33	3	6	11	17	23	30	
Orava-riverine lake — Balon (1967)	2496	5.4	18	22	35	38	47	
Rivers								
Labe by Děčín — Chitřavádivelu (1971)	108	1	5	11	20	29	42	50
Vltava by Prague — Chitřavádivelu (1971)	21	1.6	8	17				
Ohře — Chitřavádivelu (1971)	43	1.2	7					
Vltava by Měchenice — Chitřavádivelu (1971)	76	1.5	6	11	15	35	63	
Dunaj-arm Žofin — Chitřavádivelu (1971)	565	3	7	13	19	27	36	
Dunaj-delta — Somova Papadopól (1970)	134	3	6	9	14			
Thames — Williams (1967)	4009	0.3	3	8	15	20	26	32

Table 14. Survey of the index of the population growth rate and the index of population linear growth intensity for the length growth of the bleak in some localities

Locality	φCl_{1-3}	φCl_{1-5}	φC_{11-3}	φC_{11-5}
Orlík 1981 — authors	27.32	21.43	35.79	23.62
Orlík 1982 — authors	26.26	20.92	32.73	22.01
Poltruba 1980 — authors	14.81	12.39	23.22	16.80
Řeháková bouda 1982 — authors	18.83	16.17	32.19	22.80
Males	20.27	17.59	33.69	23.84
Females	19.29	16.19	33.24	23.13
Riverine lakes				
Slapy — Oliva and Frank (1959)	30.12	16.32	33.51	17.75
Slapy — Oliva (1970)	27.88	18.06	32.09	18.87
Lipno — Vostradovský (1963)	23.84	—	23.05	—
Vranov — Oliva (1963)	23.36	15.89	34.06	18.25
Orava — Balon (1967)	16.94	14.12	21.16	15.31
Rivers				
Vltava by Prague — Chitřavádivelu (1971)	23.08	—	35.08	—
Labe by Děčín — Chitřavádivelu (1971)	19.97	17.40	34.23	24.29
Dunaj-arm Žofin — Chitřavádivelu (1972)	17.13	14.69	24.89	18.27
Dunaj-delta — Somova — Papadopól (1970)	10.68	—	14.54	—
Thames — Williams (1967)	20.97	17.20	42.02	27.86
Tuusula-lake — Vasnecov (1934)	25.47	—	46.53	—

Table 15. Survey of the index of the population rate and the index of population linear intensity for the weight growth of the bleak in some localities

Locality	φC_{wh1-3}	φC_{wh1-5}	φC_{w1-3}	φC_{w1-5}
Orlík 1982 — authors	8.36	9.75	72.89	51.19
Poltruba — authors	2.32	3.22	70.00	53.47
Řehákova bouda — authors	2.92	4.11	79.41	58.92
Males	3.42	4.79	85.56	61.72
Females	2.92	3.94	79.41	57.92
Orava — riverine lake — Balon (1967)	5.06	5.80	63.85	45.38
Rivers				
Labe by Děčín — Chtravádíveľu (1971)	2.78	4.89	104.17	75.78
Vltava by Prague — Chtravádíveľu (1971)	4.30	—	102.67	—
Vltava by Měchenice — Chtravádíveľu (1971)	2.86	5.46	89.41	72.40
Dunaj-arm Žofín — Chtravádíveľu (1972)	3.44	4.62	70.00	53.07
Dunaj-delta — Somova — Papadopol (1970)	2.26	—	53.33	—
Thames — Williams (1967)	1.82	3.24	127.27	86.00

The growth rate of the bleak from the localities studied can be compared, according to some authors, by means of the index "K" from the growth equation. But also these statements do not seem to be precise, since it is always necessary to take into account all data on the growth inserted into the curves for growth, as well as the values t_0 and L_∞ which depend on the amount of the data on the growth in individual years.

Since the bleak is treated as the scrap fish, information on its growth is rather scanty; but when we consider its value as the food supply for carnivorous fishes its importance is not negligible. The slow growth rate in the Orlík riverine lake seems to be related with the large number of noncarnivorous fishes in the reservoir and their food competition.

SUMMARY

1. The growth of the bleak in the Orlík riverine lake was studied in the years 1981 (177 sp.) and 1982 (66 sp.). Further 58 specimens of the bleak were studied from the natural pond Poltruba and Řehákova bouda (60 sp.).
2. Exponential characteristics of the growth was documented by the Bertalanffy growth equation for all localities examined.
3. The growth rate from the Orlík riverine lake is slower in comparison with other reservoirs in Czechoslovakia. The slow growth in the natural ponds of the inundation area of the river Labe (Poltruba, Řehákova bouda) is comparable rather with the growth rate in Czech rivers; this is convincingly documented by the data both of the length growth and of the weight growth.
4. The slow growth rate from the riverine lake Orlík is probably caused by the overfishing of the scrap fishes there and the resulting food competition.
5. The length and weight rate was evaluated by the means of the indices of the population growth rate and the population linear growth intensity.

The application of the indices mentioned seems not very suitable because it does not cover satisfactorily the changes in the growth rate in the individual years of life.

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SEXUAL PARASITISM IN THE EUROPEAN TREE FROG (HYLA ARBOREA)

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Abstract. Noncalling adult males *Hyla arborea* (L.) were found in a satellite association with about 2% (range = 0 to 8.7%) of calling males in a small pond in south Bohemia during the individual nights of the breeding period. The calling males were significantly larger than their satellites. The importance of satellite mating strategy is discussed.

The satellite mating strategy of the male (sexual parasitism) was described for some families of anuran amphibians, where the male attracts its mates by means of species-specific calls (Hylidae, Microhylidae, Pelobatidae, Bufonidae, Ranidae). Tree frogs (Hylidae) are a very good object for behavioural studies. Therefore the satellite tactic was found in many hylid species (*Hyla regilla*, *H. cinerea*, *H. versicolor*, *H. crucifer*, *H. chrysoscelis*, *H. picta*, *H. ebraccata*, *Pseudacris triseriata*) and was studied in depth on some species (Perrill et al., 1978, 1982; Fellers 1979; Miyamoto and Cane 1980; Perrill 1984; Roble 1985). The importance of this strategy is evident from published data and is probably a frequent phenomenon in Hylidae. This report deals with satellite mating strategy in *Hyla arborea*.

METHODS

I studied *H. arborea* in a small pond near the town of Veselí nad Lužnicí, south Bohemia. I marked a large sample of the population (102 males and 21 females were toe-clipped for individual identification), measured the snout-vent length of the all specimens and censused the frogs during 35 nights in the spring of 1986 to determine the frequency of calling and satellite associations. I used the method of Perrill et al. (1978): each observation was started at least one hour after the start of calling of the males and each association was observed for at least one minute. I worked with the aid of hand and head lamps, which did not appear to affect the behaviour of tree frogs. The mating strategy was studied with brief irregular intervals during the whole breeding season (Table 1). The observation was started two days after the entrance of the males in to the pond. Generally, only one complete census was obtained per night.

RESULTS

The breeding period of *H. arborea* lasted from April 29 to about June 23. Satellite associations occurred between May 1 and 23 at the time of the largest concentration of tree frogs in the water. The males entered the pond irregularly from night to night at a certain period of the breeding season (Table 2). These data are approximative, complete counts of male *H. arborea* could not be made for some choruses because the secretive habits of this species.

Table 1. Frequency of satellite associations during the breeding season

Date	Number of males		Number of satellite associations	Percent of calling males in a satellite association
	Calling males in the pond	Observed calling males		
5/1	29	17	1	5.9
5/2	29	17	1	5.9
5/3	29	23	2*	8.7
5/5	34	34	0	0
5/6	17	14	1	7.1
5/7	15	12	0	0
5/8	0	0	0	0
5/11	42	30	0	0
5/12	42	29	1	3.4
5/13	42	32	0	0
5/14	48	43	2	4.7
5/15	36	27	0	0
5/18	44	33	1	3.0
5/19	46	39	2	5.1
5/20	14	10	0	0
5/23	33	27	1	3.7
5/24	17	10	0	0
5/25	2	2	0	0
5/26	5	5	0	0
5/27	32	24	0	0
5/30-6/2	0	0	0	0
6/3	1	1	0	0
6/4	0	0	0	0
6/11	20	16	0	0
6/12-13	0	0	0	0
6/16	11	9	0	0
6/17	4	4	0	0
6/18	3	2	0	0
6/23-25	0	0	0	0
Total	595	460	12	47.50
Mean	24.79	19.17	0.50	1.98

(from 24 nights with the occurrence of males in the pond)

* One of these associations involved a calling male with two satellite males.

I screened a total of 460 calling males among which I discovered 12 satellite associations (2.6%) only. The mean proportion of calling males with associated satellites was 1.98% (range = 0 to 8.7%) in the individual nights (Table 1). Out of the 11 satellite males observed 2 only were found in a satellite posture in 2 nights. On other occasions all these males called and adopted a strategy typical of territorial males (see Howard 1978). I was unable to determine with my method the opportunistic tactic of the males. On one occasion, I observed two satellites of one calling male and once I saw a satellite male snatching a female as it moved toward the calling male.

The calling male defends its calling sites against intruders with territorial calls only. I never observed physical attacks among territorial males.

Table 2. Observation of satellite males

Animal number	Total number of nights observed, date	Size (mm)	Calling	Satellite	Not calling (nights)	Amplexing	Distance from calling male (cm)	Size of calling male (mm)
5	6 5/1-6/18	37	5	1	0	0	10	38
14	6 5/1-5/19	39	5	1	0	0	5	41
28	8 5/2-6/11	40	7	1	0	0	30	40
35	7 5/4-5/19	42	6	1	0	1*	5	42
41	11 5/4-6/17	41	9	1	0	1	5	43
44	3 5/3-5/11	33	2	1	0	0	25	43,41
48	2 5/3-6/5	34	0	2	0	0	40,35	42,1
70	6 5/13-5/27	37	3	2	1	0	50,5	42
74	3 5/14-5/19	37	2	1	0	0	25	42
75	4 5/14-5/23	39	3	1	0	0	100	42
76	1 5/14	40	0	1	0	0	0	1

* This satellite snatched successfully the female.

The position of the satellite in relation to the calling male was not uniform (behind, side by side, in front of the territorial male; swimming in water, sitting on the shore, among emergent vegetation and on branches above the water). Usually, the satellite male was oriented towards the calling male (in 10 out of 12 cases). An exception were the males number 36 and 76 (Table 2). The former was directed in a opposite position; the reason was a female in the

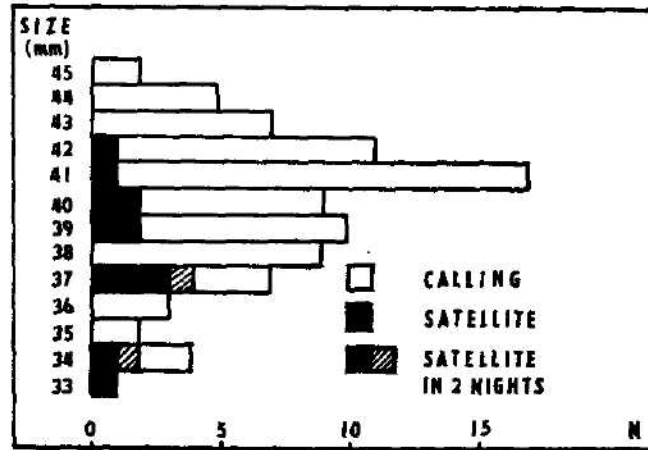


Fig. 1. Size distribution of calling and satellite males.

vicinity, which this male afterwards successfully intercepted. The latter male was in direct contact with the caller's vocal sac (for at least 25 minute). I observed a similar position on another occasion at another pond in the vicinity of the study area. Roble (1985) described this posture for *Pseudacris triseriata*.

The size distribution of 11 satellite males was compared to that of the dominant males ($N = 10$) from satellite associations. Both samples were also compared to the size distribution of all measured adult (calling) males present in the pond ($N = 85$). The satellite males were, as a group, significantly smaller both in comparison with the dominant males ($t = 3.45$, $df = 19$, $P < 0.005$) and the sample of all adult males ($t = 2.05$, $df = 94$, $P < 0.025$). The calling males with associated satellites were, as a group, larger in comparison with the sample of all adults, but the statistical significance of this difference was very low ($t = 1.71$, $df = 93$, $P < 0.05$).

DISCUSSION

The mean proportion of calling males with associated satellites was considerably less for *H. arborea* (1.98%) in comparison with published data for *H. regilla* (17.02%, Perrill 1984) and *H. cinerea* (16.74%; Perrill et al., 1978). My value is close to the proportion obtained for *H. chrysocelis* and *H. picta* (1.7% and 6.9%; Roble 1985). The density of the breeding population may be one of the ecological factors that may influence the sexual behaviour of the males (Perrill et al., 1978). Schneider (1977) and Perrill (1984) reported that a high density of tree frogs decreases the distance

among calling males. Sullivan and Sullivan (1985) found that satellites of the pelobatid frogs *Scaphiopus couchi* and *S. multiplicatus* occurred in choruses only that contained more than 20 males. It is possible that the high proportion of satellites of *H. regilla* and *H. cinerea* (Perrill 1984, Perrill et al., 1978) was associated with the very high density of the populations examined. On the other hand, Roble (1985) suggested that the ratio of satellite males was independent of the density for *H. chrysoscelis* and *H. picta*. I found satellites of *H. arborea* in the first half of the breeding season only, when the concentration of males in the water was the biggest.

Two hypotheses were suggested to explain the satellite breeding strategy of males (Wells 1977). First satellite males are waiting for call sites to become available after it has been abandoned by the calling male, secondly that satellite males intercept females approaching the calling males. A number of studies (Perrill et al., 1978; Perrill 1984; Miyamoto and Cane 1980; Forester and Czarnowsky 1985; Roble 1985) supported the later version, which is valid also for *H. arborea*.

It is still unclear, whether a correlation exists in tree frogs between body size and the probability that a male will use the satellite strategy (see discussion of Perrill et al., 1982). Roble (1985) found no significant differences between the body size of satellite and the dominant males of *H. chrysoscelis* and *P. triseriata*. By contrast, Gerhardt (1982) and Perrill et al., (1982) observed that small males tended to adopt a satellite tactic more frequently than large males. Also Sullivan and Sullivan (1985) suggested that satellite males of *Scaphiopus multiplicatus* were considerably smaller than their callers. The results from my rather small samples confirm this trend. The difference between satellites and calling males of *H. arborea* was significant (mean body size of satellites = 38.1 mm, SD = 2.8, N = 11; mean size of calling males = 41.4 mm, SD = 1.5, N = 10). Five males from the lowest size group of the sample of adult males (33 - 37 mm - 29.4%, N = 17) adopted a satellite tactic on 7 out of the 12 observed associations (mean body size of adult males = 39.9 mm, SD = 2.7, N = 85). Six satellites occurred in size group 39 - 42 mm (12.8%, N = 47), but none in the highest group 43 - 45 mm (N = 14) (Fig. 1).

In general, there may be two reasons for a more frequent adoption of satellite tactic by the smaller than the larger males:

- 1) The small male has to use its energy resources more economically than the larger male. In terms of energy output, vocalization is among the most demanding activities of the tree frogs (Taigen and Wells 1985).
- 2) The mating calls of small male is less attractive to female than that of larger males. The silent small male uses satellite strategy to eliminate this disadvantage and enhance its mating success.

It is known that females of some species are able to determine the male fitness by distinguishing among differences in spectral components of his mating call and are able of choosing larger (older) males (Ryan 1980, 1983, Forester and Czarnowsky 1985). Probably also males may obtain information about the quality of each other from their calls (Robertson 1985). Therefore the small satellite might look for larger territorial males with attractive mating calls. Forester and Czarnowsky (1985) called attention to the fact that successful small males may reduce differences in mean body size between amplexed and unamplexed males of *H. crucifer*.

Finally, the mating success of small males may contribute to the maintenance of a wide genetic variability of the population. The satellite strategy adopted as a mating tactic by the young male may be continued in older age for energy-saving reasons.

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**THE VENTROLATERAL THORACIC REGION AND THORACICO-ABDOMINAL
JUNCTION OF PLEA MINUTISSIMA (HETEROPTERA, PLEIDAE)**

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Abstract. Data on morphology of pleural thoracic region and thoracico-abdominal junction of nepomorphan Heteroptera are summarized, detailed data on *Plea minutissima* are provided and compared with other nepomorphan families. A number of characters of *Plea minutissima* are unique, especially: (1) coaptation apparatus with two new, hitherto unknown elements; (2) extremely developed anterior projection of the second abdominal segment; (3) presence of abdominal sternum 1 in adults.

