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GYRODACTYLUS BARBI SP. N. (MONOGENOIDEA) FROM THE FINS OF BARBELS

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Abstract: A description is given of a new species of the genus *Gyrodactylus* Nordmann, 1832 — *G. barbi* — recovered from the fins of *Barbus barbus* (L.), *B. lacerta cyri* Filippi and *B. meridionalis petenyi* Heckel.

The species described herein was observed on the fins of the *Barbus barbus* (L.), *B. lacerta cyri* Filippi and *B. meridionalis petenyi* Heckel from various rivers in Czechoslovakia, USSR and Yugoslavia during the years 1961 to 1974. Hosts were collected with nets or electric shocker. Host preparation and methods concerning preparation, observation, measurement, illustration and description of the new species were employed as given by Ergens and Lom (1970).

Gyrodactylus barbi sp. n.

Host and locality: *Barbus barbus, B. lacerta cyri* and *B. meridionalis petenyi*; Rivers Želivka, Bečva, Teplá (Czechoslovakia), Lenkoranka (Azerbaijan SSR) and Orakhovstica (Yugoslavia).

Specimens studied: Fifteen.

The holotype is represented by a specimen collected on the *Barbus barbus* caught on May 17, 1966 in the River Želivka near Dolní Kralovice (Czechoslovakia). The measurements (in milimeters) of its hard parts of opisthaptor are given in parentheses in the description.

Type specimens (holotype and paratypes) are deposited in the collection of the Institute of Parasitology, Czechoslovak Academy of Sciences, Prague, Coll. No. 375.

Description: Total length of anchors 0.064—0.071 (0.064), shaft 0.045 to 0.053 (0.047), point 0.030—0.034 (0.030), root 0.020—0.024 (0.020). Ventral connecting bar with well-developed lateral processes and a membranous extension measuring 0.013—0.017 (0.016). Length of this bar 0.006—0.008 (0.007), width 0.026—0.035 (0.030). Dorsal connecting bar measures 0.002—0.004 × 0.019—0.023 (0.003 × 0.021). Total length of marginal hooks 0.028—0.033 (0.030), the hook proper measures 0.006—0.007 (0.006).

G. barbi sp. n. *has been placed in the species — group of G. scardinii* Malmberg, 1957. It most closely resembles *G. scardinii* and *G. gobiensis* Gläser, 1974, but differs from them in morphological details of marginal hooks.

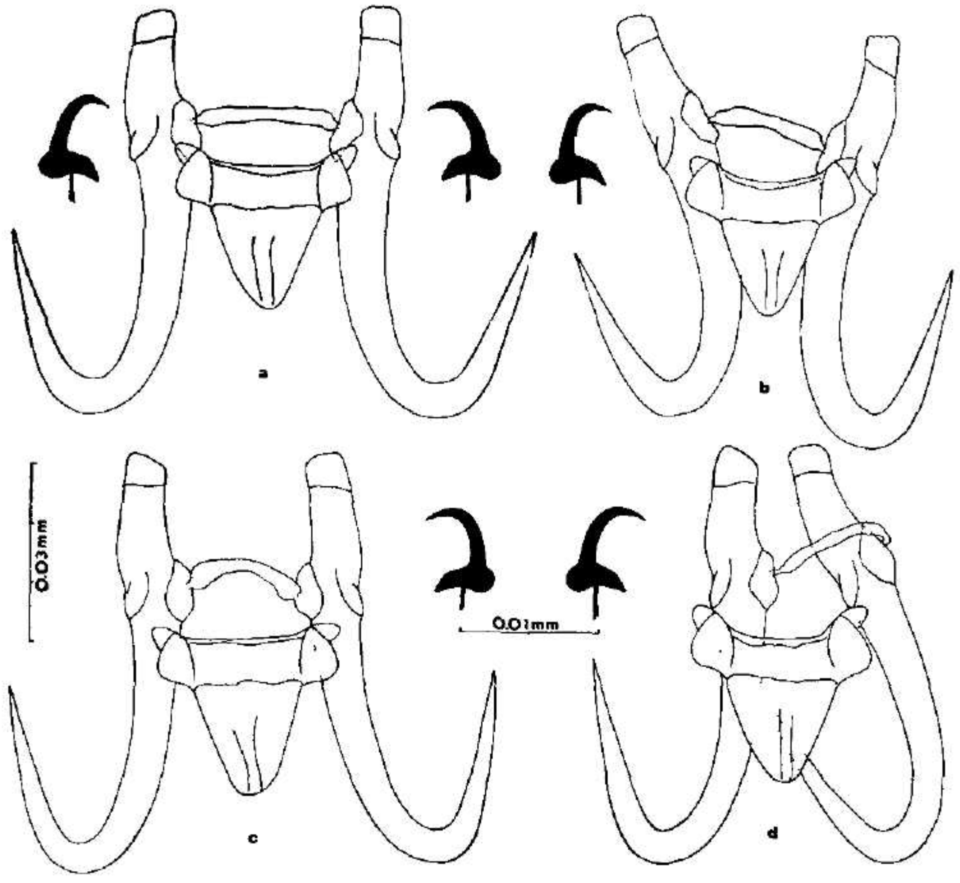

Fig. 1. Hard parts of the opisthaptor of *Gyrodactylus barbi* sp. n. a — holotype; b — paratype; c — specimen from *B. meridionalis petenyi*, River Orakhovstica (15. 7. 1970); d — specimen from *B. lacerta cyri*, River Lenkoranka (6. 4. 1974).

Acknowledgment

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ON THE OCCURRENCE OF BARBUS PLEBEJUS IN THE POPRAD RIVER (VISTULA BASIN, CZECHOSLOVAKIA) WITH REGARD TO ITS ASSUMED HYBRID ORIGIN

Ivan KRUPKA and Juraj HOLČÍK

Dedicated to Dr. S. Hrabě, Professor Emeritus of zoology, on the occasion of his 75th birthday

Received July 17, 1975

Abstract: The authors describe in detail 7 specimens of *Barbus plebejus* Bonaparte, 1832 from the Czechoslovak stretch of the Poprad river (Vistula basin). By comparing this species with sympatrically occurring *Barbus barbus* and *Barbus meridionalis petenyi* and with the data from literature they came to the conclusion that this fish is a valid species and not a hybrid between *B. barbus* and *B. meridionalis petenyi*. It is supposed that *B. plebejus*, which is a new species of fish for Czechoslovakia, occurs also in the rivers of the Danube basin.

INTRODUCTION

Numerous and from the systematic point of view very problematic cyprinoid genus *Barbus* Cuvier, 1817 is represented by two species in the basins of the rivers Danube, Vistula and Dniester. There are *Barbus barbus* (Linnaeus, 1758) and *Barbus meridionalis petenyi* Heckel, 1847,*) inhabiting sympatrically the upper and middle stretch of many rivers. Kux and Weisz (1958, 1964), Weisz and Kux (1962) and Dorko (1963) have found the hybrids between both species in the basins of the rivers Poprad, Tisa, Hron and Ipeľ respectively and Kux and Weisz (1958) gave also a short description of these hybrids. The same type of hybrid was found also by Rolik (1967) in the river San (Dniester river basin). Because the last author (Rolik, 1970) changed her opinion afterwards and claimed this hybrid to be a new subspecies *waleckii* of the species *Barbus cyclolepis* Heckel, 1840, the question of the systematic status of this form arose again. This question became more urgent after 1971, when M. Karaman published his revision of the genus *Barbus* from Europe, North Africa and Middle and Near East respectively and lumped together *B. cyclolepis*, *B. plebejus*, *B. prespensis*, *B. graecus*, *B. euboicus* and *B. ciscaucasicus* into one species *B. plebejus*. Therefore we welcomed the opportunity to investigate the few specimens of peculiar barb caught by the expedition of the Laboratory of Fishery Research and Hydrobiology led by Ing. A. Kirka CSc. on the Poprad river during the

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*) Starmach and Rosól (1961) claimed this form to be a valid species *B. petenyi*, whilst Karaman (1971) considers it to be only the more recent synonym of *B. peloponnesius* Cuvier & Valenciennes, 1842. We are holding here the opinion of Oliva and Chitravadivelu (1972) who proved this form to be the subspecies *petenyi* Heckel, 1847 of *B. meridionalis* Risso, 1826.

autumn of 1974. By comparing this form with *B. barbus* and *B. meridionalis petenyi* originating from the same river as well as with the data of literature we have come to conclusion that this form is different in many characters from other two coinhabiting species. With regard to the paper of M. Karaman (l.c.) we indicate this form to be *Barbus plebejus* Bonaparte, 1832. The purpose of this paper is to describe this form and discuss the problem of its assumed hybrid origin between *B. barbus* and *B. meridionalis petenyi*.

MATERIAL AND METHOD

In the stretch of the river Poprad between the village Podolínec and the leaving of Czechoslovak borders there were caught 492 specimens of *B. barbus*, 285 specimens of *B. meridionalis petenyi* and 7 specimens of *B. plebejus*. The latter species was taken from the following localities (number of specimens in brackets): Poprad river above Medzibrodie (1), below Sulín (1), at Hniezdne (2) and at Mníšek (3). The fish were caught by electroshocking machine (300 V, 3 A) and fixed on the spot by 4% solution of formaline, then put into 50% alcohol and deposited in the collection of the institute.

Biometrical analysis was made by the standard technique. The sex of fish was determined by dissection. From the key scales taken out from the first row of scales above the base of pelvics dry mountings were made for counting of scale radii and measuring the length of the oral, lateral and caudal radii, respectively. The measurements found after calculations into per cents (in scales the ratio of the lateral and caudal radius to the oral one was calculated) are summarized in tables only as to the simple arithmetical average along with the empirical range. Ten specimens of *B. barbus* and *B. meridionalis petenyi* each, taken in the Poprad river atHniezdne have been used for comparison. Also these were biometrically treated and the values found were used for calculation of the hybrid index according to Hubbs and Kuronuma (1942). This index has been estimated only at such values where the difference between the average of the measurements was 1% at least. In counts the hybrid index was calculated only for the number of scales in lateral line and number of gill rakers on the outside of the first gill arch, respectively, because of no differences in other features of compared species.