The thoracic pleura is perhaps the best-known region of the exoskeleton of aquatic Heteroptera and ripicolous Nepomorpha (Gelastocoridae, Ochteridae). Its morphology is closely linked with the method of acquisition, distribution, and circulation of air in the external air-bubble. Its characteristics are also commonly used for the reconstruction of phylogenetic relationships. The study of the thoracic pleural region of nepomorphan Heteroptera has been performed by a considerable number of authors. Recently it has been studied systematically by Parsons (1960, 1967, 1969, 1970, 1971a, b, 1972a, b, 1974, 1976), who has dealt in particular with the morphology of the lateral pterothoracic region and thoracico-abdominal junction in model representatives of the majority of families of the suborder Nepomorpha — Gelastocoridae (genus *Gelastocoris*), Nepidae (genus *Nepa* and *Ranatra*), Belostomatidae (genus *Belostoma* and *Lathocerus*), Corixidae (genus *Diaprepocoris*, *Hesperocorixa* and *Micronecta*), Naucoridae (genus *Ambrysus*, *Cryphocricos*, *Heleocoris*, *Limnocoris* and *Pelocoris*), Aphelocheiridae (genus *Aphelocheirus*), and Notonectidae (genus *Notonecta*). The situation in Ochteridae (genus *Ochterus*) has been partially clarified by Popov (1971) and Rieger (1976).

Corresponding data on Pleidae and Helotrephidae do not exist. The data on Pleidae are urgently needed for comparative studies and for a successful interpretation of the complicated morphology of the thoracic pleura in a probable sister group of pleids, the Helotrephidae.

In the present paper the ventrolateral thoracic region and thoracico-abdominal junction of model representative of Pleidae are described and compared with the situation in other aquatic bugs and partially in ripicolous Nepomorpha. The respiratory significance of the morphological characteristics is not considered since it will be the subject of a separate study.

MATERIAL AND METHODS

Adults of *Plea minutissima* Leach 1817, were collected in the field in Southern Bohemia and preserved in Bouin's fluid or 70% ethanol. The preserved specimens were dissected in 80% ethanol under a stereoscopic microscope. Soft tissues were

removed by hand, with watchmaker's forceps, since clearing in lactic acid tended to soften and distort the skeleton. The transverse or parasagittal cuts were made by hand, using a sharp razor blade. Separated parts of skeleton were mounted in Euparal and examined under a microscope. For examination under the scanning electron microscope, specimens were lyophilized in Leybold — Heraeus apparatus. They were coated with a gold-palladium mixture in Pollaron apparatus, examined under a Tesla Stereoscan, model BS 300, and photographed with Orwo N 22 roll film.

Material of *Plea minutissima* were compared with the specimens of *Paraplea ltu-rata* (Fieber) (Vietnam) and *Paraplea pullula* (Stål) (Sudan) (both with non-reduced hindwings).

The morphological terminology applied is derived from several sources, viz. Parsons (1967, 1974, 1976), and Snodgrass (1927).

STRUCTURE OF THE VENTROLATERAL THORACIC REGION AND THORACICO-ABDOMINAL JUNCTION

1. Modal situation of nepomorphan Heteroptera and literary data on *Plea*

The lateral thoracic pleura of typical nepomorphan Heteroptera has been described in Parson's papers (1960, 1967, 1969, 1970, 1971 a, b, 1972 a, b, 1974, 1976) and will be only briefly summarized and illustrated here (Fig. 1). The literary data on the 1st abdominal sternum, spiracles and scolopophorous organs of aquatic Heteroptera are summarized for the first time.

(a) Pleura of the prothorax. Larsen (1945) considers that the propleura of nepomorphan bugs is represented by the episternum only. Parsons (1967) and Rieger (1976) are of the opinion that it is episternum and epimeron combined. Popov (1971), who bases his homologisation of pleural sclerites mainly on the conceptions of Matsuda (1962, 1970), considers the region in question to be epimeron. Parsons (1967) divided nepomorphan Heteroptera into two groups according to the morphology of the prothoracic pleura. She described the 1st group as the group with an unmodified coxal cleft of the posterior (supracoxal) lobe of the propleura. The representatives, which she placed in this group — *Notonecta*, *Hesperocorixa*, *Ochterus*, *Gelastocoris* — have the supracoxal lobe divided by a coxal cleft. The visible part of the pleural seam is long. She defined the 2nd group as that with a modified coxal cleft. The representatives which she placed in this group — *Belostoma*, *Lathocerus*, *Ambrysus*, *Aphelocheirus*, *Nepa*, and *Ranatra* — have a relatively longer supracoxal lobe than the representatives of the 1st group. The pleural seam is not externally visible. The supracoxal lobe is partially divided only in representatives of Belostomatidae and Naucoridae. Parsons (1967) considers that the greater entirety of the propleura in the 2nd group is an adaptation to the method of predation — the capturing of prey with the forelegs — and a respiratory adaptation.

(b) Pleura of the mesothorax. The mesothoracic epimeron is extensive sclerite. Parsons (1976) distinguished its dorsal, lateral and ventral parts. The dorsal part is localised vertically under the axillary area of the forewing and passes into the postalar bridge. The lateral and ventral parts lie more or less horizontally and form the so-called supracoxal lobe of the mesepimeron. The lobe overlaps to a great extent the metepisternum. The posterolateral corner of the supracoxal lobe terminates in the wing-anchoring knob (or process) of the mesothoracic epimeron, which fits into a fovea on the costal margin of the forewing. This formation is obvious to a varying extent in all

the representatives of nepomorphan Heteroptera studied so far (Kopelke, 1978, 1979; Parsons, 1960, 1970, 1971 a, b, 1974, 1976; Popov, 1971). Wefelscheid (1912) points out the very close relationship of the external margin of the lobe and the costal margin of the forewing. The presence of the wing-anchoring knob is usually denied (Popov, 1971; Puchkova, 1980). The dorsal part and the supracoxal mesepimeral lobe form the anterior, internal and ventral walls of the air chamber of the metathoracic spiracle. The mesepisternum lies entirely ventrally. Its extent is generally smaller than the extent of the ventral mesepimeral lobe. The shape of mesepisternum, like that of the mesepimeral lobe, are generically specific.

(c) Pleura of the metathorax. The metathoracic epimeron is relatively smaller than the mesothoracic one and has quite a different shape. The metepimeron lies vertically and is located under the axillary region of the

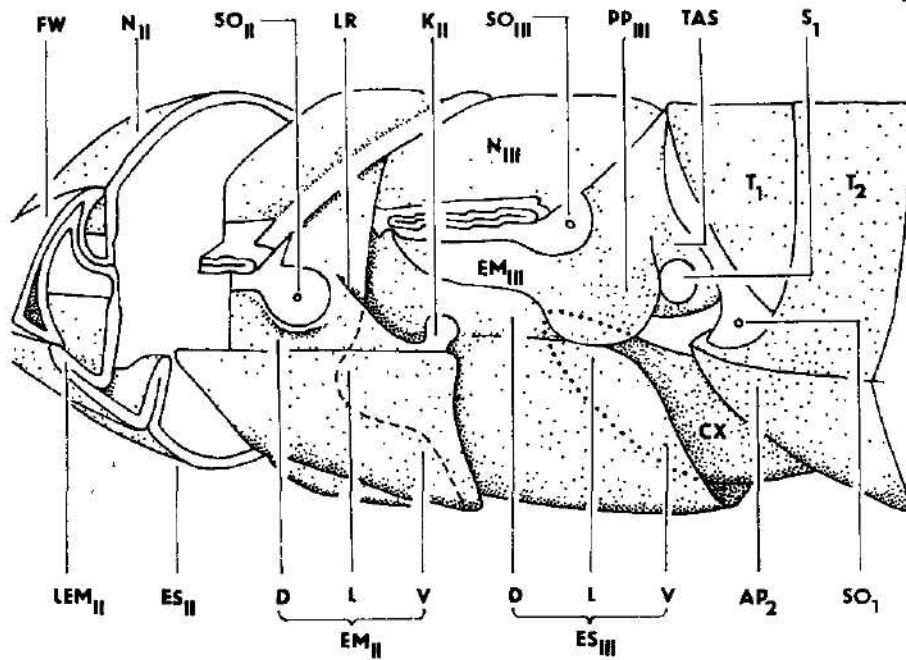


Fig. 1. Modal situation of pterothorax and first two abdominal segments of nepomorphan bugs as illustrated by Parsons (1976, Fig. 14A) — modified. Diagrammatic lateral view. Mesothorax cut transversely, wings removed posteriorly to transverse cut. Heavy broken line indicates position of lateral intersegmental boundary.

Lettering: AP₂ = lateral abdominal projection of the second abdominal segment; CX = metacoxa; DEM_{II}, DES_{III} = dorsal part of mesothoracic epimeron, metathoracic episternum; EM_{II,III} = mesepimeron, metepimeron; FW = forewing; K_{II} = wing-anchoring knob of the posterior corner of ventral (supracoxal) mesepimeral lobe; LEM_{II}, LES_{III} = lateral part or lobe of mesothoracic epimeron, metathoracic episternum; LR = lateral ridge of mesothoracic epimeron; N_{II,III} = mesonotum, metanotum; PP_{III} = posterior projection or lobe of metepimeron; S₁ = 1st abdominal spiracle; SO_{II, III, 1} = scolopiferous organ of mesothorax, metathorax, abdominal segment 1; T_{1, 2} = tergite of abdominal segment 1, 2; TAS = thoracic-abdominal sclerite; VEM_{II}, VES_{III} = ventral portion (supracoxal lobe) of mesepimeron, metepisternum.

hindwing. It shares in the formation of the postalar bridge. Its lower posterior corner terminates in an oval or pointed postalar projection (cf. Parsons, 1974, 1976). In some representatives of Corixidae it takes the form of a caudally directed lobe. In her paper of 1970 Parsons considers this metepimeral lobe mistakenly to be a "thoracico-abdominal lobe of thoracico-abdominal sclerite". Popov (1971) and Puchkova (1980) note a knob on the surface of the metepimeron in *Plea* and draw attention to its coaptative function. According to both authors the function of this projection replaces the function of the knob-like process of the posterolateral corner of the supracoxal mesepimeral lobe. The metepisternum can be divided into dorsal, lateral and ventral parts (Parsons, 1976). The dorsal part lies mainly vertically and projects forwards considerably beneath the mesepimeron. The boundary between the mesothorax and metathorax curves sharply anteriorly into the mesothoracic region in the lateral part of the body. The ventral and lateral part of metepisternum terminates caudally in a rounded supracoxal lobe.

(d) Thoracico-abdominal region. In adults of nepomorphan bugs the first abdominal segment is laterally fused with the metathorax. The region of junction and first two abdominal segments is termed the lateral thoracico-abdominal region (sensu Parsons, 1976). In the region below the postalar projection of metepimeron the respective posterior lobe of metepimeron is joined to the metathorax by triangular thoracico-abdominal sclerite (Parsons, 1970, et al.). Its origin is unclear. According to Larsen (1945) it is a derivate of the first abdominal sternum. Parsons (1976) considers that the thoracico-abdominal sclerite is a recessed, posterior part of the metathoracic epimeron. In her earlier papers she also allows for the partly abdominal origin of the sclerite — since the sclerite is also broadly continuous with the metathorax, however, it is not clear whether it is metathoracic, abdominal or a combination of both (Parsons, 1971 a). The lateral region above and behind the thoracico-abdominal sclerite behind the 3rd phragma, is membranous. Parsons (1971 b) defines it as functional thoracico-abdominal membrane. Thoracico-abdominal membrane is formed partly by the unsclerotized portion of the 1st abdominal segment and partly by the membrane between the 1st and 2nd abdominal segment. The thoracico-abdominal membrane differs in extent in various representatives of nepomorphan Heteroptera. It passes into the 1st tergum, into the metacoxal membrane and attaches itself to the 1st antecosta. Thanks to the existence of this membrane the boundary between the thorax and the abdomen is considerably less precisely locatable than the boundary between the prothorax and mesothorax or the meso- and metathorax. The low third phragma is anteriorly continuous with the metathoracic postnotum. The phragma represents the first abdominal antecosta (Parsons, 1976).

In connection with the varying degree of desclerotisation in the thoracico-abdominal region, the degree of retention of the 1st abdominal sternum is also problematical. Matsuda (1976) states that the reduced first sternum becomes a part of the postcoxal bridge in the metathoracic region and draws attention (Matsuda, 1955) to the taxonomic and phylogenetic significance of the morphology of the basal abdominal segment.

Wefelscheid (1912) described in *Plea minutissima* the narrow sclerotised stripe in the region which corresponds to the location of the 1st sternum. Hoppe (1912) noticed a ligament which corresponds by its position to the

1st abdominal sternum in *Notonecta*. Bare (1928, Pl. xlix, Fig. 1) illustrated the 1st abdominal sternum in *Buenoa margaritacea* (Notonectidae, Anisopinae). Rawat (1939) ascertained that in *Ilyocoris cimicoides* (Naucoridae) there are semicircular sclerites in the postmetacoxal position and considers them remnants of the 1st sternum.

An entire, medially undivided 1st abdominal sternum has not so far been unequivocally proved in adults nepomorphan Heteroptera or the majority of other Heteroptera. An exceptional situation in this respect is that of Gerromorpha (Møller Andersen, 1982), certain Enicocephalomorpha (Wygodzinsky & Štys, 1970 etc.) and perhaps also certain Leptopodomorpha (cf. Cobben, 1978).

In the lateral thoracico-abdominal region in the wider sense of the word there is a forward-pointing lateral projection of the abdomen — abdominal projection of the second abdominal segment (Parsons, 1970, etc.). In some representatives of nepomorphan Heteroptera it reaches as far as the metathoracic region.

(e) Spiracles. The 1st spiracle — mesothoracic — holds in all the representatives studies so far of the suborder Nepomorpha an intersegmental position in the ventral part of the membrane between the pro- and mesothorax, posteriorly to the coxa of the forelegs (Bare, 1928; Hoppe, 1912; Kopelke, 1978, 1979; Kramer, 1935; Parsons, 1971a, 1972a, b; Rawat, 1939; Thorpe & Crisp, 1947; Wefelscheid, 1912). The 2nd spiracle — metathoracic — lies in the dorsal part of the mesepimeron and can be in 3 different positions, designated by Parsons (1974) as S_1 to S_3 . S_1 — the spiracle is in the lateral intersegmental air space under the lateral epimeral ridge of the mesothorax (Belostomatidae, Nepidae, Gelastocoridae, Aphelocheiridae, and some Naucoridae). S_2 — the spiracle lies more ventrally, in the so-called ventral intersegmental air space (*Cryphocricos* and *Limnocoris* (Naucoridae)). S_3 — the spiracle lies above the lateral epimeral ridge of the mesothorax in the subalar air space (Notonectidae and Corixidae). The spiracle has a quite exceptional position in Corixidae, where it is in close proximity to the mesothoracic scolopophorous organ (Hagemann, 1910; Parsons, 1974, 1976; Popham, 1961). The position of the 3rd spiracle — the 1st abdominal spiracle — is often described differently in literature in the same representatives of aquatic Heteroptera. It differs in representatives of different families. Parsons (1971a) stated that in all representatives of aquatic Heteroptera the spiracle lies in the thoracico-abdominal sclerite, which is more or less sclerotized. However, for example, in representatives of the *Notonecta* it is predominantly membranous. The same author (Parsons, 1970, 1971a, b) considers that Larsen's (1945) interpretation, that the spiracle in adults lies in the region of the 1st abdominal segment, is based on morphological characters of a secondary nature which are rather functional adaptations than primary landmarks. Bare (1928), Hoppe (1912), but also, for instance, Cobben (1978), stated that, especially in the nymphs of *Notonecta*, *Buenoa* (Notonectidae) and *Plea* (1st instar), the 1st abdominal spiracle lies intrasegmentally, in the area of the 1st abdominal sternum. In the adults of the majority of aquatic Heteroptera it is situated between the posterior metepimeral projection and the anterior projection of the 2nd abdominal segment (Parsons, 1970) — in other words, more or less laterally. In *Aphelocheirus* it lies ventrally (Parsons, 1969). In the adults of Corixidae it lies patently laterally

— most dorsally — in the functional thoracico-abdominal membrane (Parsons, 1976).