RESULTS

Description of *Barbus plebejus* from the Poprad river (Fig. 1 and 2): D III (IV) (7) 8, A III 5, P I (14) 15, V II 8, lateral line (53) 61 $\frac{11-13}{7-9}$ 65 (68), gill rakers on the outside of first gill arch 10—12, pharyngeal teeth 2.3.5—5.3.2. Ratio of the lateral and caudal radius of scale to the oral one 1.0 and 1.9 : 1.0 respectively, number of radii on scales 49—62 (54.1 in average). The last spine of the dorsal fin weak, moderately ossified with fine serration sharing about 2/3 of its total length (Fig. 2). Lower lips fleshy, with well developed lobes, moderately furrowed or smooth. The middle lobe exceeds 1/3 of the length of the adjacent lobes, it is rounded or pointed. Barbs smooth, the first pair is short and only exceptionally reaches the front of nostrils, the second pair exceeds the middle of eyes. The back between the head and base of dorsal fin arched, forming a blunt keel in front of that fin. The front of the base of pelvics exactly below the front of dorsal fine base or, sometimes, slightly behind it. The edge of the dorsal fin moderately concave, S shaped. The upper lobe of the caudal fin longer and more pointed than the lower one. Back darkly gray, sides light brown, belly yellowish-white. Sides display dark blotches with dissolved edges. Expressive pigmentation in the form of small dense dark spots reaches the line between P—V and V—A. Dorsal fin greyish, with dark spots, anal fin yellowish, occasionally with spots, pectorals and pelvics yellowish with orange tinge of their edges, similarly as in the lower edge of the caudal fin. Well developed sexual di-

Table 1. Counts and measurements of *Barbus plebejus* from the Poprad river

No. Coll.	1	2	3	4	5	6	7
longitudo corporis	206.0	212.0	223.0	211.0	212.7	208.0	195.0
pondus in g	158.0	192.0	183.0	164.0	170.0	167.0	134.0
sex	♂	♂	♂	♂	♂	♀	♂
radii D	III/8	III/8	III/8	III/8	IV/7	III/8	III/8
radii A	III/5	III/5	III/5	III/5	III/5	III/5	III/5
radii P	I/15	I/15	I/15	I/15	I/15	I/14	I/15
radii V	II/8	II/8	II/8	II/8	II/8	II/8	II/8
squamae linea lateralis	53	68	63	61	62	63	65
squamae linea transversalis	12/8	13/8	11/8	12/8	11/7	12/9	12/8
num. spin. branchialium	11	12	12	10	11	10	10
ossa phar. *inferior*	2–3–5 5–3–2	2–3–5 5–3–2	2–3–5 5–3–2	2–3–5 5–3–2	2–3–5 5–3–2	2–3–5 5–3–2	2–3–5 5–3–2
in % longitudo corporis							
longitudo capitis	27.4	24.6	25.5	25.4	25.9	27.3	25.9
distantia praeorbitalis	12.7	12.3	12.9	12.7	12.7	13.6	13.3
longitudo cirri I	5.9	5.0	4.8	5.9	5.6	4.4	4.9
longitudo cirri II	7.3	7.0	6.6	8.1	6.8	7.9	6.6
distantia inter for. nasalia	4.3	4.3	4.3	4.0	4.9	5.1	4.9
diameter oculi	3.2	3.2	3.1	3.4	3.4	3.3	3.3
distantia inter oculos	7.1	6.6	7.3	6.3	7.2	7.7	6.7
distantia postorbitalis	11.2	10.6	11.5	10.7	11.1	11.2	10.3
altitudo capitis	14.6	14.6	14.9	14.9	14.5	15.6	14.1
latitudo capitis	15.7	15.2	15.4	14.9	14.9	16.1	14.6
distantia praedorsalis	52.2	52.5	53.5	53.2	52.3	54.1	52.4
distantia praeventralis	53.9	54.8	54.9	54.5	55.2	56.6	54.2
distantia praeanalis	77.3	76.6	74.9	76.1	78.0	78.3	77.3
altitudo corporis	20.8	21.7	19.8	20.9	20.8	21.3	21.3
latitudo corporis	15.8	17.1	14.3	14.5	15.0	15.6	16.4
longitudo pedunculi caudae	17.1	19.3	18.8	18.0	17.6	16.0	18.8
altitudo pedunculi caudae	11.5	12.0	11.1	11.3	10.8	10.6	11.0
latitudo pedunculi caudae	8.8	8.4	8.1	7.8	8.2	7.0	9.5
minima altitudo corporis	9.6	9.8	9.4	9.4	9.5	9.7	9.3
distantia P – V	27.7	33.0	29.8	31.3	31.6	29.9	31.5
distantia V – A	23.9	23.7	23.8	22.0	23.3	22.0	24.1
longitudo D	13.0	13.0	12.6	12.6	11.1	13.0	12.1
longitudo A	7.7	7.1	7.7	7.1	7.5	6.7	7.2
longitudo C I	20.6	27.4	20.6	21.3	22 8	22.4	21.5
longitudo C II	20.2	21.5	19.6	20.1	21.2	21.6	20.1
longitudo P	16.6	16.8	16.6	16.7	17.8	17.4	15.9
longitudo V	14.3	13.8	14.0	14.1	15.3	14.0	14.4
altitudo D	16.0	17.5	18.4	18.1	18.8	18.0	18.2
altitudo A	15.1	16.0	15.5	13.7	16.1	18.8	14.8
in % longitudo capitis							
distantia praeorbitalis	46.4	49.8	50.7	50.0	48.9	49.4	51.5
longitudo cirri I	21,6	20,1	18,8	23,3	21,5	16,1	18,8
longitudo cirri II	26.6	28.5	28.1	31.7	26.4	29.1	25.4
distantia inter for. nasalia	15.6	17.6	16.7	15.9	19.1	18.5	18.8
diameter oculi	11.5	13.0	12.3	13.3	13.1	12.0	12.9

Table 1 (Continued)

No. Coll.	1	2	3	4	5	6	7
distantia inter oculos	25.8	26.8	28.5	24.6	27.6	28.2	25.7
distantia postorbitalis	40.7	43.1	45.1	42.2	42.7	40.9	39.6
altitudo capitis	53.1	59.4	58.5	58.8	56.0	57.1	54.5
latitudo capitis	57.2	61.7	60.2	58.8	57.8	59.1	56.4
in % longitudo pedunculi caudae							
altitudo pedunculi caudae	66.8	62.2	59.1	62.6	61.3	66.3	58.7
latitudo pedunculi caudae	51.4	43.4	42.9	43.4	46.7	43.7	50.6
minima altitudo corporis	*56.3*	*50.5*	*50.0*	*52.1*	*53.9*	*60.5*	49.7
in % distantia P—V							
longitudo P	60.0	50.7	55.6	53.3	56.3	58.2	50.4
in % distantia V—A							
longitudo V	59.8	58.2	58.7	64.1	65.7	63.8	59.6

morphism — females display a deep anal fin which reaches or exceeds the base of the caudal fin. The counts and measurements are summarized in Tab. 1.

Eleven out of 29 measurements of *B. plebejus* show different values whilst others display more or less intermediate position between *B. barbus* and *B. meridionalis petenyi* from the same river (Tab. 2). The most characteristic features by means of which *B. plebejus* from the Poprad river differs from *B. barbus* and *B. meridionalis petenyi* respectively are summarized in Tab. 3, and comparison based on the calculated hybrid indices is in Tab. 4. In the latter one also the hybrid indices calculated for "hybrids" between *B. barbus* and *B. meridionalis petenyi* from the Topľa river are introduced, based on values in Tab. 7 from the paper of Kux and Weisz (1958). From the results clearly follows the distinct position of *B. plebejus* and also the remarkable variability of all three species. It is noteworthy that the assumed hybrid from the Topľa river is practically identical with *B. plebejus* from the Poprad river in spite of some differences in particular features, which can be ascribed to the relatively small size of fish from this river. The grand average of hybrid index for these "hybrids" is almost the same as that from population of *B. plebejus* from the Poprad river. Typical features characteristic of *B. plebejus* from the Poprad river are more scales in the lateral line, relatively weak last spine of the dorsal fin showing fine and uncomplete serration, moderately concave edge of the dorsal fin, position of the front of pelvics base which lies under the front of dorsal fin base, colouration characterized by shifting of pigmentation of sides on the line between P—V and V—A and partly keeled back.

To which extent the population from the Poprad river is related to *B. plebejus* one can judge from the following shortened description of this species according to M. Karaman (1971, p. 199—200 — in free translation):

Barbus plebejus Bonaparte, 1832

D IV 8, A III 5, lin. lat. 49—82, gill rakers 6—11. Body moderately low and prolonged. Maximal body depth 16.7—29.4 % and head depth 22.2—30.3 % in standard length.*) Back in front of the dorsal fin moderately arched, more or less rounded, frequently keelless. In some subspecies (*escherichi*, *strumicae*, *plebejus*) slight keel. Head prolonged, its depth 52.6—66.7, and width 41.7—62.5 % of the head length. The head mostly moderately pointed, in some subspecies blunt (*plebejus*, *pergamonensis*) or rostrated (*strumicae*, *cyclolepis*, *ciscaucasicus*). The nose moderately long 37.0—47.6 % of the length. Diameter of eye 12.0—20.0 % of the head length. Mouth inferior, horseshoe-shaped, lips well developed and fleshy. Populations from the western part of area show better developed lips, regularly with well developed middle lobe, whilst in the eastern populations lips are frequently thin and without the middle lobe. The length of the first pair of barbs 13.3—32.3 % and the second one 20.8—45.5 % of the head length. Dorsal fin usually with straight, but in some populations (*cyclolepis*, *escherichi*) with moderately concave, edge. Its length is 11.1—16.7 % and its depth 15.4—25.0 % of the standard length. Last spine in the dorsal fin moderately or weakly ossified, with small serrae on its rear edge. Serrations reach 1/3—3/4 of the total length of this spine. Number of gill rakers varies from 6 to 11, mostly from 7 to 9. Number of scales in lateral line 49—82, mostly 52—76; this character is a good distinstive feature of the particular subspecies. Body colouration very variable, however the presence of numerous dark spots on the dorsal side of the body is typical. This character is contrast in *B. plebejus*, while in *B. barbus* only the juveniles show the spots.

As it can be seen, the population from the Poprad river is identical with *B. plebejus*. There are only very slight and negligible differences in some measurements (some longer snout and smaller eye). A very close similarity can be seen also when the values introduced by Pešev (1971) for the barb population inhabiting the Bulgarian rivers flowing into the Black Sea and even in features not mentioned by M. Karaman (l.c.) are compared.**) There are the position of barbs against the nostrils and eyes, and number of radii on scales. According to Pešev (l.c.) the first pair of barbs only rarely reaches the nostrils and the second one mostly exceeds the centre of the eye. The number of scale radii in Bulgarian populations from the Kamchia river varied from 30 to 74 with 54.1 in average.

We leave the question of the subspecific status of *B. plebejus* from the Poprad river open. It is necessary to note, however, that as it follows from the description of particular subspecies given by M. Karaman (l.c.), Rolik (1970) and Stephanidis (1971) the variation of the particular features is too big and overlapping too extensive to prove an actual existence of the majority of them, mainly if 75 % rule should be used. This can be seen from Tab. 5, where particular subspecies of *B. plebejus* are chronologically arranged along with their most important features and data on their area of distribution. M. Karaman (l.c.) writes e.g., that scales in the lateral line are of primary importance to distinguish subspecies, but also this character in most populations strongly overlaps, as one can see in Tab. 5.

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*. All proportionate measurements recalculated from values given by M. Karaman (l.c.) who writes on the ratio of particular body proportions to standard length.

**) Pešev (l.c.) suggested this form to be very close to *B. tauricus* Kessler, 1877 which, according to M. Karaman (l.c.) is only a subspecies of *B. plebejus*.

Table 2. Counts and measurements of ***Barbus barbus*, *Barbus meridionalis petenyi*** and 2 semples of ***Barbus plebejus***

Locality	Poprad river									Marica river		
Species	*Barbus barbus*			*Barbus meridionalis petenyi*			*Barbus plebejus*			*Barbus plebejus*		
	x̄	min.	max.	x̄	min.	max.	x̄	min.	max.	x̄	min.	max.
longitudo corporis in mm	242.6	187.0	303.3	175.1	172.2	181.0	209.7	195.0	223.0	121.0	100.0	142.0
pondus in g	265.7	134.0	490.0	105.0	88.0	122.0	166.9	134.0	192.0	29.0	18.0	40.0
radii D	8.0	8	8	8.2	8	9	7.9	7	8	8.0	8	8
radii A	5.0	5	55	5.0	5	5	5.0	5	5	5.0	5	5
radii P	13.6	12	15	13.5	13	15	14.9	14	15	13.0	13	13
radii V	8.0	8	8	7.1	7	8	8.0	8	8	8.0	8	8
squamae linea lateralis	58.8	55	61	55.5	51	60	62.1	53	68	67.0	66	68
squamae linea transversalis	12/7	12/7	12/7	10/8	10/7	12/9	12/8	12/8	12/8	13/8	12/8	13/8
num. spin. branchialium	11.6	10	13	8.8	8	10	10.7	10	12	8.5	8	9
ossa phar. inferior		2—3—5 5—3—2			2—3—5 5—3—2			2—3—5 5—3—2			2—3—5 5—3—2	
in % longitudo corporis												
longitudo capitis	26.1	24.5	29.1	26.1	25.6	27.2	26.0	24.6	27.4	25.3	24.7	26.0
distantia praeorbitalis	12.8	12.4	13.3	12.4	11.9	13.2	12.9	12.3	13.5	11.6	11.5	11.6
longitudo cirri I	5.5	5.0	5.8	5.1	4.4	6.1	5.2	4.4	5.9	6.3	5.8	6.8
longitudo cirri II	7.0	6.5	7.4	7.5	6.7	8.7	7.2	6.6	8.1	7.9	7.8	8.0
distantia inter. for. nasalia	4.7	3.7	5.4	5.0	4.4	5.5	4.5	4.0	5.1	4.1	3.6	4.5
diameter oculi	3.6	3.1	4.0	3.6	3.2	4.3	3.3	3.1	3.4	4.1	3.6	4.5
distantia inter oculos	7.6	6.7	8.4	7.1	6.4	7.8	6.7	6.3	7.7	6.2	5.9	6.5
distantia postorbitalis	11.1	10.2	13.2	10.7	10.1	11.3	10.9	10.3	11.5	10 7	10.6	10.8
altitudo capitis	15.2	14.4	15.6	15.4	14.3	16.5	14.7	14.1	15.6	14.2	13.7	14.6
latitudo capitis	15.0	14.2	16.3	15.8	15.0	17.0	15.3	14.6	16.1	14.5	14.2	14.8
distantia praedorsalis	53 3	51.5	57.3	52.0	49.8	53.4	52.9	52.2	54.1	50.4	49.4	51.5
distantia praeventralis	53.2	52.0	54.9	56.3	53.3	57.9	54.9	53.9	56.6	50.6	49.3	51.8
distantia praeanalis	75.7	74.3	77.0	77.7	73.9	80.8	78.6	76.1	86.5	72.5	72.0	73.0
altitudo corporis	21.7	18.9	23.3	20.7	19.2	22.4	20.9	19.7	21.7	18.9	18.3	19.5
latitudo corporis	16.1	15.0	17.3	16.2	14.7	18.1	15.5	14.3	17.1	13.9	13.5	14.1
longitudo ped. caudae	19.4	18.2	20.5	17.6	16.4	19.2	18.0	16.0	19.3	21.0	20.8	21.2
altitudo ped. caudae	12.4	11.0	13.9	10.4	9.9	11.0	11.2	10.6	12.0	10.5	9.9	11.0
latitudo ped. caudae	8.1	7.4	9.5	8.6	8.0	9.7	8.3	7.0	9.5	7.3	6.7	7.8

minima altitudo corporis	10.3	9.7	10.8	8.6	7.9	9.3	9.5	9.3	9.8	9.1	8.1	10.0
distantia P–V	29.2	27.9	30.3	31.5	29.7	33.6	30.7	27.7	33.0	27.1	27.0	27.2
distantia V–A	24.3	22.7	26.3	22.8	22.0	24.1	23.3	22.0	24.1	24.3	23.0	25.6
longitudo D	12.6	12.0	13.2	13.1	12.1	14.0	12.5	11.1	13.0	13.9	13.0	14.8
longitudo A	7.7	7.1	8.2	7.9	7.5	9.1	7.3	6.7	7.7	8.7	8.0	9.3
longitudo C I	26.2	21.9	29.7	21.8	19.4	22.9	22.4	20.6	27.4	21.5	19.0	24.0
longitudo C II	23.1	21.0	26.3	20.5	18.0	22.5	20.6	19.6	21.6	20.8	19.0	22.5
longitudo P	18.6	17.7	19.5	16.6	15.7	18.1	16.8	15.9	17.8	18.1	17.2	19.0
longitudo V	15.8	15.0	17.3	13.0	11.3	14.3	14.3	13.8	15.3	15.5	14.7	16.3
altitudo D	22.7	20.8	24.7	17.0	15.8	18.2	17.9	16.0	18.8	18.2	17.8	18.5
altitudo A	16.9	15.3	19.4	21.7	19.7	23.2	15.7	13.7	18.8	19.5	17.0	21.9
in % longitudo capitis												
distantia praeorbitalis	49.2	43.9	51.5	47.5	46.6	48.7	49.5	46.4	51.5	45.7	44.2	47.1
longitudo cirri I	21.1	19.0	23.7	19.5	17.2	22.4	20.0	16.1	23.3	25.1	22.3	27.7
longitudo cirri II	26.8	24.7	29.2	28.8	26.3	31.0	27.7	25.4	31.7	31.2	30.8	31.7
distantia inter for. nasalia	18.1	14.5	20.7	19.3	17.0	20.7	17.5	15.6	19.1	15.9	14.6	17.3
diameter oculi	13.8	12.0	15.4	13.9	12.4	16.2	12.6	11.5	13.1	15.9	14.6	17.3
distantia inter oculos	29.1	23.0	34.2	27.1	24.2	29.0	26.8	24.6	28.5	24.4	23.7	25.0
distantia postorbitalis	42.6	35.3	44.3	41.0	39.3	42.9	42.0	39.6	45.1	42.2	41.5	42.9
altitudo capitis	58.5	49.5	61.9	58.9	55.5	62.8	56.8	53.1	59.4	55.9	55.7	56.2
latitudo capitis	57.7	48.8	62.8	60.5	55.1	64.5	58.7	56.4	61.7	57.3	56.9	57.7
in % longitudo pedunculi caudae												
altitudo pedunculi caudae	63.7	59.0	72.5	59.5	55.2	65.6	62.4	58.7	66.8	49.9	47.8	51.9
latitudo pedunculi caudae	41.9	36.1	52.1	48.8	44.8	54.6	46.0	42.9	51.4	34.5	32.2	36.8
minima altitudo corporis	53.4	49.2	59.1	49.1	46.1	51.5	53.3	49.7	60.5	43.1	39.0	47.2
in % distantia P–V												
longitudo P	63.7	58.3	69.2	52.8	48.0	58.5	55.0	50.4	60.0	66.8	63.7	69.9
in % distantia V–A												
longitudo V	65.1	57.1	76.2	57.4	47.8	63.9	61.4	58.2	65.7	60.7	57.3	64.1
n		10			10			7			2	