In *Plea minutissima* the positions of the spiracles are already noted by Wefelscheid (1912, Fig. 6, 8, 10). He stated that the 1st spiracle lies in the intersegmental membrane between the 1st and 2nd sternum of the thorax, the 2nd spiracle leads into the cavity above the "Subcoxalplatte" below the forewing and the 3rd spiracle lies in the caudally turned corner of the metathoracic tergite and comes out in the space between the tergite and the wing. Wefelscheid (1912) also stated that the 1st abdominal spiracle lies in the "Ventral-phragma" and in the course of ontogenesis shifts to its frontal margin. The given data are in accordance with Heymon's (1899) general conclusion that the 1st to 3rd spiracles are intersegmental and in the course of development have a tendency to adopt a position in the preceding segment.

(f) Scolopophorous organs. In aquatic Heteroptera there are 3 conspicuous scolopophorous organs (Larsen, 1957). The mesothoracic is located in the mesothoracic postalar bridge of the mesepimeron, the posteroventral — axillary region of the forewing. It is either completely or partly surrounded by a collar-like elevation. The scolopophorous organ of the metathorax is very tiny and is situated posteroventrally in the axillary area of the hindwing. The organ of the 1st abdominal segment lies laterally in the area of the membranous unsclerotised region of the 1st abdominal tergum.

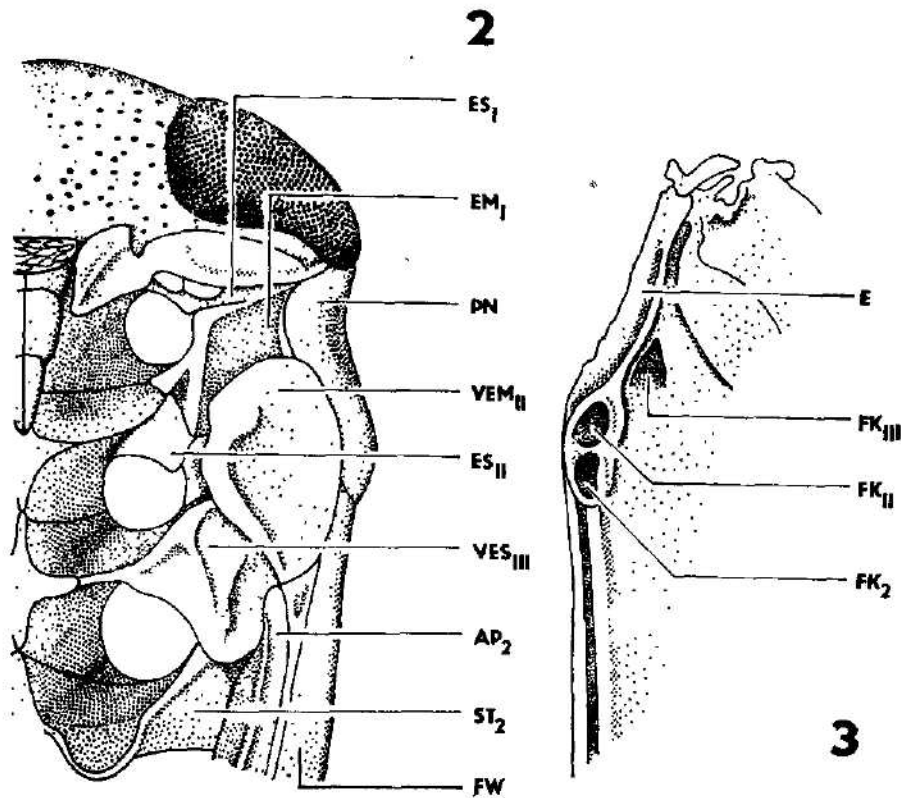
The first more detailed study of the scolopophorous organs of aquatic bugs is the paper of Hagemann (1910), where he deals, inter alia, with the morphology of the mesothoracic scoloparium in *Corixa punctata* and draws attention to its auditory function. Popham (1961) considers on the basis of the results of experiments that it is an organ of balance, capable perhaps also of registering changes in pressure and sound-waves and of signalling the flooding of the air chamber of the metathoracic spiracle. Prager (1973, 1976) studied in detail the morphology of this scoloparium and demonstrated the ability to register sound-waves within the range of 0.2 — 20 kHz with a certain physiological asymmetry. Arntz (1972) also demonstrated this ability in *Notonecta obliqua* and even ascertains it (Arntz, 1975) in the metathoracic scoloparium of *Nepa cinerea*. Wefelscheid (1912, pp. 66–69, Fig. 27–31) described and illustrated the mesothoracic "Tympanal organ" in *Plea minutissima*, Hoppe (1912) in *Notonecta glauca* and Rawat (1939) in *Ilyocoris cimicoides*. Prager & Streng (1982) point out that the scoloparia are in direct contact with the air spaces outside the body, which also fulfil the function of their resonator.

2. Adult of *Plea minutissima*

(a) Pleura of the prothorax (Fig. 2). The pleural region of the prothorax is almost entire. Laterally it passes in a more or less indented or raised anteroposterior line to the pronotum. The margin of the propleura surrounding the hip socket is anterolaterally divided by the coxal cleft. In its extension there lies, before the strengthened border, an obvious pleural sulcus. Anterior to the sulcus lies a narrow proepisternum. The region behind the sulcus can be considered to be the proepimeron. It is strengthened by two sclerotised borders. The 1st follows the direction of the sulcus propleuralis. The 2nd extends from the coxal cleft posteriorly to the inner cutaway margin of the proepimeral lobe, where it forks at its conclusion.

The laterocaudal part of the proepimeral lobe is inserted under the anterior margin of the ventral (supracoxal) lobe of the mesepimeron. The mediocaudal part of the lobe then overlaps the anterior part of the mesepisternum. The lower surface of the internal part of the posterior margin of the epimeral lobe and the upper surface of the anterior part of mesepisternum bear tiny bumps and short ridges with microtrichia. The two surfaces form the stridular apparatus.

The mesothoracic spiracle is situated beneath the medial-facing projection of the internal margin of the proepimeral lobe. It lies in a narrow trench formed by the secondarily sclerotised membrane between the pro- and mesothorax. In the preparation and dissection of the skeleton the above region always remains a part of the prothorax. Truly membranous is only a very narrow strip lying posterior to the above-mentioned trench-like sclerotisation. The spiracle does not enter its area.



Figs. 2-3. *Plea minutissima*. 2 - head, thorax and anterior abdomen, ventral view of the left half of the body. 3 - base and embolus region of right forewing, view of internal surface. (Schemes without scale. Fig. 2 - length of illustrated part of the body is circa 1.25 mm).

Lettering as in Fig. 1; in addition: E = embolus; EM_I = proepimeron; ES_I = proepisternum; FK_{II} = wing-anchoring fovea, where fits knob of the posterior corner of supracoxal mesepimeral lobe; FK_{III} = wing-anchoring fovea, where fits knob of the metepimeron; FK₂ = wing-anchoring fovea, where fits knob of the abdominal projection of the second abdominal segment; PN = pronotum; ST₂ = second abdominal sternum.

(b) Pleura of the mesothorax (Figs. 2, 4-7). The mesothoracic epimeron is the largest sclerite of the ventrolateral region of the thorax. Its dorsal part lies in the subalar region, is relatively narrow and has a very uneven surface. The greater part of its area is taken up by a large mesothoracic scoloparium (Pl. I, Fig. 1), surrounded by a marked collar-like border. The scolopophorous organ is more or less circular, with its surface turned latero-ventrally. It has a radially pleated membrane and a large central domed knob

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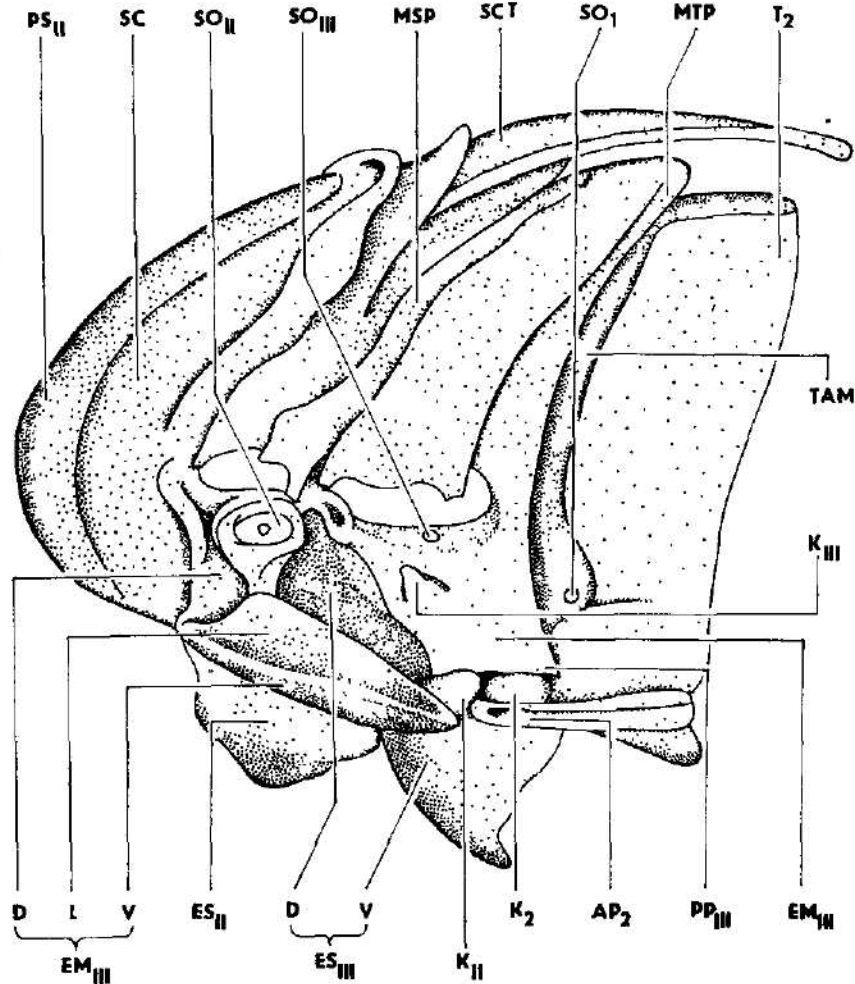


Fig. 4. *Plea minutissima*. Lateral view of pterothorax and first two abdominal segments. (Schema without scale.).
 Lettering as in Fig. 1; in addition: K_{III} = wing-anchoring knob of metepimeron; K₂ = wing-anchoring knob of abdominal projection of the second abdominal segment; MSP = mesopostnotum; MTP = metapostnotum; PS_{II} = mesothoracic prescutum; SC = mesothoracic scutum; SCT = scutellum; TAM = functional thoracico-abdominal membrane.

of scolops. Anteriorly of the border of the scoloparium the dorsal part of the mesepimeron forms a narrow trench, dorsoventral in direction. The upper posterior corner of the dorsal part of mesepimeron is connected: (1) by a hooked ridge extending from the collar of the scoloparium backwards to the metepimeron, (2) by an extremely narrow ridge extending dorsally to the mesopostnotum — this ridge basically forms an insignificant postalar bridge.

The posterior edge of the collar-like border of the scoloparium has the form of a high ridge, behind which the sclerite runs down anteromedially in the form of a trench. In the inner wall of this trench, close above the lateral epimeral ridge and the intersegmental boundary, lies the metathoracic spiracle (Figs. 5, 7). It is relatively small and oval to elipsoid in shape.

The lateral and ventral part of the mesepimeron forms a large irregularly shield-shaped supracoxal lobe. The greater part of the surface of this is turned completely ventrally. Anteriorly it extends forward over the proepimeral lobe, medially over the small, narrow, completely ventrally lying mesepisternum. To the rear it extends over the ventral metepisternal lobe. The lateral part of

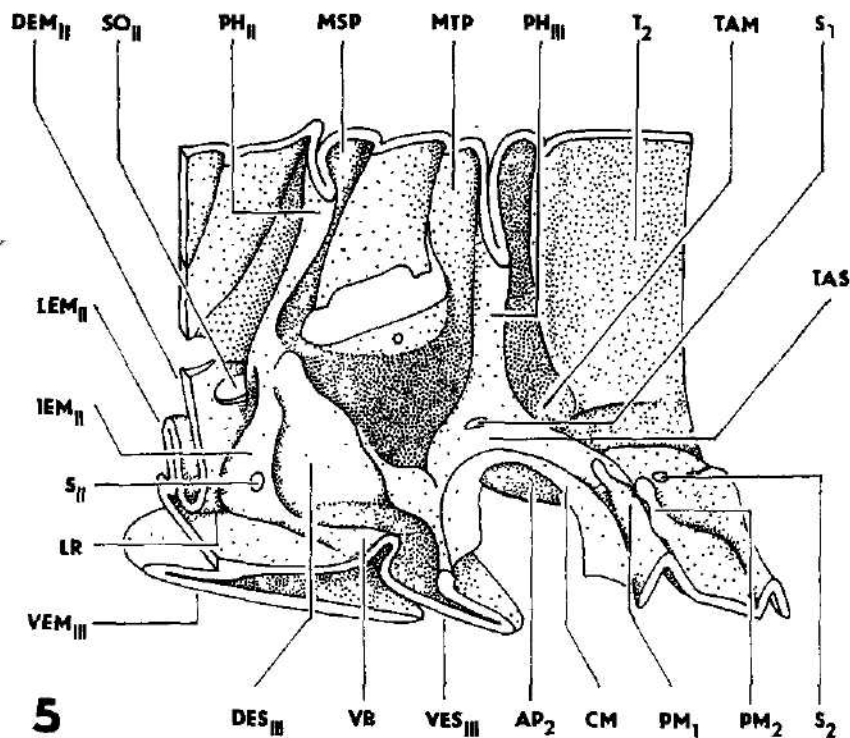


Fig. 5. *Plea minutissima*. Internal view of pterothorax and first two abdominal segments, cut parasagittally through metacoxal cavity. (Schema without scale.)
 Lettering as in Figs. 1, 4; in addition. CM = metacoxal membrane; IEM_{I, II} = anteromedial invagination of dorsal portion of mesothoracic epimeron; PH_{II, III} = second, third phragma; PM_{1, 2} = muscle process of the 1st abdominal sternum, 2nd abdominal sternum, VB = ventral intersegmental boundary between the meso- and metathorax.

the supracoxal lobe forms a wide depression, into which the emboliar edge of the forewing fits exactly. The posterior corner of the lobe extends to just in front of the abdominal projection of the second abdominal segment and dorsally it arches out into the functional and striking wing-anchoring knob.

(c) Pleura of the metathorax (Figs. 2, 4-7). The metepimeron lies completely laterally in the subalar and subaxillary region of the hindwing. It takes the shape of an irregular lozenge. Its posterior upper corner extends into a broad postalar bridge and fuses with the metapostnotum. The posterior lower corner forms a short and sharp lobe of metathoracic epimeron. Below half the height of the sclerite, behind its anterior margin, is an anterolaterally directed knob (Fig. 4, Pl. I, Figs. 5, 6) which fits into the small fovea on the inner surface of the forewing in its corial region, close behind the emboliar cleft (Fig. 3).

The intersegmental boundary between the meso- and metathorax extend extremely forwards in the lateral region in connection with the trench-like depression of the posterior edge of the dorsal part of the mesepimeron and cannot be distinguished on the outside of the skeleton. The 2nd phragma (Fig. 5) also lies relatively to the fore. The dorsal part of the metepisternum (Fig. 4) lies completely laterally, has the shape of an irregular triangle and is considerably indented. It thus forms the inner wall of the large air chamber of the metathoracic spiracle. In its lower part it is inserted under the supracoxal lobe

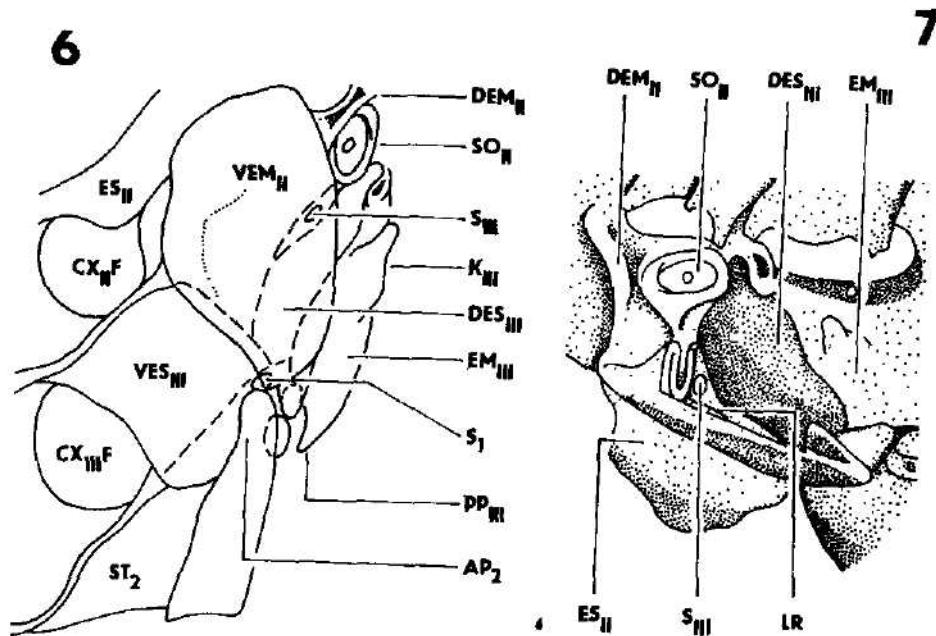


Fig. 6-7. *Plea minutissima*. 6 - ventral view of pterothorax and anterior abdomen, left half of the body. Heavy broken line indicated position of the margins ventrally not visible sclerites. 7 - lateral view of mesepimeral and metepimeral region with the indication of position of the metathoracic spiracle. (Schemes without scale.) Lettering as in Figs. 1, 2; in addition: CX_{II}F, CX_{III}F = mesocoxal, metacoxal fovea, S_{III} = metathoracic spiracle.

of the mesepimeron and passes into the ventral supracoxal lobe of the metepisternum. This lobe is firmly connected to the 2nd abdominal segment at 2 points (Figs. 2, 6): (1) its posterior edge fits into the excision of the metacoxal ridge of the 2nd abdominal sternum, (2) the lateroposterior cutout of the posterior edge is depressed around the anterior projection of the 2nd abdominal segment.

The metathoracic scoloparium is insignificant (Fig. 4, Pl. I, Fig. 2). It is situated in the lower part of the membranous axillary region of the hindwing, close above the upper margin of the metepimeron. Its membrane is not distinguishable from the axillary membrane. All that can be distinguished is the knob of its scolops, which is pointed in a more dorsal direction.

(d) The thoracico-abdominal region (thoracico-abdominal junction and first two abdominal segments) (Figs. 4-7). The 3rd phragma (Fig. 5) is considerably developed. It fuses with the metapostnotum and closes the thoracic cavity almost to the half of the width of the body. The strong and close boundary of the ventral metepisternal lobe and the 2nd abdominal segment has already been mentioned. The morphology of the whole lateral thoracico-abdominal region also has considerably concentrated form. The abdominal projection of the 2nd abdominal segment (Fig. 4; Pl. I, Fig. 4) extends considerably forwards under the metepimeron and touches the posterior corner of the mesepimeral supracoxal lobe. The abdominal projection is flattened and dorsally it arches out into the wing-anchoring knob (Figs. 4, 6; Pl. I, Fig. 4). The origin of this knob is not clear (the 1st dorsal laterotergite; a separated part of the metepisternal lobe - viz., the lateroposterior cutout of the lobe - or both?). The above mentioned knob fits into a fovea in the emboliar edge of the forewing situated close above the fovea into which fits the knob of the posterior corner of the supracoxal lobe of the mesepimeron (Fig. 3). The thoracico-abdominal sclerite (Fig. 5) (sensu Parsons, 1970) is not evident from the lateral view. It is completely hidden behind the pointed posterior metepimeral projection. It contains the 1st abdominal spiracle, the opening of which is turned completely ventrally into the trench-shaped air chamber between the projection of metepimeron and the thoracico-abdominal sclerite. Laterally and dorsally there is connected to the thoracico-abdominal sclerite a functional thoracico-abdominal membrane, which forms a deep dorsoventral cleft behind the posterior edge of the metepimeron and behind the 3rd phragma. In the cutout, through which this membrane extends in the lateral region in a posterior direction to the area of the 2nd tergum, the 1st abdominal scolopophorous organ (Fig. 4; Pl. I, Fig. 3) is placed. The scoloparium is externally particularly well visible is the small round knob of the scolops and the circularly-structured membrane around the latter.

Ventrocaudally the thoracico-abdominal sclerite changes into a narrow sclerotised strip which extends anteriorly of the 2nd abdominal sternum and the 2nd antecosta across the entire width of the abdomen (SEM). The metacoxal membrane is connected to this strip in front. The above-mentioned sclerotisation has its own muscle process (Fig. 5), situated somewhat more laterally and further forward than the muscle process of the 2nd sternum. In all probability this sclerotisation, which laterally passes into thoracico-abdominal sclerite, is the considerably reduced, but entire 1st sternum*).

*) Since the origin of the thoracico-abdominal sclerite is problematic, its morphogenesis as well as the ontogeny of the position of the 1st abdominal spiracle were

DISCUSSION AND CONCLUSIONS

The propleura in *Plea minutissima* bears secondary sclerotisation in the form of strengthened ridges. In spite of this both the coxal cleft and the propleural sulcus are obvious on it. The given type can be included in Parsons' (1967) 1st group of nepomorphan Heteroptera "with an unmodified coxal cleft".

The general morphology of the ventral mesopleural surface is unique within the families of nepomorphan bugs represented in the Palearctic. The proepimeral lobe is inserted under the supracoxal mesepimeral lobe which at the same time overlaps partly the mesepisternum and metepisternum. The supracoxal lobe of the mesepimeron is the largest sclerite of the thorax. The lateral mesepimeral region is relatively narrow. It contains a scolopophorous organ completely surrounded by a collar-like sclerotisation which recalls the situation in some Naucoridae (*Limnocoris*), Aphelocheiridae (*Aphelocheirus*) and Corixidae (cf. Parsons, 1974). The metathoracic spiracle adopts a position which can still be evaluated as an extreme S_3 position (cf. Parsons, 1974) and can be derived theoretically from the situation in *Notonecta*. In representatives of the genus *Notonecta* the spiracle is extended dorsoventrally, its ventral margin is hidden from the lateral viewpoint behind the dorsally curved external edge of the supracoxal mesepimeral lobe. In *Plea minutissima* the spiracle adopts a position corresponding to the position of the ventral margin of the spiracle in *Notonecta*. The metathoracic spiracle opens, as it does in representatives of the genus *Notonecta* and *Corixa*, into the subalar space. Its air chamber is, however, thanks to the strong indentation of the dorsal part of the mesepimeron and metepisternum, relatively deeper than in the two genera mentioned. The anteromedial indentation of the dorsal part of the mesepimeron causes in the lateral area the extreme shifting forward of the intersegmental boundary between the meso- and metathorax, almost beneath the axillary area of the forewing. The formation of the intersegmental boundary thus recalls the situation in certain Naucoridae and Belostomatidae. The extremely strong boundary between the supracoxal metepisternal lobe and the 2nd abdominal segment has no parallel in nepomorphan Heteroptera. This characteristic can be evaluated as marked autapomorphy of Pleidae, as can the position and form of the lateral abdominal projection of the 2nd abdominal segment, extending to almost half the length of the metepimeron. The extent of the thoracico-abdominal region (sensu Parsons, 1976) is considerably reduced in comparison with the situation in other representatives of the suborder Nopomorpha. The position of the 1st abdominal spiracle, its shifting in the course of ontogenesis and the sclerotisation of the ventral part of the thoracico-abdominal region show that the thoracico-abdominal sclerite of *Plea mi-*

studied. The spiracle is in the 1st nymphal instar still situated completely intra-segmentally and the 1st sternum is clearly distinguishable. The situation is the same in nymphs of the 2nd, 3rd and 4th instars. In specimens of those instars the ventral longitudinal intersegmental muscles between the 1st and 2nd sternum can also be safely distinguished. In nymphs of the 5th instar the spiracle lies beneath the posterior corner of the ventral metepisternal lobe in triangular lateral region of the 1st sternum. In adults it is already found entirely in the region of the metathorax, beneath the posterior metepimeral lobe, which on the contrary, extends, almost into the abdominal region (Fig. 6).

nutissima is mainly of abdominal origin and the part played by the metepimeron in its morphology is either minimal or non-existent.

A strongly developed coaptative apparatus of the forewing in the metathoracic lateral region was ascertained, formed by:

- (1) a dorsal knob of the posterior corner of the supracoxal mesepimeral lobe, which fits into a fovea in the emboliar margin of the forewing;
- (2) by an anterolaterally pointing knob of the metepimeron, which fits into a fovea on the internal surface of corium of the forewing;
- (3) a dorsal knob of the lateral abdominal projection of the second abdominal segment, which fits into a fovea in the emboliar margin of the forewing.

These knobs or projections fix the forewings to the body wall in a position of rest on two planes more or less at right angles to one another.

The wing-anchoring knob of the posterior corner of the mesepimeral supracoxal lobe is developed to varying extents in all the representatives of nepomorphan Heteroptera investigated so far. The data by Popov (1971) and Puchkova (1980) on its non-functional nature or its non-existence in *Plea* are mistaken. The metepimeral wing-anchoring knob was described by both the above authors (Popov, 1971; Puchkova, 1980) and their data are confirmed by the results of this study. The fixation of the forewing by a dorsal knob of the lateral abdominal projection of the 2nd abdominal segment has no parallel in nepomorphan Heteroptera.

Parsons (1974) ascertained on a model representatives of the Naucoridae that the morphology of the lateral thoracic and thoracico-abdominal region can have extrageneric and intrageneric variability within in individual family, which suggest that the modification of this region need not correspond to phylogenetic relationships and that they are partly caused by functional differences. The family Pleidae is a relatively small, and its representatives are relatively morphologically uniform. In three of pleid species (cf. material) no differences of any greater significance were ascertained. Phylogenetic conclusions, however, with regard to the findings of Parsons (1974, 1976) cannot be expressed responsibly without a more detailed morphological study of representatives of a probable sister group of Pleidae — the Helotrephidae — and without the study of representatives of Anisopinae (Notonectidae).

The morphology of the thoracic pleura and the thoracico-abdominal region in *Plea minutissima* has some features which seem to be unique in nepomorphan Heteroptera and can be evaluated as the autapomorphies of the Pleidae.

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The plate I will be found at the end of this issue.

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**THE EFFECT OF THE LENGTH COMPOSITION OF THE ROACH POPULATION
ON THE GILLNET SELECTIVITY (PISCES)**

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Abstract. Between 1980 and 1983, a direct method was used of comparing the length composition of roach caught by gillnets and haul seines to estimate selectivity curves and to evaluate their variability depending on changes of the length composition. The relative efficiency (in percentage) of particular selectivity curves with respect to length groups of 14 to 24 cm ranged between 1 and 14, 3 and 22, 25 and 36, 55 and 96, 80 and 100, 62 and 87, 48 and 69, 32 and 55, 20 and 44, 13 and 36, 8 and 30% resp. The modal length determined from 16 independent values varied within 180.5 ± 0.8 mm. The left and right-side steepness of selectivity curves is directly proportional to the length composition of the population and it is increased with increasing the number of individuals in relevant length groups.

INTRODUCTION

The theory of gillnet selectivity was proposed by Baranov already prior to World War I (Baranov, 1914) and complemented later by the same author (Baranov, 1948). There is a basic assumption that the efficiency of the gillnet with a given mesh size with respect to different species of fish may be described by a normal Gaussian curve with one peak corresponding to an optimal (modal) size of fish caught, which is more or less symmetric with the same height for gillnets with different mesh sizes. On the basis of these simplification, Baranov (l. c.) proposed a method of calculating the modal length of particular types of gillnet and method of constructing the selectivity curve. A further assumption about the shape of the selectivity curve was complemented by Holt (1957) in the sense that the standard errors of the size distributions of fish from two gillnets with different mesh sizes are also identical.

The assumption about the symmetric character and presence of one peak of selectivity curves is most suitable in the case of fish with a smooth body without any prominences (spines, teeth). Later it was shown that in species with these prominences, there are selectivity curves of different shapes, e.g. bimodal in the walleye *Stizostedion vitreum* (Hamley and Regier, 1973). Hamley (1975) concluded the objections against the mentioned principles indicating that the height of selectivity curves mostly increases with increasing mesh size of the gillnet, the modal length may exert variations and the physical principle of the geometric similarity of the fish body shape and relevant mesh of the gillnet, adopted for deriving the selectivity curves, is not quite valid with all the consequences.

The theory of the gillnet selectivity belongs to those studied in most details (Hamley, 1975), however, in spite of this, the number of works aimed at this

problem decreased remarkably in the last years (Cvancara in his Current references in fish research report only 12 works between 1980 and 1985. The reason for this is, besides others, in a remarkable variability of selection curves depending on the number of specimens caught, on the time of gillnetting, on changes of the population length composition, which remarkably complicates the use of these curves when deriving the length and subsequently the age composition (Libosvářský, 1975).

Thus, the work presented here is aimed at the effect of changes of the length composition of the roach population on changes of the shape of the selectivity curve.

MATERIAL AND METHOD

Similarly as in a preceding work (Pivnička et al., 1984) four types of the gillnet were used, of a length of 30 m, marked with letters A, B, C and D with the following parameters: A — height 3.6 m, mesh size $a_A = 28.1 \pm 2.6$ mm, fiber thickness 0.209 ± 0.018 mm; B — 2 m, $a_B = 27.9 \pm 4.8$ mm, 0.199 ± 0.011 mm; C — 2.9 m, $a_C = 28.6 \pm 3.4$ mm, 0.167 ± 0.014 mm; D — 2.5 m, $a_D = 39.7 \pm 2.9$ mm, 0.24 ± 0.011 mm. The haul seine was characterized by its length of 30 m, height of 2.75 m and mesh size of 8.3 ± 0.7 mm. The length composition of fish from gillnets A, B and C were evaluated together or independently (in the case of the gillnet of the type C). The gillnet of the type D served only for obtaining an estimate of the modal length of remaining gillnets. The colour of all gillnets was the same (green), the girth of fish was not measured.

For the estimate of the selectivity curves, a method was used based on comparing the size distribution of the catch from gillnets and from the haul seine, where the efficiency of 100% was achieved starting from the roach length of 60 mm. The selectivity was evaluated as a relative efficiency (S_{ij}) of a gillnet with a mesh size of "i" with respect to fish of a length group j, $S_{ij} = C_{ij}/N_j X_i$, where C_{ij} is a number of fish of the j-th length group caught by the gillnet of a mesh size of i, N_j is a relative number of the j-th length group in the population (the length composition of the population is considered on the basis of the representation of length groups in a haul seine), X_i is a fishing effort of the mesh i. The values of the relative efficiency leftward and rightward of the modal length were fitted by a simple power curve of the type $y = ax^b$. The peak of a selectivity curve obtained in this way was drawn by the eye. Similarly, however, mathematically more complex described independent left and right parts of selection curves, e. g. Sechin (1969, 1989a), Hamley and Regier (1973).

RESULTS

The effect of the time of gillnetting on the length composition

The selectivity curves were estimated on the basis of material sampled at the spawning time (in May). For this reason, it was necessary to check, whether the catchability of particular length groups is not different after this period (i. e. from July to the half of September). The length composition for gillnets were compared between 1977 and 1979 (Table 1, Fig. 1). It was assumed (with respect to the gillnet mesh size) that roaches exceeding 21 cm will be represented in summer period in the gillnets to a lesser extent and by contrast to this, roaches will be prevalent near the modal length (18 cm) length groups of 22 cm and larger should be theoretically no more caught by the gillnets used (Baranov, 1948). In 1977, at the time of spawning, the most frequently caught length group (20 cm) was shifted in the summer period to 21 cm, in 1978 from 21 cm at the spawning time to 22 cm. In 1979, the most numerous

Table 1. Length composition of roaches in the Kličava reservoir between 1977 and 1979 at the spawning time (sp) and after this period (psp), n — number of fishes, r — relative representation, the most numerous group considered as 100

Length group cm	1977				1978				1979		
	sp n	r	psp n	r	sp n	r	psp n	r	sp n	r	psp n
13					11	4.5					
14					1	0.1					
15	10	2.6							5	1.3	2
16	70	18.4					10	10.9	67	18	9
17	111	29.2	15	15.2	11	4.5	13	14	98	26.3	9
18	206	54.2	52	52.1	86	35	6	6.5	97	26	15
19	160	42.1	80	80.3	183	74.1	17	18.4	122	32.7	17
20	380	100	88	88.3	194	78.9	69	75	223	59.8	20
21	207	54.5	99	100	246	100	68	74	366	98.1	20
22	76	20	76	76.2	196	79.7	92	100	373	100	35
23	25	6.6	34	34.1	62	25.2	61	66	149	39.9	20
24	5	1.3	9	9.1	12	4.9	10	11.1	21	5.6	3
25							1	1			
Total (n)	1250		453		1002		347		1521		150

length group at the spawning time remained the same even after this period (22 cm). In the summer period, 1979, however the number of roaches of the modal length increased. In the first two years, the population was growing older and the fishes increased in their length (the mean increase between 1977 and 1982 was of 1.6 cm per year for roaches of the given length group -

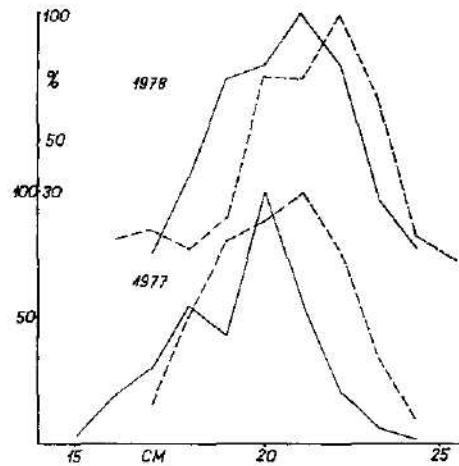


Fig. 1. Comparison of the length composition of fish in gillnets at the spawning time — solid line 1250 and 1002 specimens and from July to September — 347 and 453 specimens- dashed line in years 1977 and 1978; x — axis : body length in cm, y-axis : relative length composition.