Table 3. Main distinctive characters of *B. plebejus*, *B. barbus* and *B. meridionalis petenyi* from the Poprad river

Character	Species		
	Barbus barbus	*Barbus plebejus*	*Barbus meridionalis petenyi*
Scales in lateral line	(55)57 – 61	(53)61 – 65(68)	51 – 57(60)
Last spine in D	strongly ossified, completely serrated	moderately ossified, finely and uncompletely serrated	moderately ossified without serrations
Edge of D	Heavily cut out	moderately concavex, S shaped	straight or convex
A of females	short, does not reach the base of C	long, reaching or exceeding the base of C	long, reaching or exceeding the base of C
Back	with keel	partly keeled	keelless
Barbs	1. papillated 2. first pair does not reach, reaches or exceeds the front of nostrils 3. second pair reaches the rear edge of eye	1. smooth 2. first pair only rarely reaches the front of nostrils 3. second pair exceeds the centre of eye	1. smooth 2. first pair usually reaches the front of nostrils 3. second pair reaches the ce[illegible] of eye
Base of V	behind the base of D	under (rarely slightly behind) the base of D	under $^{1}/_{3}$ of base of D
Central lobe of mandibular lip	short, reaches $^{1}/_{3}$ of length of adjacent lobes	medium, reaches $^{1}/_{2}$ of adjacent lobes length	long, exceeds $^{1}/_{2}$ of adjacent lobes length
Sides pigmentation	coherent, usually reaching the P – V line	dense small spots reaching the P – V line	dense small spots above the P—V line

DISCUSSION

The remarkable similarity of *B. plebejus* from the Poprad river with other populations of this species on one hand and its *quasi* intermediate position between *B. barbus* and *B. meridionalis petenyi* on the other hand seemingly complicate the question of its systematic status. In spite of the small number of investigated specimens and lack of knowledge on the anatomy, hybridization and ecology of the majority of species belonging to the genus *Barbus*, we are of the opinion that in the Poprad river, along with *B. barbus* and *B. meridionalis petenyi*, also *B. plebejus* occurs. Although we do not deny the possibility of hybridization between *B. barbus* and *B. meridionalis petenyi*, we cannot consider it to be proved. To support our view we are introducing following arguments:

1) Similarity of assumed hybrids found in the river Vistula, Dniester, Poprad, Tisa, Ipeľ and Hron with *B. plebejus* is so puzzling that one only can hardly suppose their hybrid origin. It has to be emphasized that *B. plebejus* inhabits also the rivers where neither *B. meridionalis petenyi* non *B. barbus*, occurs. All assumed hybrids between these species display such characters which are claimed to be specific for *B. plebejus:* fine and uncomplete serration of the last spine, which is weak and slightly ossified, and the higher number of scales in lateral line. If *B. plebejus* from the basins of the rivers Vistula, Dniester and Danube were of hybrid origin, the number of scales in its lateral line should be intermediate between *B. barbus* and *B. meridionalis petenyi*. As it follows from literature devoted to hybrids of Teleosts (e.g. Hubbs, 1955; Hubbs and Miller, 1943, 1953; Hubbs, Hubbs and Johnson, 1943; Hubbs, Walker and Johnson, 1943; C. Hubbs and Strawn, 1957; Nikoljukin, 1952; Kobayashi, 1962; Suzuki and Kato, 1966; Arnault and Spillmann, 1966; Nelson, 1968; Elder, Garrod and Whitehead, 1971) the intermediacy of the scale counts appears to be a general rule. The exception has been found only in intrageneric hybrids of the genus *Rhodeus*, where the number of perforated scales in the side line (which is short in this genus) of hybrids was found to be higher than in parental species (Holčík and Duyvené de Wit, 1962). But also in this case the total number of scales between the head and base of caudal fin was intermediate.

2) The fact that according to some external characters *B. plebejus* from the Poprad river and other rivers as well occupies an intermediate position between *B. barbus* and *B. meridionalis petenyi* need not be the evidence of its hybrid origin. The intermediacy of *Acanthorhodeus chankaensis* between *A. macropterus* and *Rhodeus sericeus* led Berg (1948) and Holčík (1963) to assumption that this fish is of hybrid origin, mainly when calculated hybrid index showed intermediate position between supposed parental species (Holčík l.c.). Later on it was shown by Holčík (1976) that this assumed hybrid is a valid species *A. chankaensis* (syn. *A. atranalis*) which inhabits also those rivers where the supposed parental species do not occur together.

3) In fishes as well as in birds and mammals the natural intrageneric hybrids are more rare than the intergeneric ones (Nikoljukin, 1948; Hubbs, 1955). The reason is that the genera are less geographically isolated than the species of the same genus. When the species of the same genus occur sympatrically, the hybridization is prevented by the number of isolating mechanisms beginning from different spawning time and place through

Table 4. Hybrid indices for *Barbus plebejus* from the Poprad river and for the hybrid of this paper and from table 7 of the paper by Kux and Weisz (1958). Data for *B. Barbus*

Character						Poprad			Locality
sex		♂	♂	♂	♂	♂	♂	♀	average
Longitudo corporis		206.0	212.0	223.0	211.0	212.7	195.0	208.0	209.7
Linea lateralis		176	−279	−127	−67	−97	−188	−127	−101.3
Numerus spin. branchialium		21	−14	−14	57	−14	57	57	21.4
Distantia praedorsalis		85	62	−15	8	77	69	−62	32.0]
Distantia praeventralis		23	52	55	42	65	32	110	50.9
Distantia praeanalis		80	45	−40	20	115	80	130	61.4
Altitudo corporis		90	0	190	80	90	40	40	75.7
Longitudo pedunculi caudae		128	6	33	78	100	33	189	81.0
Altitudo pedunculi caudae		45	20	65	55	80	70	90	60.7
Minima altitudo corporis		41	29	53	53	47	59	35	45.3
Distantia P — V		−65	165	26	91	104	100	30	64.4
Distantia V — A		27	40	33	153	67	13	153	69.4
Longitudo C I		127	−27	127	111	77	107	86	86.9
Longitudo C II		112	62	135	115	73	115	58	95.7
Longitudo P		100	90	100	95	40	135	60	88.6
Longitudo V		54	71	64	61	18	50	61	54.1
Altitudo D		118	91	75	81	68	79	82	84.9
Altitudo A		−150	−75	−117	−267	−67	−175	70	−111.6
Average for counts		98.5	−146.5	−70.5	−5.0	−55.5	−65.5	−35.0	−40.0
Average for measurements		54.3	42.1	52.3	51.7	63.6	53.8	75.5	56.0
Grand average		76.4	−52.2	−9.1	23.4	4.1	−5.9	20.2	8.0
Average for counts	with regard to population from the Topľa river	176.0	−279.0	−127.0	−67.0	−97.0	−188.0	−127.0	−101.3
Average for measurements		44.3	47.5	38.1	41.3	60.3	42.9	74.8	49.7
Grand average		110.2	−115.8	−44.5	−12.9	−18.3	−72.6	−26.1	−25.8

distinct ecological requirements up to mating peculiarities in the course of spawning (Hubbs, 1955, 1961; Nelson, 1968). Moreover, as found by C.

between *B. barbus* and *B. meridionalis petenyi* from the Topla river. Calculated from table 1 (set at 0) and *B. meridionalis petenyi* (set at 100) from table 2 of the present paper

Topla										
♂	♂	♂	♂	♂	♀	♀	♀	♀	♀	average
78.0	102.0	128.5	132.0	210.0	117.0	153.0	173.0	183.0	197.0	147.4
—67	85	—127	—36	—158	—67	55	—67	—279	—218	—87.9
—	—	—	—	—	—	—	—	—	—	—
254	215	0	23	177	31	131	100	169	254	135.4
—29	—39	—23	—81	—35	—10	32	65	45	16	—5.9
—70	—110	—50	—130	—195	—75	5	—275	—110	—260	—127.0
—130	210	150	—100	150	—30	120	200	40	30	64.0
11	—17	0	6	22	—28	44	89	78	61	26.6
—	—	—	—	—	—	—	—	—	—	—
6	88	12	—18	76	6	65	94	65	41	43.5
13	30	—87	—52	13	—9	9	39	130	52	13.8
167	180	193	133	227	113	53	200	167	—33	140.0
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
35	70	20	25	100	—5	15	65	20	40	38.5
—54	39	—32	—36	39	43	—7	71	—18	4	4.9
18	91	23	47	107	25	89	104	49	86	63.9
33	58	50	133	—158	70	100	167	163	107	72.3
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—67	85	—127	—36	—158	—67	55	—67	—279	—218	—87.9
21.2	67.9	21.3	—4.2	43.6	10.9	54.7	76.6	66.5	33.2	39.2
—22.9	76.5	—52.9	—20.1	—57.2	—28.1	54.9	48.0	—106.3	—92.4	—24.4

Hubbs (1967a, b) the hybridization frequency and the survival rate of hybrids decrease wit increasing sympatry, which is applicable both in intra-

Table 5. Comparison of particular populations of B. plebejus with that from the Poprad river. Data according to Berg (1948), Karaman (1955), Rolik (1970), M. Karaman (1971), Pešev (1971), Stephandis (1971)

Form	Scales in lateral line	Number of gill rakers	Length of P in % of P − V	Distribution
plebejus Bonaparte, 1832	55−75	9−11	62.5−76.9	Italy, Northern Dalmatia
cyclolepis Heckel, 1843	61−76	6−9	76.9−90.9	Marica river (Bulgaria)
lacerta Heckel, 1843	57−73	6−9	66.7−83.3	rivers Kura, Arax, southern inlets of the Kaspian Sea, upper part of the Tigris and Euphrat basins, Aleppo
ciscaucasicus Kessler, 1877	60−71	7−9	83.3−90.9	rivers Kuma, Terek, Sulak, Shuraozen, Rubaschay, Chiraschay, Kurakh-chay, Samur (Transcaucasus)
goktschaicus Kessler, 1877	60−68	9	55.6	Sevan lake and tributaries (Lower Caucasus)
tauricus Kessler, 1877	53−64	12	58.8−71.4	streams of the Crimean Peninsula
escherichi Steindachner, 1897	52−63	8−15	66.7−90.9	Asia Minor from Istanbul to Sochi, European inlets of the Marmara Sea, Bulgarian rivers flowing into the Black Sea
kubanicus Berg, 1912	55−68	10	66.7	Kuban river basin
prespensis S. Karaman, 1924	52−64	8−9	55.8−76.9	Prespa river (Macedonia)
eubocius Stephanidis 1943	48−69	7−9	?	Euboia Island (Aegean Sea) Sperkhios river (Greece)
strumicae S. Karaman, 1955	68−82	8−11	83.3−100.0	Struma river basin (Macedonia)
waleckii Rolik, 1970	55−70	9−13	?	Vistula and Dniester rive basins
ercisianus M. Karaman, 1971	63−70	7−8	76.9−90.9	Van lake (Asia Minor)
koswigi M. Karaman, 1971	63−73	6−7	71.4−83.3	Upper part of the Tigris river basin
pergamonensis M. Karaman, 1971	48−61	8−11	62.5−71.4	Bergama (Pergamos, Asia Minor)
cholorematicus Stephanidis, 1971	56−64	?	?	Cholorema river (Greece)
—	53−68	10−12	50.4−60.0	Poprad river (Vistula basin, Czechoslovakia)

generic and intergeneric hybrids as well. These are the reasons why the same type of hybrids are only rarely found in different rivers. If *B. plebejus* from the Central Europe were a hybrid it would be a rather rare exception.

4) By crossing of sympatrical species of the same genus the hybrids show increasing variability and between both parental species there exist almost continual row of transitional forms, and many of them are nearly identical with one of the parents (Nikoljukin, 1952). With regard to the extensive variability of the genus *Barbus* (which is the cause of difficulties in the systematics of this group), *B. plebejus* from the Poprad river, and as one can deduce from the papers of Kux and Weisz (1958) and Rolik (1970) and mainly from the description of this species by M. Karaman (1971) also in other rivers of the whole area of its distribution, does not show particular variation. All specimens are mutually similar and mostly easily identifiable.

5) It was found by many authors (e.g. Hubbs, **Hubbs and Johnson,** 1943; Nikoljukin, 1952; Hubbs, 1955, 1961; Nelson, 1968) that the hybridization in nature is conditioned mainly by environmental changes. The single proved case of hybridization inside the numerous genus *Barbus**) between *B. capito* (Güldenstädt, 1773) and *B. brachycephalus* Kessler, 1872 is claimed to be the result of continual drying of the Chu river (tributary of the Aral Sea) when *B. brachycephalus* came into the contact with *B. capito* and was forced to use the same spawning grounds with the latter species (Nikolskij, 1931, according to Rolik, 1970). In other rivers where both species occur sympatrically the hybridization has not been observed. On the other hand, *B. plebejus* inhabits different rivers together with *B. barbus* and *B. meridionalis petenyi* and it can be hardly possible to suppose that in all rivers the environmental conditions either changed naturally or were induced artificially.

6) Introduction of some of the *Barbus* species into the rivers of Central Europe, which would be a further factor inducing hybridization in nature (Hubbs and Hubbs, 1947; Hubbs, Hubbs and Johnson, 1943; Hubbs, 1955; Nelson, 1968), cannot be considered at all. Both *B. barbus* and *B. meridionalis* are the aboriginal species in river basins of the Danube, Vistula and Dniester.

7) Intrageneric hybridization in nature often occurs in cases, when one of the parental species is rare (Hubbs and Hubbs, 1947; Nikoljukin, 1952; Hubbs, 1955). However, in rivers of Central Europe both *B. barbus* and *B. meridionalis petenyi* are common fishes. It is true that their frequency varies, but assumed hybrids were also found at those localities where the density of both species was the same (e.g. the Ondava river at Nižný Mirošov, Stročín, Breznica, Lomné, Dobrá, Slovenská Kajňa, Hencovce, the Torysa river at Ploské, the Neresnica brook above Zvolen, the Ipeľ river vetween Lučenec and Fiľakovo — Weisz and Kux, 1962; Dorko, 1963; Kux and Weisz, 1964). Moreover, assumed hybrids were recorded also in cases when one of the parental species presumed was absent (the Topľa river

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*) Almaca (1967, 1972) admits possible hybridization between *B. steindachneri* and *B. microcephalus*, *B. steindachneri* and *B. comiza* and *B. microcephalus* and *B. comiza* respectively but he does not bring a detailed description of these hybrids, so their existence cannot be considered to be proved. Presumable parental species are very close to one another and hybrids differ from them only in few measurements (intermediate position of the barb length and the head profile).

at Rokytovo and Bardejov, the Hornád river between Spišská Nová Ves and Stará Huta, the Ondava below Mikulášov — Kux and Weisz, 1958; Weisz and Kux, 1962; Dorko, 1963).

8) Disjunctive distribution of *B. plebejus* is not some exceptional phenomenon in fishes as one can see in *Leuciscus souffia*, *Barbus meridionalis*, *Hucho hucho*, *Cyprinus carpio*, *Rhodeus sericeus* as the most known examples.

9) Relatively rare occurrence of *B. plebejus* in the Poprad river and other flows of the Danube, Vistula and Dniester basins (although in the San river in some localities this species is rather dense and reaches 10—13% of the total abundance of fish stock — Rolik, 1971) is not unique or proving its hybrid origin. For example *Gobio uranoscopus* occurs very rarely in some rivers and, moreover, together with *Gobio gobio* and *Gobio kessleri*, but nobody doubts of its validity.

Resuming all facts and circumstances we are concluding that the Rolik's determination that *B. barbus* × *B. meridionalis petenyi* is in fact a distinct species *B. cyclolepis* (i.e. *B. plebejus*) is right, and that this species, which is new for Czechoslovakia, occurs not only in the Poprad river but very probably also in rivers of the Danube river basin. Although the hybridization between *B. barbus* and *B. meridionalis*, or between these two and *B. plebejus*, is not excluded we suppose that it is possible only exceptionally. Such hybrids are probably very rare and very similar to the parental species. Anyway, the hybridization between these species should be experimentally verified.

Key for identification of *Barbus* species of Czechoslovakia

1 (4) Last unbranched ray in D strongly or moderately serrated
2 (3) Serrated last ray in D in a form of strong spine, lateral line with 51—60 scales .... *Barbus barbus* (Linnaeus, 1758)
3 (2) Serrated last ray in D moderately ossified, lateral line with 60—66 (rarely less or more) scales .... *Barbus plebejus* Bonaparte, 1832
4 (1) Last unbranched ray week and smooth, without serration .... *Barbus meridionalis petenyi* Heckel, 1847

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Appendix

On June 29th, 1975, 6 further specimens of *B. plebejus* were caught in the Poprad river at Medzibrodie, measuring 187—270 mm of standard length. The biggest one was female, others were males. After counting their principal characters the diagnosis of *B. plebejus* from the Poprad river is as follows: D III—IV 8, A III 5, lat. line $(53)60\,\frac{11-14}{7-11}\,66\,(68)$, sp. br. 10—14.

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The plates (Figs 1 and 2) will be found at the end of this issue.

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ON THE BALI TIGER, PANTHERA TIGRIS BALICA (SCHWARZ, 1912)

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Dedicated to the memory of Doc. Dr. Walter Černý

Abstract: The available data on the Bali Tiger, *Panthera tigris balica* (Schwarz, 1912) are summarized in the present paper. Three hitherto unknown skulls and two skins of the Bali Tiger are described and compared to the material of other island forms of the species, especially *Panthera tigris sondaica* (Temminck, 1844). Skull as well as external characteristics of the Bali Tiger are given and differences from the Javan and Sumatran tigers shown. The author disagrees with the opinion that the Bali Tiger is consubspecific with the Javan Tiger; according to his observation it represents a well defined, distinct subspecies of the Tigor which is now most probably completely extinct.

1. INTRODUCTION

Problems of intraspecific taxonomy and systematics of the Tiger have been several times extensively discussed (e.g. Pocock, 1929; Brongersma, 1935; Weigel, 1961; Mazák, 1965 and others). In general, all the authors agree that there are four or five continental subspecies of the species *Panthera tigris* (Linnaeus, 1758) and three separate insular forms, the latter being *Panthera tigris sumatrae* Pocock, 1929 from Sumatra, *Panthera tigris sondaica* (Temminck, 1844)*) from Java, and *Panthera tigris balica* (Schwarz, 1912) from the island of Bali.

Panthera tigris balica, the Bali Tiger, is indubitably the least known of all the subspecies of tiger.

Schwarz (1912) described his "*Felis tigris balica*" on the basis of a female skull and skin that originated from South Bali (Denpasar) and is till the present time preserved in the Senckenberg Museum in Frankfurt a.M. under the No. 2576. This specimen was for long years the only known material evidence of the subspecies in question, this being evidently the main reason why Pocock (1929 : 540) at his time claimed that *balica* as a subspecies did not rest "on a very secure basis". Contrary to him Sody (1932 : 233—235; 1933 : 89; 1949 : 166—169) does not seem to have any doubts about the validity of this tiger subspecies.

Quite recently Hemmer (1969) raised once again the problem of the Bali Tiger. He discovered two other skulls of tiger that originated from the island of Bali, viz. from Medevi and Poeloekan. Both skulls are housed

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*) For the dating of Temminck's publication containing the original description of "*Felis tigris sondaicus*" see Mazák (1967 : 541).

in the Naturkunde-Museum in Stuttgart and, like the type specimen, are those of females.