Pivnička, 1982). A more remarkable recruiting of the population by younger age groups near to the modal length, i. e. 4th and 5th age group, was manifested only in 1979.

Thus, the length composition of gillnetted roaches in the spring period remained unaffected e. g. by an assumed higher activity and, in connection with this, by a higher catchability of length groups of 20 to 23 cm. A shift in the

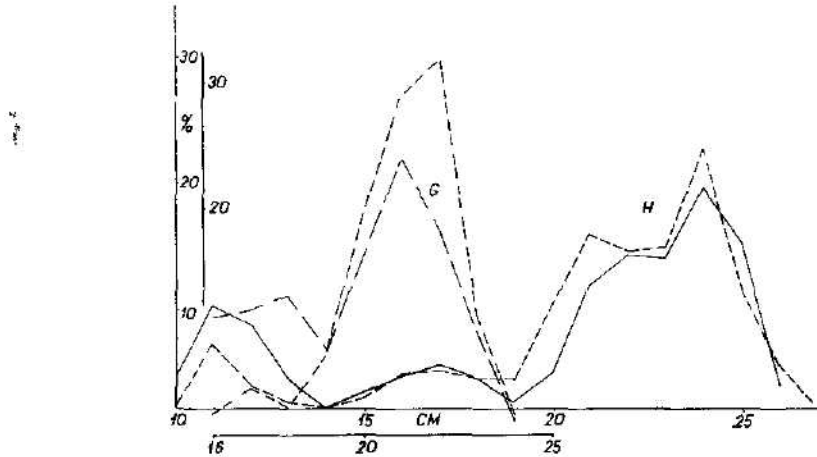


Fig. 2. An example of changes of the length composition of roaches during the spawning — in gillnets (G) in May, 1979, dot and dash line 17.5, 372 specimens, two dashes and dot line 22.5, 602 specimens and in the haul seine (H), solid line 20.5 — 745 specimens, dashed line 21.5, 792 specimens; x-axis: body length in cm, y-axis: relative length composition— for gillnets valid bottom values on x-axis and right values on y-axis.

length composition in the course of the season may be explained by a length growth of individuals.

A certain variability in the length composition of fish from the gillnets, however, also from the haul seine, should also be assumed even within a relatively short spawning period. This may be connected with the presence of several local populations in the dam, with stepwise changes of length groups entering into the spawning grounds, or it may be only random depending on a number of fish caught in particular day or catch. (Fig. 2). As a matter of fact, the zero hypothesis of the same length composition of fish caught by a haul seine on particular days between 1981 and 1982 may be refused on the basis of the χ^2 test at a significance level of 95 to 99 % (in gillnets at a significance level of 90 to 95 %), however, the whole trend in the representation of most numerous length groups remained unaltered.

The variability of the selectivity curve of the C type gillnet

By gillnets of the type C, sufficient numbers of fishes were sampled between 1980 and 1983 which made it possible to evaluate for them independently the variability of selectivity curves in particular years and the effect of the length

Table 2. Length composition of roaches in the haul seine (h) and gillnets of type (C), values of the relative efficiency of a relevant selectivity curve (S_C) and values of the mean selectivity curve of the gillnets C (\bar{S}_C)

Length group cm	1980			1981			1982			1983			Total		
	h	C	S_C	h	C	S_C	h	C	S_C	h	C	S_C	h	C	\bar{S}_C
9	1			12			6			3			22		
10	1			43			79			16			139		
11	5			59			309			45			418		
12	15			29	1		184	2	1	1			386	3	
13	36			4			159	2	2	141			340	4	
14	90	1					3		6	102			195	6	0.5
16	102	35	5	4			16		13	29			151	37	10
16	89	78	28	13			33		28	55			211	159	28
17	30	90	98	84	37		68	1	66	88			262	272	85
18	31	57	67	142	92		99	12	99	23			230	267	92
18	54	81	51	171	77		73	30	84	36			271	211	73
20	55	73	39	99	44		43	25	84	36			268	157	57
21	79	68	31	119	23		27	19	68	108			423	157	45
22	84	54	24	202	20		21	47	41	216			525	191	35
23	14	11	19	195	14		17	87	29	21			484	136	28
24	2		16	119	3		7	76	21	27			468	68	24
25				22	1		5	40	16	16			217	34	18
26				2			3	26	12	7			46	14	
27				2			43	14		1			4		
Total (n)	688	539		1324	315		2271	382		739	470		5022	1705	

composition of roachas on the shape of these curves (Table 2, Fig. 3). The modal length and steepness of left as well as right branches of selection curves varied stepwise.

In 1980 and 1981, the modal length achieved a value of 169 and 170 mm, respectively, in 1982 183 mm and in 1983 180 mm. Simultaneously, with increasing the mean length of the population the steepness was increased pro-

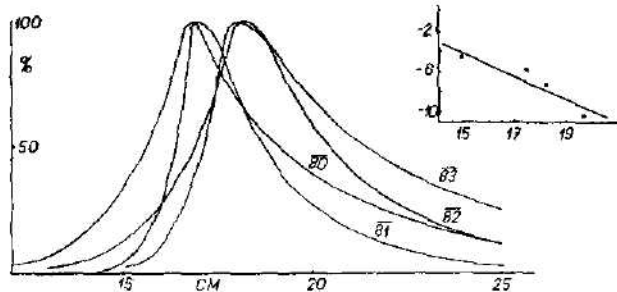


Fig. 3. Changes of the shape of the selectivity curves for C-type gillnets in 1980 to 1983, right top a dependence of the steepness of the right branch of these curves on the mean length of the population in cm — x-axis.

portionally of the right branch of selectivity curves (Fig. 3). In years, when there were few fishes in the population belonging to length groups of 22 cm and above, the resulting efficiency of the gillnet estimated was higher (1983) and vice versa (1981). This also follows from a methods of estimates of the relative efficiency of a gillnet with respect to a given length group. The same dependence (increase of the steepness and decrease of efficiency at an increased number of fishes of length groups below the modal length) is also valid for the left branch of the selectivity curve.

Thus, the length composition of the population affects the shape of the selectivity curve, which is most symmetrical in the case, when having in the population a majority of fishes of length group near the modal length.

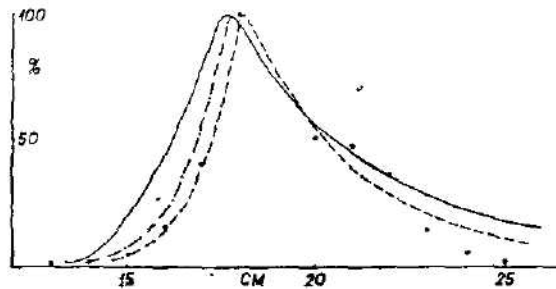


Fig. 4. The mean selectivity curve for gillnets of types A, B and C for 1980 to 1983 — solid line, steeper versions of its left branch — dot and dash line, smoothed length composition curve of the same gillnets in 1967 to 1986 — dashed line and its particular points — heavy circles.

Table 3. Material caught by gillnets of types A, B and C in 1980 and B and C in 1981 to 1983 and values of the relative efficiency of a relevant selectivity curve S , n — number of fishes, S — mean selectivity curve for the whole period, S_s — symmetric selectivity curve (Pavnička et al., 1984) and values of the relative efficiency of gillnets between 1967 and 1986 Set (for 14492 roaches)

Length group cm	1980		1981		1982		1983		S_{st}	S	S_s
	n	S	n	S	n	S	n	S			
12											
13	1	0.4	1	4	2	1	1			0.5	
14	3	2		8	2	2	2			0.8	
15	43	10		14	1	4	3	1	2	4	2.8
16	104	33	4	22	16	14	25	4	4	20	12.2
17	104	96	43	35	46	31	100	16	16	43	36
18	82	80	131	58	28	65	181	40	40	83	72.2
19	116	62	162	97	22	100	124	98	100	97	98.3
20	103	51	60	75	22	83	37	87	94	74	91
21	88	42	35	48	65	64	41	69	51	57	57.3
22	90	35	37	32	120	49	35	55	48	44	24.5
23	16	29	23	20	111	37	62	44	36	35	7.1
24	2	25	9	13	57	28	83	36	16	28	1.4
26				8	47	22	35	30	5	22	0.2
26					23	17	16	25	1	18	
Total (n)	752		445		540		709				

The variability of selectivity curves for C-type gillnets, expressed as a relative efficiency with respect to length groups of 16 to 24 cm ranged between 12 and 66; 45 and 100; 65 and 100; 45 and 87; 28 and 68; 18 and 55; 11 and 44; 7 and 36; 4 and 30.

The modal length variability

Under an assumption that catching of a fish is dependent only on the relative geometry of fish body and on the mesh size of the gillnet, the modal length will be constant. Here, it is inadmissible to confuse the modal length with a most frequently represented length group in gillnet, which varies depending on a varying length composition of the population (in our case it ranged between 17 and 22 cm). The variability of the modal length of the selectivity curve is remarkably lower. Out of the total number of 9 independent selection curves it is possible to calculate a mean modal length value of 177 mm (4×170 mm, 4×180 mm, 1×190 mm).

The relationship between the fish length (L) and gillnet mesh size (a) was expressed as $a = kL$, where k is a constant (of 0.15 for the roach). However, by evaluating data, reported by Baranov (l. c.) it is also possible to obtain a value of 0.16. For the two variants it is possible to obtain an estimate of the modal length of 188 and 176 mm. Last, by a method of intersections of length composition curves of gillnets with different mesh sizes (with the use of the D-type gillnet) it is possible in 1981 and 1982 to estimate the modal length of gillnets of the types B and C stepwise as 184, 191, 187 and 192 mm. When evaluating all these independent data, we obtain a mean value of the modal length of 180.5 ± 8 mm, which corresponds well to the ascertained values of modal lengths of selectivity curves (170 to 190 mm).

The mean selectivity curve

In total 9 independent selectivity curves were available with respect to length groups of 12 to 25 cm (gillnets A, B, C in 1980 and B, C in 1981 – 1983). The values of the relative efficiency, separately on left and right branches were fitted by a two simple power function, which were connected by the eye at a site of the modal length to obtain the required bell-shaped selectivity curve (Fig. 4). The ascendent left branch was constructed in a further, less steepness variant, after eliminating certain extreme values of the relative efficiency.

It is known (Baranov, 1948; Hamley, 1975) that if a gillnet caught fish from the population with the same number of a fish in all length groups, the length composition of this catch would be simultaneously equal to the selectivity curve. This situation can be simulated by evaluating of mean length composition for a long period with a sufficiently high number of fish. This is the case of the Kličava reservoir between 1967–1986 the total of 14,485 roaches were caught and all situations in length composition in the population were recorded. Newly born strong age groups occur in average after 4 years (Pivnička, 1984). Fig. 4. shows on the one hand particular points of the relative representation of individual length groups and, on the other hand, the shape of a mean length composition "curve" (after eliminating less represented smallest, 12 and 13 cm, and longest, 24 and 25 cm, length groups). The difference of this "curve" from the mean selectivity curve between 1980 and

1983 is comparable with respect to the variability of 4 selectivity curves of C-type gillnets, or with respect to the variability of selectivity curves of A, B, C type gillnets from 1980 to 1983 (Tab. 3).

The shape of the selectivity curve

The effect of the length composition on the steepness of selectivity curves may be shown by way of examples of years 1983 and 1981. In 1983, when the lowest number of fish in length groups of 21 to 25 cm was caught by gillnets as well as haul seine, the mean length of the population was of 14.9 cm. In agreement with this, the steepness of the right branch of the selectivity curve was low ($b = -4.369$). In 1981, the mean length of the population was the highest - 19.7 cm and the portion of length groups of 21 to 25 cm was high and also the steepness of the right branch of the relevant selectivity curve was the highest ($b = -8.85$). The same holds for left branches.

Out of the total number of 14485 roaches gillnetted between 1967 and 1983 (modal length of 18.5 cm) length groups of 14 and 15 cm represented stepwise 1.6 and 4.3% and the same portion corresponded to length groups on the right side of the catch curve of 24 and 25 cm (5.3 and 1.4%). The length group of 14 cm is, however, distanced from the modal group by 4 cm, whereas the length group of 25 cm by 7 cm.

The shape of the selectivity curve and its right-side steepness is also affected by the mesh size and by the presence of corresponding length groups of fishes in the population. For example, the selection curve of D-type gillnets (mesh size of 39 mm) would be, when it could be constructed, skewed on the right side. The reason for this is in a high value of the modal length (of about 26 mm), which is simultaneously the longest length group occurring in the population. The right side of the selection curve of these gillnets should decrease for this reason very rapidly to zero values of the relative efficiency.

The reconstruction of the length composition

The reconstructed length composition from the back calculated relative efficiencies of the gillnet based on an estimate from individual nonsmoothed values, would completely correspond to the length composition of the haul seine. However, when fitting the relative efficiency values by a smoothed selectivity curve, then the reconstructed length composition is different from haul seine values, the difference being the larger, the bigger is the distance of original points from the selection curve.

As expected, the most precise reconstruction of the length composition in all the years was obtained in the range of the gillnet modal length. More distant length groups are reconstructed with larger or smaller imprecisions. Length groups on the right branch of the selection curve were most properly reconstructed between 1981 and 1983. In addition to this, in 1983, the representation of length groups of 19 to 25 cm was low and almost identical in gillnets as well as in the haul seine, so that it is not surprising that the reconstruction of this part of the population agreed well with haul seine values. According to material caught by D-type gillnet, (in 1983 23 fishes per 1 gillnet, in 1982 38 fishes in 1981 10 and 1980 13 fishes) it is to consider their presence in the population. The fact that they were caught at spawning places neither by the haul seine nor by the gillnets may be explained only by their absence in the spawning

Table 4. Relative length composition of roaches from the haul seine (hr) and after a reconstruction of gillnet catches with the help of a relevant selectivity curve (G_{sr}) and total mean selectivity curve (G_{sr})

Length group cm	1980		1981		1982		1983		Total	
	hr	G_{sr}	hr	G_{sr}	hr	G_{sr}	hr	G_{sr}	hr	G_{sr}
12	14.7	61	14.4	14	55.6	68	100	99.3	70	70
13	35.3	35	2	1	48	43	63	100	65	55
14	88.2	100	2	1	0.9	2	1	72.3	37	26
15	87.3	73	8.9	6	4.8	17	38	20.6	29	30
16	29.4	25	41.6	40	14.8	24	13	39	40	61
17	30.4	24	70.3	73	18.1	9	6	62.4	50	52
18	52.9	44	84.7	73	10.3	9	8	16.3	44	44
19	53.9	47	49	67	10.9	9	26	7.9	52	44
20	77.5	48	58.9	59	32.6	34	63	4.3	51	55
21	82.4	66	100	100	65.3	82	71	6.4	81	74
22	13.7	13	96.5	96	65.9	100	48	14.9	100	100
23	2	2	58.9	61	68.9	68	46	19.1	88	66
24			10.9	0.9	100	71	46	11.3	89	49
25					56.8	45		5	41	26
26					12.9			0.7	9	

shoul with respect to the fact that D-type gillnets were used beyond the spawning places, too. For this reason, the reconstruction of the length composition in 1983 cannot be considered as reliable.

The representation of reconstructed length groups of the right part of the curve in 1980 was underestimated as compared to the length composition of roaches from the haul seine especially length group of 22 cm). By contrast to

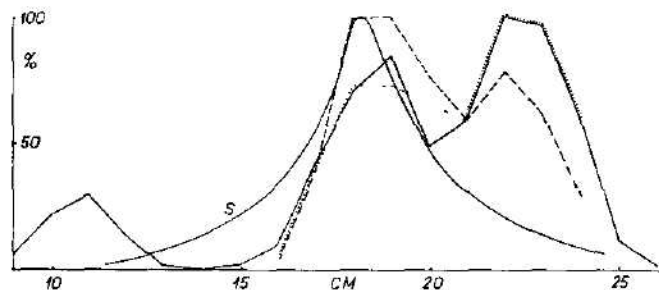


Fig. 5. An example of the reconstruction of the length composition of the roach population in 1981 with the help of a selectivity curve (S) from this year, solid line — length composition of material caught by a haul seine 1324 specimens, dotted line reconstruction of this length composition with the help of selectivity curve S and dashed line reconstruction with the help of a mean selectivity curve for a period of 1980 to 1983.

this, in 1982 errors were encountered in reconstructing the length group of 22 cm as the most numerous, since in haul seine catches the most numerous group was of 24 cm.

The length groups reconstructed with the help of the left branch of the selectivity curve were in a good agreement with the length composition of the haul seine catches between 1980 and 1982. In 1983, it was necessary to select a different course of the left part of the selectivity curve. The variability of the relative efficiency of individual selectivity curves (1980–83) for length groups of 14 to 24 cm ranged between 1 and 14; 3 and 22; 25 and 35; 55 and 96; 80 and 100; 62 and 87; 48 and 69; 32 and 55; 20 and 44; 13 and 36; 8 and 30 (Tab. 4).

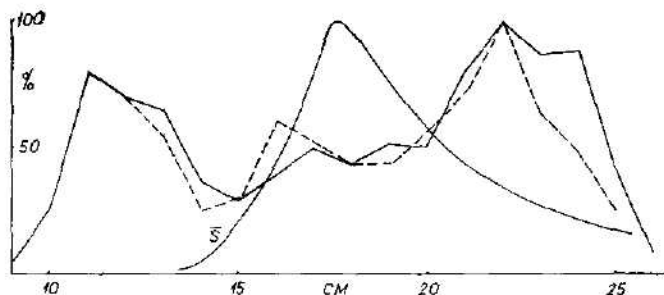


Fig 6 A reconstruction of the length composition of roaches between 1980 and 1983 with the help of a mean selection curve S, solid line a mean length composition, dashed line a reconstruction.

For each year, the reconstruction was also provided of the length composition with the help of a mean selectivity curve for the period of 1980 to 1983. It is to conclude that the results of the reconstruction with the help of a mean selection curve are worse as compared to the use of independent selectivity curves for particular years. (Fig. 5.) With respect to the fact that the four independent selectivity curves (1980 to 1983) represent four basic types of the length composition of the roach population it is more advantageous to use for the reconstruction a curve, which was estimated in a year, when the length composition of the gillnet catch was most similar to the length composition to be reconstructed (the mean situation during four years is shown in Fig. 6). The reconstruction of the length composition corresponds well to the ascertained length composition of the population with an underestimation of length groups of 24 and 23 cm, which is connected with a rather high efficiency of the gillnet with respect to these lengths, i. e. they are caught more efficiently as compared to values corresponding to their length.

DISCUSSION

Estimates of the age composition, mortality, biomass, production as well as yield are always affected by the selectivity of net used. This type of the selectivity cannot be avoided in free waters (an exception may be represented for example by experimental ponds, where all the fishes may be fished out). The gillnets are frequently an only one possible device for catching, which may be used in newly filled dams, either because the suitable catching sites are missing or for a few number of working people. The selectivity of gillnets may be most properly estimated by comparing their length composition with a known length composition of the population. This is the most precise method (though if it is necessary to take into account a variability of the selectivity curve and thus also its limited applicability) however, it is also the most expensive one. A further method of obtaining an estimate of the selectivity is in comparing the length composition of fish from gillnets with the same of the haul seine of a known selectivity. Here, it is, however, necessary to consider that this haul seine may select fishes of certain length groups depending on the time of catching, experiences of the fishermen, presence of local populations, etc. The selectivity of the gillnet may be estimated by comparing length composition from gillnets with different mesh sizes. The principle is similar as in the preceding case (Baranov, 1948; Hamley, 1975). The attempts to predict the shape of the selection curve only on the basis of comparing the fish body morphology and mesh size of a given gillnet still meets variable success (Sechin 1969, 1969a, Hamley 1975). However, the length composition of the population remarkably modifies the shape of a relevant selection curve for a given type of the gillnets. The steepness of both branches as well as the modal length are varied. The representation of length groups in the gillnet is affected by the flexibility of gillnet twines or by the degree of their damage.

The height of the selection curve is also similarly dependent on the length composition of the population. When having in the population most fish in the region of the modal length of the gillnet, then the catch as well as selectivity curve will be higher than those in a case where there are few fishes of these length group in the population. The height of the selection curve is also affect-

ed positively by the height of the body of the fish species caught. After comparing selection curves of different species (McCombie and Berst, 1969; Hamley, 1975) with our data for the roach, chub and rudd, it is possible to conclude that the curves are very steep on the left side in species with elongate shapes of the body (salmons, chub, catfish). By contrast to this, species with a high body have a selectivity curve more or less symmetrical

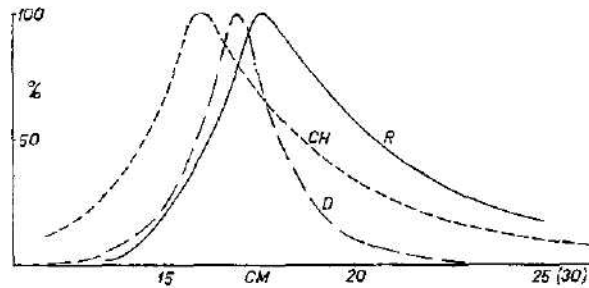


Fig. 7. Selectivity curve shapes for high-body species (rudd — D), medium height body species (roach R) and low-body species (chub CH); the curve for chub shifted by 5 cm leftward.

(tilapia, rudd). This is connected with the fact that fishes with elongate bodies have an essentially longer distance between the smallest and largest effective girth and thus, more individuals may penetrate into the gillnet. In addition to this, these species are usually the best swimmers and they may penetrate more actively into the gillnet as compared to species with a high body. (Fig 7)

CONSLUSION

In 1980 to 1983, by a method of a direct comparison of length composition derived from gillnets with the same of a haul seine with a known selectivity, four selectivity curves were estimated of a set of gillnets with mesh sizes of 27.9, 28.1 and 28.6 mm (28.2 mm in average) and the mean selectivity curve for the whole period was obtained.

On the basis of comparing the length composition of roaches caught by the gillnets as well as haul seine at the spawning time, and after that time, it was concluded that changes in the length composition may be explained by the length growth of fishes in the course of the season.

Independently for gillnets with a mesh size of 28.6 mm and for the set of gillnets, the effect was evaluated of the population length composition on the steepness of left and right branches of selectivity curves. The steepness of both branches is directly proportional to the number of fishes of relevant lengths in the population. The variability of the relative efficiency of selectivity curves of the set of gillnets for length groups of 14 to 24 cm for years 1980–83 varied between values 1 and 14; 3 and 22; 25 and 35; 55 and 96; 60 and 100; 62 and 87; 48 and 69; 32 and 55; 20 and 44; 13 and 36; 8 and 30%.

The mean value and variability of the modal length obtained by an estimate based on 16 independent values was of 180.5 mm \pm 0.8 mm. The relative efficiency of a mean selectivity curve between 1980 and 1983 with respect to

length groups of 12 to 25 cm achieved values of 0.5; 0.8; 4; 20; 43; 83; 97; 74; 57; 44; 35; 28; 22 and 18. The selectivity curve exerts one peak and left-side steepness. The reconstruction of the length composition between 1980 and 1983 performed with the help of the relevant selectivity curve is more precise than that performed with the help of a mean selectivity curve.

The left-side steepness of selection curves is characteristic particularly for fish with an elongate body shape, the species with a high body having rather symmetrical selectivity curves. However, the length composition affects the steepness in these cases, too.

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**QUALITATIVE AND QUANTITATIVE TROPHIC DYNAMICS IN A HILL STREAM
FISH, *BARILIUS BENDELISIS* FROM UPLAND FLUVIAL SYSTEM
OF THE GANGES OF CENTRAL HIMALAYAS**

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Abstract. Wide range of trophic spectrum of fish diet is indicative that the *B. bendelisis* (Hamilton), inhabiting high altitude fluvial system of the Ganges of Central Himalayas is euryphagic omnivorous, which shows the versatile feeding habit of the fish. Analyses of quantitative trophic dynamics, which was expressed in terms of seasonal variations in gastrosomatic index (GSI), mean stomach fullness index (MFI) and condition of feed, have revealed that the feeding intensity attains two peaks in a span of one year, first in the month of May and second in December. The variation in feeding intensity appears to be correlated mainly with the developmental condition of the gonads (spawning period) vis a vis availability of food items in the high altitude lotic environment of the Ganges. An interesting fact also emerges from the studies of seasonal variations in the mean fullness index (MFI) in different size groups and its correlation with the maturity of the fish that the females attain maturity earlier than male.

INTRODUCTION

Barils group comprising mostly small sized fish have scarcely attracted the attention of fishery ecologists in the past. However, *Barilius bendelisis* (Hamilton) locally known as 'fulra' is an important food fish of the poor people and is naturally found in the high altitude fluvial systems of the Ganges of Central Himalayas (India) and prefers crystal clear water, inhabiting streams, rapids as well as pools at elevations ranging from 914 m to 1,524 m above msl. The fish prefers water temperature between 12.0 °C and 19.8 °C. The fry of this fish species have been observed moving in shoals in the side channels of the main river, where the water current is relatively low. Day (1878) reported two varieties of *B. bendelisis* (Hamilton) — *B. bendelisis* var. *chedra* (Hamilton) and *B. bendelisis* var. *cocsa* (Hamilton) but Badola et al. (1982) reported that these two varieties as sexually two different forms of the same species 'cocsa' being the female and 'chedra' the male *B. bendelisis*.

While some work has been done on the trophic dynamics in different hill-stream fishes of Indian subcontinent by Jyoti and Malhotra (1975), Das and Pathani (1978), Somvanshi and Bapat (1979), Singh and Bahuguna (1983) and Sharma (1983, 1984a, 1984c, 1984d, 1984e). However, no information is available on qualitative and quantitative trophic dynamics of a hillstream fish, *B. bendelisis* (Hamilton) from upland fluvial system of the Ganges of Central Himalayas, except that of scattered reports on biological and ecological aspects of this species. Chacko and Venka-

Table 1. Visual estimate of stomach fullness
(scale devised by Ball 1961, and Hunt and Jones, 1972)

Condition of stomach	Points
Distended	10
Full	8
3/4-Full	6
1/2-Full	4
1/4-Full	2
Trace	1
Empty	0

traman (1945) contributed on a short note on the bionomics, Badola and Singh (1980) on feeding habit, Singh and Singh (1981) on olfactory apparatus and Badola et al. (1982) on sexual dimorphism of *B. bendelisis* (Hamilton). Hence, the present contribution is an attempt to provide more informations on the qualitative and quantitative trophic dynamics in *B. bendelisis* (Hamilton).

MATERIAL AND METHODS

B. bendelisis (Hamilton) were collected weekly from the high altitude tributaries of the Ganges river system laying in the Central Himalayas (India) and brought to the laboratory. The total length and somatic weight were determined to the nearest 0.5 cm and 1.0 g respectively and the data on size, sex and stage of sexual maturity were recorded for each specimen. The abdomen was opened and the gut uncoiled for its measurement of the total length. The stomach was then removed and preserved in 10% buffered formalin for future analyses. A visual estimate of the stomach fullness was made for the analysis of quantitative trophic dynamics using a scale (Table 1) devised by Ball (1961) and subsequently modified by Hunt and Jones (1972) and the values of seasonal mean fullness index (MFI) were determined.

The condition of feed in various months was calculated from the total number of specimens that fall into different categories. Specimens with distended and full stomachs were categorized as actively fed, those with 3/4 full and 1/2 full stomachs as moderately fed and 1/4 full, trace and empty as poorly fed specimens.

The gastroscopic indices were determined to study monthly fluctuations in the feeding intensity. The gastroscopic index (GSI) was calculated as:

$$GSI = \frac{\text{weight of stomach contents}}{\text{weight of fish}} \times 100$$

For the qualitative analysis of trophic dynamics of the fish, the preserved gut contents were mounted on slides in Reyne's mountant (chloral hydrate 50 g, water 50 ml, glycerine 12.5 ml, gum arabica 30 g). The each food item was observed under the stereoscopic microscope. In order to find out the volumetric contribution of each food item, a volume displacement technique to measure food items $> 0.05 \text{ cm}^3$ and a squash technique, modified from Hella well and Abel (1971), to measure volume of food items $< 0.05 \text{ cm}^3$ (Ross 1974) were followed. The various food items were identified upto lowest possible taxon.

The relative length of the gut (RLG) was calculated by dividing the length of the gut by the total length of the fish.

Table 2. Monthly variations in the volumetric contribution of major food items to the gut contents of *Barrinus bendelisis* from Central Himalayas

Months	Insects & their larvae (%)	Crustaceans (%)	Protozoans (%)	Rotifers (%)	Worms & Nematodes (%)	Other* food (%)	Algae (%)	Diatoms (%)	Macrophytes (%)	Sand & Detritus (%)
January	11.5	12.0	11.5	11.5	1.5	10.0	27.5	14.0	2.5	9.5
February	13.5	14.5	12.5	12.5	2.0	7.5	29.0	12.5	4.0	4.5
March	24.0	15.0	8.0	8.0	3.0	10.0	15.0	9.5	3.0	12.5
April	21.0	17.0	13.0	13.0	5.0	11.0	11.5	7.5	1.0	13.0
May	18.5	15.0	10.5	10.5	3.5	13.5	6.5	6.0	2.5	24.0
June	17.5	13.5	3.5	3.5	4.5	18.5	6.5	5.0	3.5	27.5
July	9.5	10.5	—	—	8.0	23.0	5.0	4.5	9.5	30.0
August	8.5	11.0	1.5	1.5	10.5	22.0	3.0	—	12.5	31.0
September	18.0	14.0	6.5	6.5	7.5	14.0	13.5	7.0	7.5	12.0
October	17.5	8.5	11.5	11.5	1.0	6.0	29.5	12.0	6.0	8.0
November	11.0	9.0	13.0	13.0	1.5	4.5	34.5	14.0	4.0	8.5
December	8.5	4.5	16.0	16.0	—	6.5	36.5	18.0	3.0	7.0
Mean (\bar{x})	14.92	12.04	8.93	8.93	4.0	12.04	18.85	9.17	4.92	15.63

* Other food includes pieces of mollusc shells, fish parts, etc.

RESULTS

Qualitative trophic dynamics

Qualitative analysis of the trophic dynamics of major food items and their monthly variations of fish diet has been depicted in Table 2. A detailed seasonal qualitative analysis of the gut contents of *B. bendelisis* has revealed that the fish feeds on animal food (insects and their larvae, crustaceans, protozoans and rotifers, other food including pieces of molluscan shells and fish parts) as

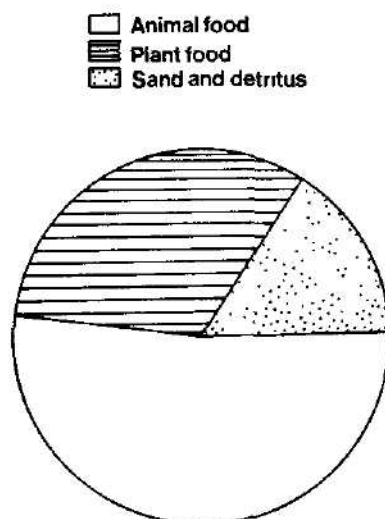


Fig. 1. Average annual diet composition of *B. bendelisis* (Hamilton).

well as plant food (algae, diatoms and fragments of leaves and stems of macrophytes).