Hemmer compared both Stuttgart skulls (which are clearly of adult specimens) as well as the type skull (which is without any doubt of a young specimen) with 19 skulls of tigers from Java and with 39 skulls from Sumatra. He claims (l.c., pp. 217–218) he has found no substantial differences between the Bali and Java skulls, whilst those from Sumatra were characterized — as already emphasized by Schwarz — by several typical features, such as the shape of planum occipitale and the form and relative length of the nasal bones. Hemmer (l.c., p. 219) also states that he did not even find any important difference in the coloration between the Java and Bali tigers*), and he therefore concludes: „Es verbleibt somit kein Merkmal, das eine systematische Trennung der Tiger dieser beiden Sundainseln wirklich rechtfertigen würde. Der Name *Panthera tigris balica* (Schwarz, 1912) ist in die Synonymie von *Panthera tigris sondaica* (Temminck, 1845) zu stellen; bei den Tigern der Insel Bali handelte es sich um eine zur Kleinwüchsigkeit neigende Population dieser Unterart, aus welcher die kleinsten rezenten Tiger stammen."

In the course of last years I had the oportunity to study more material on the Bali Tiger, the most important of which being the discovery of two skins and three skulls of adult and/or old specimens in the collections of the British Museum (Natural History) in London, and came to the conclusion that is not in accordance with that expressed by Hemmer (l.c.).**) As will be shown in the following sections of this paper, the results of my study indicate there is some evidence that the Bali Tiger may be considered to be a valid subspecies which is different from the Javan Tiger, *Panthera tigris sondaica* (Temminck, 1844).

2. MATERIAL AND METHODS

A review of the both skull and skin materials on the three races of the so-called Island Tigers, seen and measured by me, is as follows:

59 skulls of adult and fullgrown specimens; of these being 27 (10 ♂♂, 12 ♀♀) from Sumatra, 29 (17 ♂♂, 12 ♀♀) from Java and 3 (2 ♂♂, 1 ♀) from Bali.

24 skins, both flat and mounted; 15 of these (8 ♂♂, 6 ♀♀, 1 unsexed) being from Sumatra, 7 (2 ♂♂, 3 ♀♀, 2 unsexed) from Java and 2 (both males) from Bali.

Specimens listed above are housed in the following institutions: Zoölogisch Museum, Amsterdam; Museum für Naturkunde, Berlin; Institut Royal des Sciences Naturelles de Belgique, Bruxelles; Rijksmuseum van Natuurlijke Historie, Leiden; Zoological Museum of Zoological Institute of Academy of Sciences, Leningrad; British Museum (Natural History), London; National Museum, Prague; and Naturhistoriska Riksmuseet, Stockholm.

In addition, 12 skulls and 4 skins of young and young adult specimens of all the three island tiger forms (including the type specimen of *balica*) have been taken into consideration but not used in the taxonomical evaluation of the material.

Owing to the fact that materials on the Javan and Bali tigers are less abundant than those on the Sumatra Tiger, authentic photos of four Javan and three Bali tigers were also examined and used for this study.

Since the time Pocock (1929 : 535) described the subspecies *Panthera tigris sumatrae* there have, in fact, never been any doubts about its validity as the Sumatran tigers show several quite distinct features, both cranial and external, in which they differ from all the continental as well

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*) From the text of Hemmer (l.c., p. 216) it is however clear that the material examined by him was represented by the skin of the type specimen of *balica* on the one hand and by several skins of *sondaica* on the other (he does not give the exact number of *sondaica* skins, saying only he saw 15 skins of Javan and Sumatran tigers altogether).

**) Different opinions on some purely taxonomic problems do not mean, nevertheless, that Helmut Hemmer and myself disagree on major points of evolutionary systematic.

Table 1. Measurements of the Bali Tiger skulls from the collections of the British Museum (Natural History), London

Museum No.	37.12.1.2	38.3.14.5	38.3.14.6
Sex	♂	♂	♀
Age	adult	adult	adult
Locality	Sendang, N. C. Bali	Bali Island	Prapat Agoeng, W. Bali
Greatest length	297.6	295.0	262.7
Condylobasal length	267.3	266.5	238.5
Basal length I	248.7	248.0	220.4
Basal length II	239.5	239.5	212.0
Rostral breadth	85.8	87.0	76.1
Interorbital breadth	59.5	58.7	damaged
Postorbital constriction	55.3	56.2	damaged
Bizygomatic breadth	210.7	202.7	180.0
Mastoidal breadth	113.5	113.0	101.8
Supraoccipital breadth	52.2	51.4	49.0
Occipital height	84.0	81.0	71.4
Greatest length of nasals	97.0	98.0	88.0
Mandible length	197.4	196.7	173.5
Pm^4	34.0 × 17.0	33.8 × 17.6	31.0 × 16.3
M_1	24.7 × 13.0	25.3 × 13.3	22.8 × 12.0
$C\text{-}Pm^4$	88.8	90.0	81.8
$C\text{-}M_1$	104.0	106.0	95.0

Note: For the method of measurement see Mazák (1967); as to supraoccipital breadth and occipital height see Section 3.3. of this paper; all the measurements are indicated in millimeters.

as other island forms of tiger. Even the preliminary study of the available material clearly confirmed this fact and this is why only the Javan and Balinese specimens were compared in detail to ascertain whether or not the differences were significant enough to justify the status of a separate subspecies of the Bali Tiger.

Skull dimensions were taken in the usual way described, for example, in Mazák *(1967 : 559)*, and only those of really adult, fullgrown specimens (with basal skull suturae completely closed) were used for calculating the mean values of each set of measurements and (if there were 3 or more measurements in the given set) the standard deviation (*s*). As for the Bali Tiger, the material of which is very, very rare, the skull measurements quoted by Hemmer (1969 : 218) for the two Stuttgart female crania and by Sody (1949 : 168) for a female from the Buitenzorg Museum were also used in calculating the respective statistical parameters.

3. RESULTS

3.1. As already mentioned in Section 1 of this paper three skulls and two skins of adult, fullgrown Bali tigers were found in the collections of the British Museum (Natural History), London. The relevant data on these specimens are as follows:

BM(NH) No. 37.12.1.2. Skin and skull of an adult male from "Sendang, N.C. Bali"; no date of collecting is given but according to the catalogue number the specimen came to the Museum on Dec. 1, 1937. Skin as well as the skull are intact and well preserved; basal suturae of skull completely closed; rudimentary second praemolars are present in the both right and left maxillae.

Table 2. Measurements and indices of the occipital plane of skulls of tigers from Bali and Java

	Sex	Occipital height	Supraoccipital breadth	occip. h. / supraoccip. b.	*s*
Bali					
BM(NH) 37.12.1.2	♂	84	**52.2**	**1.60**	—
BM(NH) 38.3.14.5	♂	81	**51.4**	**1.58**	—
Java	♂♂	96.3	54.2	1.77	
	n = 16	(91—102)	(50—59)	(1.66—1.94)	0.10
Bali					
BM(NH) 38.3.14.6	♀	71.4	**49**	**1.43**	—
Java	♀♀	82.7	49.5	1.67	
	n = 12	*(77—86)*	*(46.5—52.5)*	*(1.60—1.80)*	*0.06*

Note: Measurements are given in millimeters; *s* = standard deviation

BM(NH) No. 38.3.14.5. Skin and skull of an adult male from the "Bali Island"; no date of collecting is mentioned, the specimen came to the Museum on March 14, 1938. Both skin and skull are intact and well preserved; basal suturae of skull completely closed; second upper premolars missing on both sides.

BM(NH) No. 38.3.14.6. Skull of an adult female from "Prapat Agoeng, W. Bali"; no date of collecting is given; it came to the Museum on March 14, 1938. Well preserved skull but damaged in the interorbital and postorbital regions; basal suturae completely closed; second upper premolars missing on both sides.

Measurements of all the three skulls are given in Table 1.

3.2. Though all the three Bali skulls from the British Museum (Natural History) are — and this should be once again emphasized — those of full-grown, adult specimens, they show rather weakly developed sagittal crests that protrude in their anterior parts only about 2 millimeters and in their posterior parts about 14 to 15 millimeters above the level of the frontal and parietal bones respectively.

The shape of the occiput is in all the three skulls the same as described by Schwarz (1912) in the type specimen of *balica*, i.e. the occipital plane *is very narrow, its lateral margins being parallel, and its upper margin forming* an isosceles triangle. As pointed already out by Schwarz (1912 : 326) and confirmed most recently by Hemmer (1969 : 217), a similar form of the occipital plane is also found in the Javan Tiger, whilst in the Sumatran Tiger the occipital plane is much broader, its lateral margins being convergent toward the upper margin which is generally not triangular but more or less rounded.

Another difference between the skulls of the Sumatran and Javan tigers mentioned by Schwarz (l.c.) and confirmed by other authors (Pocock, 1929 : 538; Sody, 1933 : 89; Hemmer, 1969 : 217) is found in the form of nasal bones. The nasals of the Sumatran Tiger are relatively broader and shorter whilst those of the Javan Tiger are more elongated and narrower. As to the Bali Tiger the nasals are principally of the same shape as in the Javan Tiger, i.e. they are long and narrow. The three Bali skulls from the British Museum (Natural History) show this cranial feature quite explicitely.

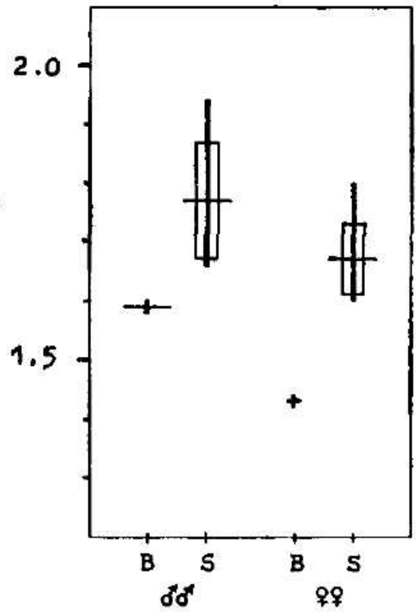

Fig. 1. A graph to show differences in the form of the occipital plane between the Bali and Javan tigers. On the ordinate values of the index "occipital height/supraoccipital breadth" are given. B = *Panthera tigris balica*; S = *Panthera tigris sondaica*. The mean value, ± standard deviation, and the extent of the individual variation are indicated; for number of specimens see Tab. 2.

Schwarz (l.c.) claims that the Bali Tiger has much flatter auditory bullae than both the Sumatran and the Javan tigers. Hemmer (l.c., p. 218), however, states he cannot confirm this feature in the Bali Tiger skulls since the form of bullae is very variable in the Javan skulls.

A comparison of the three British Museum skulls of the Bali Tiger with 29 adult skulls of the Javan Tiger has nonetheless shown that, despite the rather great extent of individual variation in the Javan specimens, the auditory bullae of the Bali Tiger display a somewhat different shape than that generally found in the Javan Tiger, being really "flatter", or less-vaulted, especially in their anterior part.

3.3. In Section 1 of this paper I have already mentioned that Hemmer (l.c.) affirms that he could not find any evident difference between the skulls of Javan and Balinese tigers.

Table 3A. Average skull measurements in Bali and Java tigers (adult, fullgrown specimens), males

	n	Bali	n	Java
Greatest length	2	296.30 (295.0—297.6) —	17	323.04 (306.0—338.0) s = 10.3
Condylobasal lenth	2	266.90 (266.5—267.3) —	16	285.04 (269.0—297.5) s = 8.75
Rostral breadth	2	86.40 (85.8— 87.0) —	17	93.33 (88.4— 99.4) s = 3.6
Interorbital breadth	2	59.10 (58.7— 59.5) —	17	61.62 (56.0— 66.5) s = 2.97
Bizygomatic breadth	2	206.70 (202.7—210.7) —	17	220.34 (198.0—243.7) s = 12.4
Postorbical constriction	2	55.75 (55.3— 56.2) —	17	54.76 (50.8— 61.8) s = 2.53
Mandible length	2	197.05 (196.7—197.4) —	17	213.37 (198.0—226.0) s = 8.1
Pm^4 length	2	33.90 (33.8— 34.0) —	16	34.36 (33.0— 36.0) s = 1.01

Note: mean value, limits of individual variation and standard deviation (*s*) are indicated

As described above, skulls of the Bali Tiger really resemble in their main characteristics those of the Javan Tiger. Yet some differences may be determined when a detailed comparison is made. I have already mentioned *that on the basis of material studied by me the difference in the shape of* auditory bullae, as noted by Schwarz (1912), can be confirmed.

As regards the occipital plane, it is true that in the both Javan and Balinese tigers it is of the same general shape. There is nevertheless a difference between the two, viz. the occiput of the Javan skulls is even more elongated than that of the Bali specimens. This fact can be clearly demonstrated by a simple index calculated as a quotient of two measurements that may be here called the "occipital height" and the "supraoccipital breadth".*)

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*) Occipital height was measured from the lower margin of the foramen occipitale magnum to the uppermost point of the occiput; supraoccipital breadth was taken as a distance between the notches of lateral margins of the occiput; the notch being situated approximately where sutura occipitoparietalis, sutura parietotemporalis and sutura occipitotemporalis meet.

Table 3B. Average skull measurements in Bali and Java tigers (adult, fullgrown specimens) females

	n	Bali	n	Java
Greatest length	4	265.92 (262.7–269.0) t = 2.25	12	281.45 (270.0–292.0) s = 7.35
Condylobasal length	4	239.50 (238.0–262.7) s = 1.77	12	252.07 (241.2–262.0) s = 6.73
Rostral breadth	1	76.1	12	81.24 (76.7– 86.6) s = 11.7
Interorbital breadth	—	—	12	54.85 (50.0– 59.0) s = 2.45
Bizygomatic breadth	4	182.62 (180.0–186.5) s = 2.40	12	189.82 (181.0–200.0) s = 5.99
Postorbital constriction	2	51.25 (51.0– 51.5) —	12	54.47 (52.7– 56.5) s = 1.14
Mandible length	3	174.50 (173.5–176.0) s = 1.10	12	187.98 (179.0–197.3) s = 6.17
Pm^4 length	4	30.72 (29.7– 31.9) s = 0.83	12	31.45 (30.0– 32.5) s = 0.74

Note: mean value, limits of individual variation and standard deviation (*s*) are indicated

In the two British Museum skulls of males of the Bali Tiger the ratio "occipital height/supraoccipital breadth" is equal to 1.60 (skull No. 37.12.1.2) and 1.58 (skull No. 38.3.14.5), whilst in 16 male skulls from Java the mean value is 1.77, with a variation from 1.66 to 1.94, and *s* is 0.10.

Similar situation may be observed in the female skulls. In the British Museum skull No. 38.3.14.6 from Bali the ratio "occipital height/supraoccipital breadth" is 1.43, whereas in 12 female skulls of the Java Tiger the average value is 1.67, with a variation from 1.60 to 1.80, and *s* is equal to 0.06.

The described difference (cf. also Fig. 1 and Tab. 2) is rather significant as may be seen from the fact that the two British Museum male skulls of the Bali Tiger with their occipital index values of 1.58 and 1.60 are thus, respectively, 1.9 and 1.7 units of the standard deviation from the mean value of 16 male skulls of the Javan Tiger. The British Museum female skull from Bali, with its occipital index being equal to 1.43, is then even 4.0 units of the standard deviation from the average of 12 skulls of Javanese females.

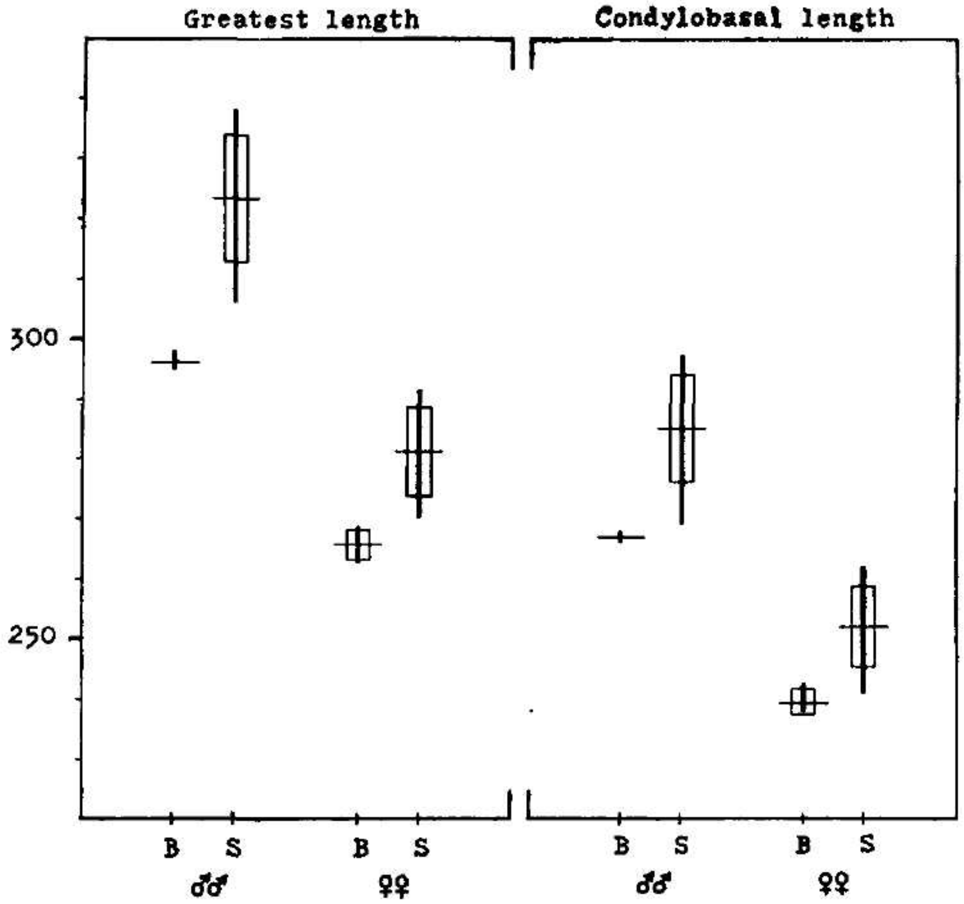

Fig. 2.

Figs. 2—5. Graphs to show differences in skull measurements (in millimeters) between the Bali and Javan tigers. B = *Panthera tigris balica*; S = *Panthera tigris sondaica*. The mean value, ± standard deviation, and the extent of the individual variation are indicated; for number of specimens see Tab. 3.

Schwarz (1912, 1913) and Sody (1932, 1933, 1949) always pointed out that the Bali Tiger is decidedly smaller than both the Javan and the Sumatran tigers. Contrary to this Hemmer (1969 : 219) says that the skull and teeth measurements of the Bali Tiger fall within the individual variation limits of the Javan Tiger and that no significant difference between the former and the latter could be found. I will comment on this Hemmer's conclusion in Section 4. of this paper and will also try to explain why Hemmer's point of view is in variance with that of Schwarz and Sody as well as with the results of this study.