The trophic composition of fish diet shows that algal and the nymphal or larval stages of insects food occupy top position ($\bar{x} = 18.17\%$, $\bar{x} = 14.92\%$) in the composition of fish diet, whereas other food including pieces of molluscan shells and fish parts ($\bar{x} = 12.20\%$), crustaceans and their larvae ($\bar{x} = 12.04\%$), diatoms ($\bar{x} = 9.17\%$), protozoans and rotifers ($\bar{x} = 4.92\%$), and worms and nematodes ($\bar{x} = 4.00\%$) rank next in order of their percentage occurrence (Table 2). The percentage composition and wide range of spectrum of animal food, plant food, and sand and detritus which were recorded to be $\bar{x} = 52.11\%$, $\bar{x} = 32.26\%$ and $\bar{x} = 15.63\%$ respectively (Fig. 1) showed that the fish was a euryphagic omnivorous.

Qualitatively, no marked difference has been observed in the food contents of male and female fishes of *B. bendelisis*.

Qualitative trophic dynamics of different major food items of *B. bendelisis* was observed as follows:

(a) Insects and their larvae: The nymphal or larval and parts of adult stages of insects form one of the important food items of fish diet and is a consistent food item almost all the year round. The percentage occurrence

of this food item reaches its peak (24.0%) in March, while lowest (3.5%) in the months of July and December (Table 2). The insect food fish comprised mainly of the genera of *Dinutes*, *Helochares*, *Paracymus*, *Potamonectes*, *Sternolophus*, *Eristalis*, *Baetis*, *Gerris*, *Helocoris*, *Micronecta*, *Isoperla*, *Perla* and *Hydropsyche*.

(b) Crustaceans: Crustaceans and their larvae were also present round the year in the gut contents of the fish and their contribution fluctuated between the range of 4.5% and 17.0% throughout the course of investigation. The crustaceans *Cyclops*, *Cypris*, *Daphnia* and *Diaptomus* were identified during the course of qualitative analysis of gut contents.

(c) Protozoans and rotifers: This food item was met within the gut contents almost round the year except in the month of July, when no protozoan and rotifer was observed. The protozoans — *Volvox* and *Zoothamnium* and the rotifers — *Brachionus*, *Philodina* and *Mytilina* contributed as fish food.

(d) Worms and nematodes: These organisms were met within the gut contents in appreciable amount (8.0–10.5%) during the monsoon months of July and August, while a very low amount (1.0–2.0%) during winter months being completely absent in December (Table 2). These are the parasitic forms and do not form as fish food. Nematodes such as *Aphelenchoides*, *Micro-laimus*, and *Chronogaster* were observed during analysis.

(e) Other food: Besides the above animal food items, fish parts and pieces of molluscan shells were also observed in the gut contents of the fish. The percental value varied from 4.5% to 23.0% in a span of one year.

(f) Algae: Algal food contributes an appreciable amount ($x = 18.17\%$) to the total annual fish food (Fig. 1). The percental value reached its peak (36.5%) in the month of December and lowest ebb (3.0%) in the month of August (Table 2). *Hydrodictyon*, *Cosmarium*, *Microspora*, *Spirogyra*, *Ulothrix*, *Gonatozygon*, *Oscillatoria* and *Polycystis* contributed as fish food.

(g) Diatoms: This food item contributed towards fish food round the year being absent in the month of August. The percentage (18.0%) of diatoms was recorded in the month of December (Table 2). *Diatoma*, *Navicula*, *Pinnularia*, *Synedra*, *Gomphonema*, *Cymbella*, *Nitzschia*, *Melosira* and *Fragilaria* constituted the dominant food element in the fish diet.

(h) Macrophytes: The fragments of leaves, stems and roots of aquatic macrophytes such as *Marselia*, *Polygonum*, *Lemna* and *Vallisneria* were mainly observed in the gut contents and their percental value ranged from a minimum of 1.0% in April and maximum of 12.5% in the month of August (Table 2).

(i) Sand and detritus: Besides the above animal and plant food, sand and detritus were also present which ranged from 4.5 to 31.0% during the course of investigation (Table 2).

Quantitative trophic dynamics

Analyses of quantitative trophic dynamics in *B. bendelisis* may be expressed in terms of seasonal variations in mean fullness index (MFI) of the stomach, condition of feed and gastro-somatic index (GSI).

(a) Seasonal variation in M. F. I.: Mean stomach fullness index (MFI) by season and size class in male and female *B. bendelisis* has been shown

Table 3. Seasonal variations in mean stomach fullness index (MFI) in *H. bendolius* in different size groups
(No. of stomachs is given in Parenthesis)

Season	Female fish					All sizes
	≤ 70 mm	70.1-90 mm	90.1-110 mm	110.1-130 mm	> 150 mm	
Winter	4.57 (42)	4.28 (43)	6.15 (27)	6.10 (18)	6.26 (12)	5.47 (142)
Summer	4.25 (17)	4.03 (21)	2.12 (79)	2.34 (24)	2.19 (38)	2.98 (179)
Rainy	2.12 (25)	2.26 (28)	1.56 (40)	1.72 (11)	1.64 (5)	1.86 (109)
Year	3.65 (12)	3.52 (92)	3.28 (146)	3.39 (53)	3.36 (55)	3.44 (474)
				Male fish		
Winter	5.02 (33)	4.98 (22)	4.86 (38)	6.48 (19)	6.30 (17)	5.53 (129)
Summer	4.78 (17)	4.67 (27)	4.58 (36)	2.19 (78)	2.40 (64)	3.72 (222)
Rainy	2.30 (11)	2.17 (33)	2.31 (45)	1.86 (80)	1.81 (56)	2.09 (225)
Year	4.03 (61)	3.94 (82)	3.91 (119)	3.51 (177)	3.50 (137)	3.78 (576)

Table 4. Condition of feed during the various months in *B. bendelisis* from fluvial system of the Upper Ganges of Central Himalayas

Month	No. of specimens examined	Poor (%)	Rating Moderate (%)	Active (%)
January	27	21.45	31.70	48.85
February	28	34.85	27.97	37.18
March	32	55.15	23.39	21.46
April	24	51.26	23.69	25.15
May	26	11.81	16.73	71.46
June	29	19.76	22.14	58.10
July	34	38.46	34.76	26.78
August	21	52.18	30.67	17.15
September	23	48.46	31.42	20.12
October	18	14.13	30.82	65.05
November	27	17.25	31.32	51.43
December	25	10.56	20.19	69.25

in Table 3. The observations on seasonal variations in MFI of the fish revealed that the value of MFI of female fish was highest ($\bar{x} = 6.15$) during winter months in the size range of 90.1 – 110 mm, while in male fishes the highest value ($\bar{x} = 8.48$) was in the same season, but in different size range (110.1 – 130 mm).

The feeding intensity expressed in terms of MFI, started declining sharply in summer and rainy season in the size range of 90.1 – 110 mm in females, while it started declining in same seasons but in size range of 110.1–130 mm in males (Table 3). During this period of slackness in feeding the most of the sampled fishes were represented by gravid females and ripe males.

(b) Condition of feed: The quantitative variation in the feeding were further examined based on the condition of feed (Table 4). In the month of February, on the onset of summer, fishes (male and female both) were found to start declining in feeding activity and the trend showed further decrease in March. During this period most of the fishes were poorly feeding. In the month of May a spurt in the actively feeding fishes was recorded and continued upto June, but after it a declining gap was observed during the months of August and September. During the period of poorly fed fishes, large number of gravid females and ripe males were encountered in the sample, which is in close correlation with the variations in MFI.

Again, when winter season starts in the month of October, the fish started feeding actively and it continued upto the month of January.

(c) Variations in G. S. I.: Monthly variation in the quantity of food taken by the fish, *B. bendelisis* was also examined in terms of variations in gastro-somatic index (GSI), which is depicted in Table 5 and Fig. 2.

An analysis of monthly variation in gastro-somatic index (GSI) of the fish revealed that the feeding intensity in both male and female attains two peaks during a span of one year. The first peak was observed in the month of May (3.254 ± 0.1050) and then the second in December (2.805 ± 0.1005), correspondingly two falls have also been recorded once during March (1.450 ± 0.0325) and then again in August (0.985 ± 0.0210) (Table 5 and Fig. 2).

Table 5. Monthly variations in the values of GSI and RLG in *Barilius bendelisis*

Months	No. of specimens examined	GSI	RLG
		Mean \pm SD	Mean \pm SD
January	35	2.105 \pm 0.0915	1.725 \pm 0.0450
February	23	1.820 \pm 0.0520	1.525 \pm 0.0410
March	27	1.450 \pm 0.0325	1.205 \pm 0.0285
April	32	1.850 \pm 0.0485	1.125 \pm 0.0220
May	25	3.254 \pm 0.1050	1.115 \pm 0.0205
June	25	2.895 \pm 0.0945	1.120 \pm 0.0235
July	18	1.210 \pm 0.0225	1.110 \pm 0.0185
August	20	0.985 \pm 0.0210	1.115 \pm 0.0198
September	25	1.250 \pm 0.0245	1.540 \pm 0.0250
October	28	1.750 \pm 0.0480	1.650 \pm 0.0270
November	26	2.505 \pm 0.0925	1.705 \pm 0.0425
December	30	2.805 \pm 0.1005	1.825 \pm 0.0455

Relative length of the gut

The relative length of the gut (RLG) varied from 1.110 ± 0.0185 to 1.825 ± 0.0455 in *B. bendelisis* (Table 5) depending on the somatic size of the fish. The alimentary tract of the fish is longer than its body length. A true stomach is absent and a sac like structure called the 'intestinal bulb' of the intestinal part is formed in place of stomach for accommodating more food. The opening of the bile duct is at $\frac{1}{2}$ length posteriorly from the junction of oesophagus and 'intestinal bulb'.

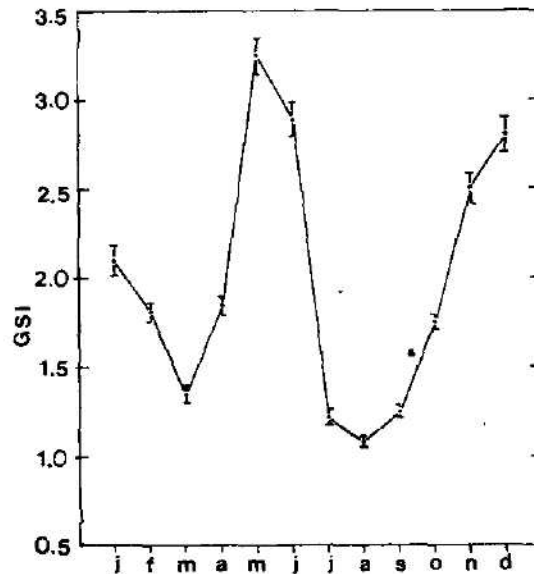


Fig. 2. Seasonal variations in GSI of *B. bendelisis* (Hamilton).

DISCUSSION

Nikolsky (1963) classified the food of a fish into basic food, secondary food, incidental food and obligatory food. The basic food of the fish, *B. bendelisis* was observed as nymphal or larval stages and somatic parts of the insects ($\bar{x} = 14.92\%$), crustaceans and their larvae ($\bar{x} = 12.04\%$), other food including fish matter and pieces of molluscan shells ($\bar{x} = 12.20\%$) and algae ($\bar{x} = 18.17\%$), which formed the major bulk of the fish diet. The protozoans and rotifers ($\bar{x} = 8.96\%$) and diatoms ($\bar{x} = 9.17\%$) comprise the secondary food which were found frequently but in less amount (Table 2). Sand and detritus contributed as incidental food as it enters into the gut incidently through water current.

The fragments of macrophytes, formed the obligatory food for the fish in absence or scarcity of basic food in the habitat. Thus, it appears that fish does not resort to feeding only on one type of food and seems to be dependent more on availability of particular food in the environment.

Nikolsky (1963) also classified the fishes into euryphagic, stenophagic and monophagic on the basis of range of diversity of the food they consumed. On the basis of the observations on the qualitative trophic analysis of fish diet it may be inferred that the *B. bendelisis* is a euryphagic omnivorous. The present inference confirms the observations made by Badola and Singh (1980).

Das and Moitra (1955, 1963) divided fishes into surface feeders, column feeders and bottom feeders on the basis of water column stratification in which fish dwells. As the fish, *B. bendelisis* dwells on the surface of the water of high altitude streams of the upper Ganges of Central Himalayas, may be called as surface feeder.

On the basis of a qualitative analysis of fish diet of an allied species, *Basilichthys (Opasarius) bola* (Hamilton) Kulkarni and Ogale (1978) reported that the *B. bola* is a carnivorous and largely a piscivorous form, rejecting all inanimate food in the natural environment. Singh and Bahuguna (1984) opined that *B. vagra* (Hamilton) is an omnivorous surface feeder. Intraspecific variations in the food constituents under varying ecological conditions are already known (Moitra 1956) in view of which the differences in the feeding of *B. bendelisis* (Hamilton), *B. bola* (Hamilton) and *B. vagra* (Hamilton) seem to be understandable.

True stomach has been reported to be absent in omnivorous fishes (Kapoor 1957). Das and Pathani (1978) have pointed out that the position of bile is an important criterion in deciding whether the fish has intestinal bulb or stomach and also the food of the fish. They observed that in *T. punitora* (omnivore), the opening of the bile duct is at $\frac{1}{3}$ length posteriorly from the junction of oesophagus and intestinal bulb. But with more and more carnivorous diet the bile duct opening is shifted towards the end of the sac (stomach). The present observations on *B. bendelisis* supports the view of Das and Pathani (1978).

Analyses of quantitative trophic dynamics expressed in terms of gastro-somatic index (Table 5 and Fig. 2) revealed that the feeding intensity attained two peaks during a span of one year, first to be in the month of May and second to be in December. This change in feeding intensity appears to be correlated mainly with the availability of food items in the natural environment vis a vis developmental condition of the gonads. The first peak in the

month of May, when fish feeds voraciously may be correlated with the post-spawning period of the fish which lends support from the observations of Malhotra (1967) made on *Botia birdi* Chaudhary. The second peak in the month of December may be well correlated with the availability of ample amount of food in the environment (Sharma 1984b).

The above fact of quantitative trophic variation and its correlation with the availability of food and breeding may be verified by the studies on seasonal variation in meanfullness index (MFI) by season and size class (Table 3). The peak in feeding intensity was observed in the winter months when food was available in ample amount in fish habitat (Sharma 1984b). The slackness in feeding was observed in summer and rainy season, which is correlated with the breeding period of the fish (A prolonged period of spawning in two successive phases: from March–April and August–September is reported, Sharma 1985).

An interesting fact is also emerged from the studies of MFI. A look at the Table 3 revealed that the female of *B. bendelisis* started slackness in the feeding intensity in summer and rainy season (breeding period) when it grows to the size of 90.1 – 110 mm after attaining the capacity to breed. On the other hand males attained the maturity in the size range of 110.1 – 130 mm, when the feeding activity declined considerably. Thus males attained maturity later than females.

The relationship between condition of feed (Table 4) and breeding in the fish, *B. bendelisis* deserves mention. During the periods of March–April and August–September majority of the fishes were found to spawn, accordingly they largely abstain from active feeding. However, during the months of May (postspawning of first phase) and October (post-spawning of second phase) most of the fishes (71.46 % and 65.05 %) feed actively. The present observation lends support of the observations made by Todd (1915) who associated the empty stomach of *Pleuronectes platessa* with advent of spawning. Homans and Vladikov (1954) have observed that haddock *Melanogrammus aeglefinus* ceases to take food during the spawning season, trying to regain the weight lost due to spawning.

The relative length of the gut (RLG) values of *B. bendelisis* varied from 1.110 ± 0.0185 to 1.825 ± 0.0455 . As the fish is an omnivorous, the length of its gut is short and is only equal to two times of its body length. This observation supports the view of Verighina and Medani (1968). The monthly variations in the RLG of the fish (Table 5) is due to an increase in the indigestible matter (Lange 1962) in the diet and on the conditions of food supply (Kapur et al. 1975).

SUMMARY

B. bendelisis (Hamilton) feeds on a wide spectrum of food, which shows that the fish is a versatile feeder utilizing favoured food when they are available and changes to others when occasion demands. However, relatively fish favours to feed on nymphal or larval stages of insects, fish matter, crustaceans and their larvae and algal food available in the high altitude fluvial system of Ganges of Central Himalayas.

The fish feeds voraciously during postspawning period to regain the weight lost during spawning. This feeding activity is enhanced when food is available

in ample amount in fish habitat. The fishes cease to feed or abstain from active feeding during the period of spawning.

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REVIEWS — RECENSE

Adiyodi, K. G., Adiyodi, R. G. (eds.): *Reproductive Biology of Invertebrates*. I. Oogenesis, Oviposition, and Oosorption; II. Spermatogenesis and sperm function. John Wiley Sons, New York, 1984, xxv + 770 and xxv + 692 pp.

The study of invertebrate reproductive biology has made steady progress and has experienced considerable growth in the past decades. Although the invertebrates surpassed not only in most of recent animal species (as many as 95%) but also in the diversity of structure, reproductive biology, development and sexual behaviour there was now comprehensive summarizing treatment of this topic in the biological literature.

The present multi-author compendium fills this gap bringing a synthesis of different knowledge. Volume I deals with female reproductive system including the structure and ultrastructure of ovaries, maturation of oocytes, origin of germ and follicular cells, ovulation, and oosorption; Volume II is devoted to male reproductive system (origin, development, germ cells, spermatogenesis, spermateliosis, spawning, and ultrastructure and physiology of spermatozoa). These volumes are arranged into 28 (or 30, respectively) chapters elaborated primarily on a phylum basis. Both female and male reproductive organs and gametogenesis of most phyla included are demonstrated on several genera representing a model object for respective group.

Indeed the work on this topic has generated a considerable number of individual results as seen also from thousands of selected references. Really up-to-date and mostly very detailed data on individual selected species are accompanied by excellent electronmicrographs (an attention is paid also to subcellular structures) and schematic drawings. In some cases, very specialized techniques have been used (ultrahistochemistry, study of cell lineages, radioassays and others).

The two-part volume is written by 54 contributors which represent the outstanding experts in invertebrate reproductive biology. Naturally, individual contributions vary from a mere compilation to elaboration of the respective group based on unpublished, original data. Moreover, there is a great unevenness in our knowledge on reproduction of individual invertebrate groups, reproduction of some phyla such as the Kinorhyncha and Nematomorpha is poorly known. That is why some groups (e. g. crustaceans, molluscs, polychaete annelids and echinoderms) are elaborated in more detail than the others. Unfortunately some groups (e. g. insects) are not included in this treatment at all.

There is hardly any need to emphasize how useful is this volume for invertebrate zoologists including not only students and research workers in systematic and/or evolutionary zoological disciplines but also specialists in respective animal phyla.

T. Šolín

Abou-Halawa, S.: Detailed morphological studies on the H-organ in the larvae of *G. mellonella*, I. The anatomy of the organ

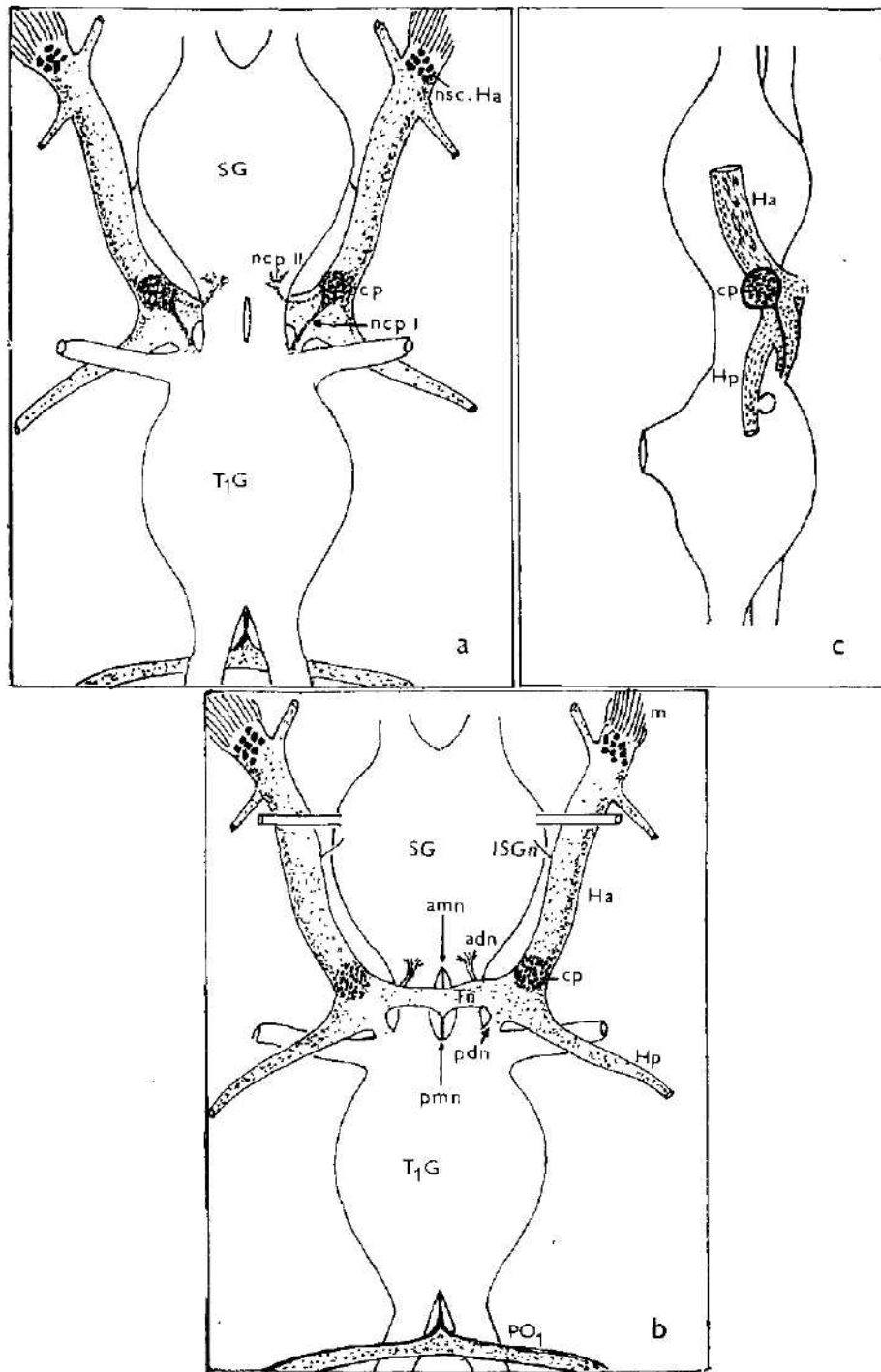


Fig. 1. Diagrammatic representation for the anatomy of H-organ in the larvae of *Galleria*; a — dorsal view, b — ventral view, c — lateral view (right side).

Abou-Halawa, S.: Detailed morphological studies on the H-organ in the larvae of *G. mellonella*, I. The anatomy of the organ

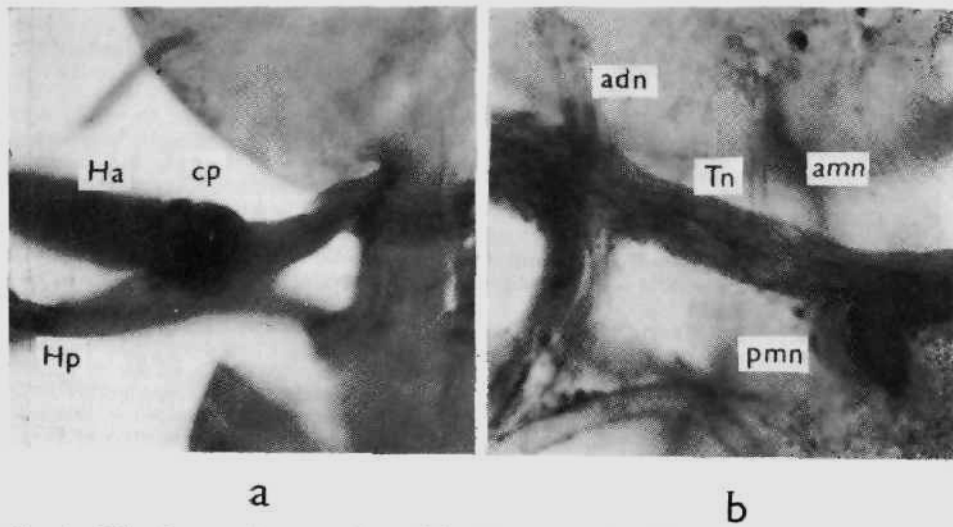


Fig. 2. Whole mount preparation of the H-organ stained by methylene blue (150X): a — ventral side to show the corpus prothoracale (cp), b — dorsal side to show the different nerves from both the SG and T₁G.

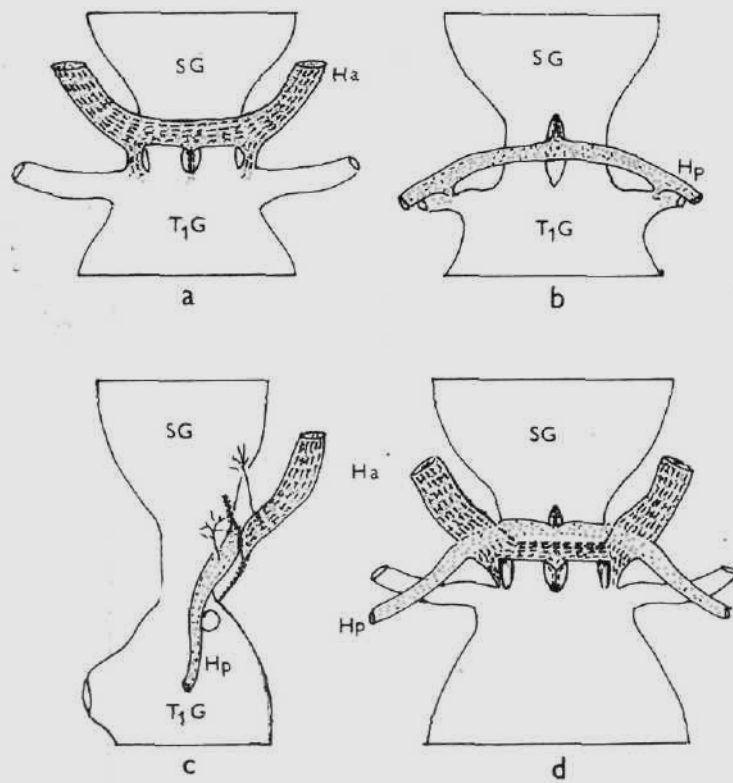


Fig. 3. Hypothetical diagrams: a — the PO of the T₁G, b — the PO of the SG, c — after their fusion in the middle part (lateral view), d — after their fusion in the middle part (dorsal view).

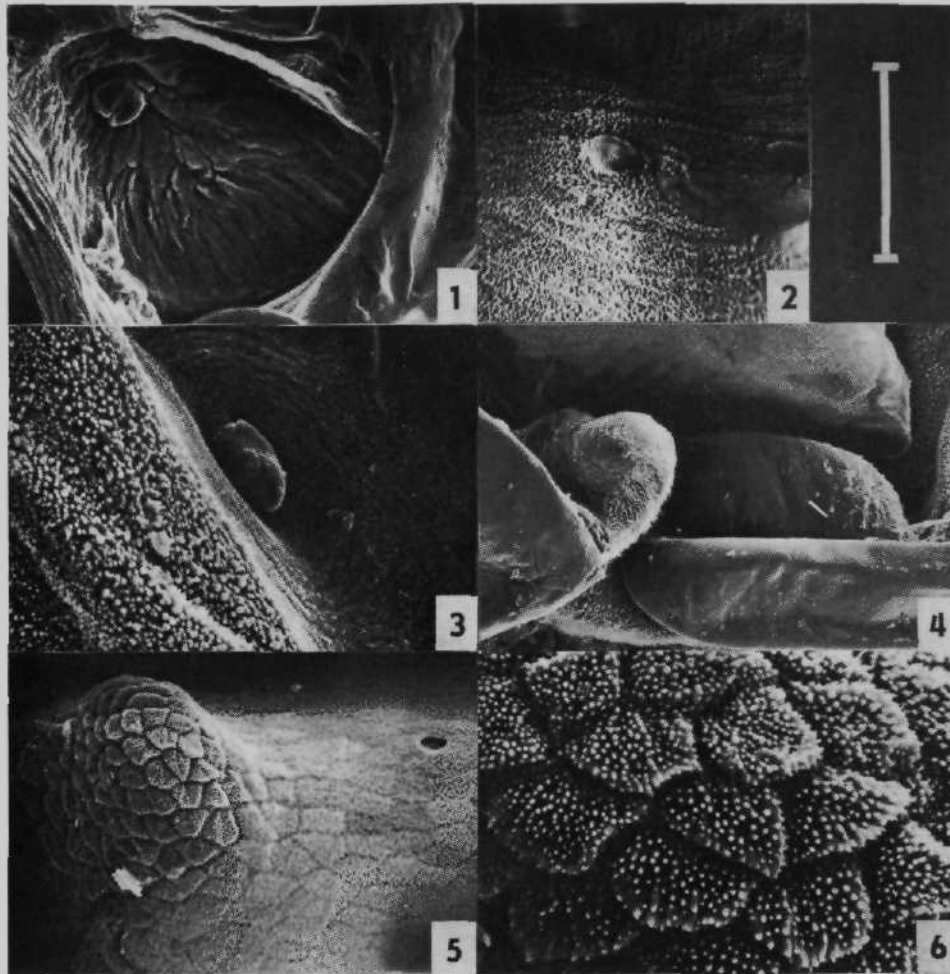


Plate I, Figs 1 — 6. *Plea minutissima* Leach. Fig. 1. Mesothoracic scolopophorous organ; ventrolateral view. (Scale = 0.057 mm). Fig. 2. Metathoracic scolopophorous organ; dorsolateral view. (Scale = 0.046 mm). Fig. 3. Scolopophorous organ of the 1st abdominal segment; anterolateral view. (Scale = 0.034 mm). Fig. 4. Wing-anchoring knob of the posterior corner of mesepimeral supracoxal lobe and wing-anchoring knob of anterior projection of the 2nd abdominal segment; anterolateral view. (Scale = 0.076 mm). Fig. 5. Wing-anchoring knob of metepimeron; lateral view. (Scale = 0.055 mm). Fig. 6. External surface of metepimeral wing-anchoring knob; lateral view. (Scale = 0.007 mm).

POKYNY PRO AUTORY

Věstník Československé společnosti zoologické uveřejňuje původní vědecké práce členů společnosti v rozsahu nejvýše 30 stran rukopisu, napsané v některé z kongresových řečí, a dále články, hodnotící životní dílo našich zoologů, vyžádané redakcí. Práce autorů, kteří nejsou členy společnosti, budou přijímány jen výjimečně.

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Hlavička práce. 1. Název pracoviště. 2. Název práce (u prací taxonomických v závorce za názvem systematické zařazení druhu nebo skupiny — např. Ostracoda: Cyprinidae), obojí v řeči, v níž je práce psána. 3. Jméno a příjmení autora.

Vlastní práce: 1. Velmi stručný abstrakt, v rozsahu nejvýše 15 řádek, v angličtině. 2. Úvod do problematiky (stručně). 3. Materiál a metodika (u známých metod pouze odkaz). 4. Vlastní část experimentální nebo popisná. 5. Diskuse. 6. Závěr. 7. Seznam citované literatury (nikoliv bibliografie!). 8. Adresa autora. 9. Tabulky, texty k obrázkům a grafům. Celý rukopis je průběžně stránkovan.

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Přepis cyrilice proveďte podle mezinárodních pravidel transliterace (nikoliv fonetické transkripce — viz ISO Recommendation R 9.. International system for the transliteration of cyrilic characters 1. Ed. October 1955 nebo Zekalle, R., 1964: *Pedobiologia*, 4: 88—91, Jena.

Obrázky a grafy kreslete černou tuší na kladívkový nebo pausovací papír v poměru 1:1 až maximálně 1:2, u taxonomických prací musí mít obrázky měřítko. Obrázky kreslete pokud možno tak, aby mohly být všechny stejným způsobem zmenšeny. Fotografie musí být ostré, kontrastní, na lesklém papíře. Obrázky sestavte do tabulí, které by bylo možno reprodukovat na šíři strany (126 mm), nebo s textem na celé zrcadlo (126 × 188 mm). Obrázky nebo obrazové tabule průběžně číslujte a v rukopise vyznačte místo, kam mají být zalomeny.

Tabulky jsou tištěny jako otevřené, tj. bez svislých linek. V tabulkách oddělte vodorovnými linkami jen záhlaví tabulky a dolní okraj. Tabulky protokolárního charakteru nebo opakující údaje z textu, případně tak velké, že by je nebylo možné vytisknout na dvě protilehlé strany, nebudou přijímány.

V taxonomických pracích dodržujte zásady, ustanovení a doporučení mezinárodních pravidel zoologické nomenklatury.

V rukopisu nepřepisujte zásadně žádné typy písma, označte pouze tužkou po straně části, které mají být vysazeny petitem.

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