All the main skull measurements of the Bali and Javan tigers are summarized in Table 3 (cf. also Figs. 2—5). It is quite clear that the dimensions of skulls of the Bali Tiger are, on average, certainly smaller than those of the

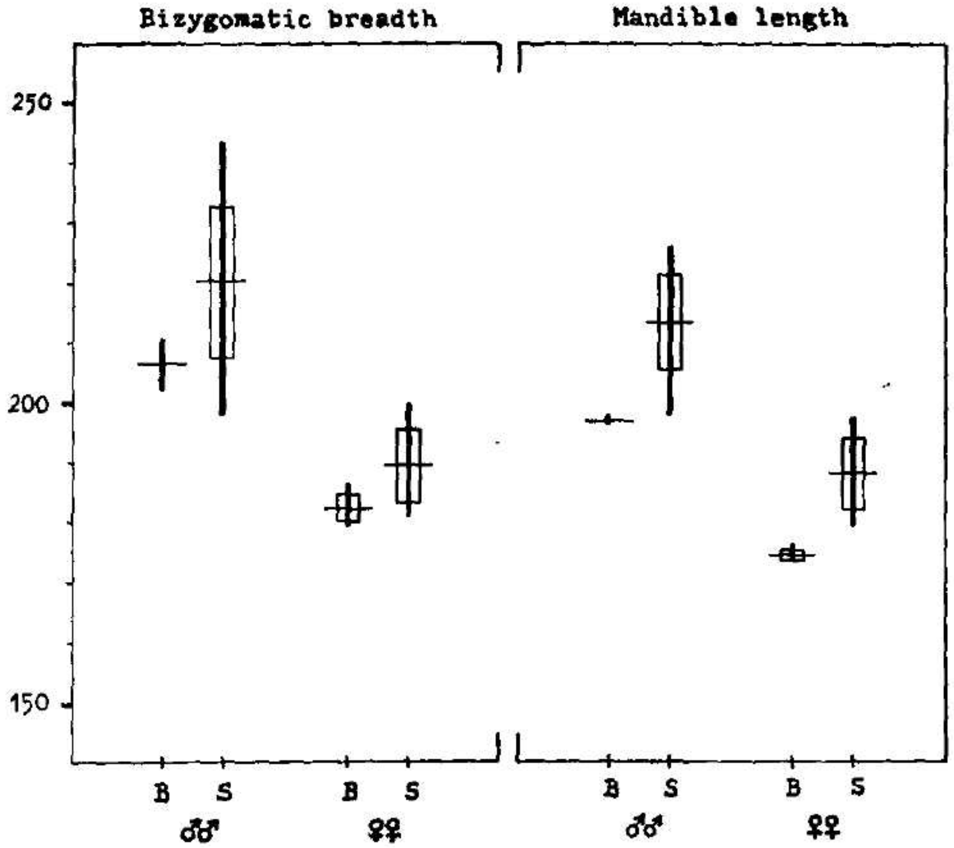

Fig. 3.

Javan Tiger, some of them falling distinctly outside the variation limits of the Javanese tigers.

The greatest length of the two British Museum skulls of Bali males is, respectively, 297.6 mm (No. 37.12.1.2) and 295 mm (No. 38.3.14.5), while in the 17 Javan males the average is 323.04 mm, with an actual variation from 306.0 to 338.0 mm.

The condylobasal length of the Bali males is 267.3 and 266.5 mm, whereas the mean value for 16 Javan males is 285.04 mm, with a variation from 269 to 297.5 mm.

A similar situation may also be noted is females. The average greatest length of 4 skulls*) of the Bali females in 265.92 mm, the variation limits being 262.7 and 269.0 mm, whilst the mean value for 12 Javan females is 281.45 mm, with an actual variation from 270.0 to 292.0 mm. The mean value of the condylobasal length is in 4 Bali females 239.50 mm (238.0 to 242.5 mm) and in 12 Javan females 252.07 mm (241.2 to 262.0 mm).

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*) The skull No. 38.3.14.6 from the British Museum (Nat. Hist.), and the three skulls the measurements of which are quoted by Hemmer (1969 : 218) and Sody (1949 : 168).

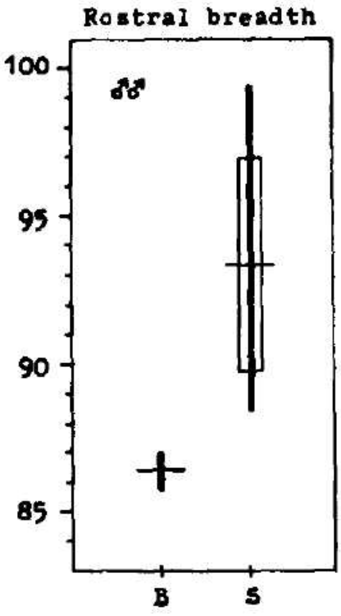

Fig. 4.

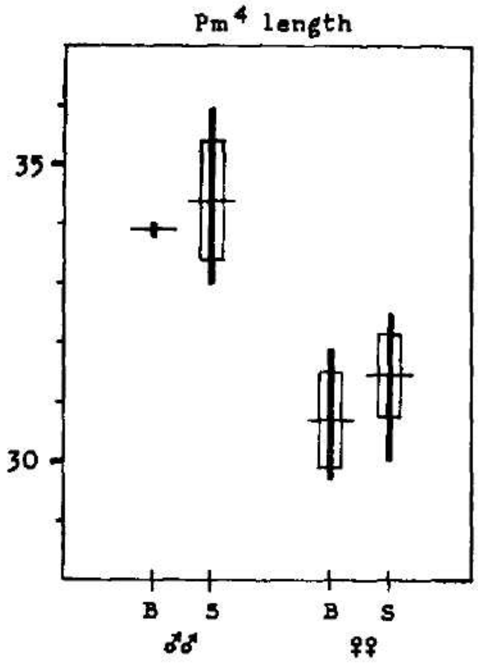

Fig. 5.

Though the skulls of the Bali Tiger differ the most conspicuously from those of the Javan Tiger in their greatest length, there are still some other measurements, such as the mandible length and the breadth of rostrum, which are also rather different.

Values of all the respective dimensions of the Bali Tiger skulls are, in general, more than one or even two units of standart deviation from the mean values found in the Javan skulls. Such differences are, indeed, significant enough to distinguish two forms on the subspecific level. As regards, for example, the greatest length of skull the two British Museum male specimens of the Bali Tiger are, respectively, 2.47 (No. 37.12.1.2) and 2.72 (No. 38.3.41.5) units of *s* from the mean value of the 17 skulls of adult Javan males.

It is , however, to be noted that the differences in skull measurements are somewhat less expressed in females than in males which is in full accordance with the situation found in other tiger subspecies (cf. Mazák, 1967 : 559; 1968 : 108—111).

3.4. As for the external characteristics of the Bali Tiger, the type skin of Schwarz's "*Felis tigris balica*" was the only specimen properly described in the respective zoological literature. Hence the two Bali Tiger skins that have been found in the collections of the British Museum (Natural History) are thus of the greatest importance. As already mentioned in Section 3.1. of this paper the both skins are those of adult males and are intact and very well preserved.

When describing coloration of the Bali Tiger Schwarz (1912 : 326) says: "Ground-colour somewhat brighter than in *sondaica* and light markings clearer white. Stripes a little broader and more duplicated. Frontal markings indistinct . . . Lower portion of cheeks white. A rather small *white* area above the anterior angle of the eye. Fur short and close." Sody (1933 : 89), who had a possibility to see some Bali skins in the possession of Mr. M. Ledeboer at Kempit, Besoeki (Eastern Java), then states that the ground coloration of the skin of the Bali Tiger is the darkest of all the Sunda tigers. Contrary to this Hemmer (1969 : 219) who studied only the type skin claims that *there is hardly at all any difference in coloration between the Javan and* Balinese tigers.

Nevertheless, the two British Museum skins, when compared to the skins of adult Java specimens, show that there *are* certain differences in colour.

The Bali skins are somewhat darker in their ground coloration than the most of Javan skins, the light coloured areas being very limited and almost purely white, while in the Java tigers a more or less intensive shade of the ground colour is observed in these areas. The black stripes are somewhat broader and frequently duplicated, especially on flanks and hind quarters, reminding thus more of skins of the Sumatran Tiger than of those of the Javan. In both British Museum skins from Bali there are numerous lines of small dark spots between stripes, mainly on the back, flanks and hind legs; and rather distinct dark markings on the frontal surfaces of fore legs. The mentioned lines of small spots as well as the more or less distinct frontal markings on the fore legs are, indeed, found also in almost all skins of both the Javan and the Sumatran tigers. The marking on the head is very distinct *in the Bali specimens, and on the front there are four to five pairs of short* and duplicated transversal stripes, this being a feature that was found in none of the Javan and/or Sumatran skins.

Hair of both Bali specimens from the British Museum is smooth and short. As stated above, both skins are those of males and it is thus not surprising that they display fine and rather long whiskers and somewhat longer hair on the nape of neck. Length of hair is, in average, slightly different from that of Javan and Sumatran tigers, the actual figures being as follows:

Bali	♂♂ (n = 2);	back	7—10 mm
		neck	15—25 mm
		belly	15—20 mm
		whiskers	75—85 mm
Java	♂♂ (n = 2)	back	8—12 mm
		neck	13—17 mm
		belly	16—30 mm
		whiskers	60—80 mm
Sumatra	♂♂ (n = 3)	back	10—17 mm
		neck	30—60 mm
		belly	20—40 mm
		whiskers	80—120 mm

All the above given characters of coloration and hair of the Bali Tiger are found, too, in the type specimen (♀ yg., Senckenberg Museum, Frankfurt a.M., No. 2576) of Schwarz's "*Felis tigris balica*". In addition, the described type of dark marking is also visible on three very rare photos of wild-shot Bali tigers, two of which were published by Gresser (1938 : 85) and Mountfort (1973 : 243) whilst the third was kindly placed at my disposal by Ir. C. H. J. Maliepaard (cf. Pl. II).

A rather great extent of individual variation in coloration and marking is well-known in various subspecies of *Panthera tigris* and we thus should not, in fact, expect very profound differences among tigers from the three islands of the Greater Sundas where there occur so many similar physico-geographical factors. In spite of this there are several quite distinct features that distinguish the Javan tigers from those of Sumatra, and it seems there is also enough evidence of the differences between the Bali Tiger on the one hand and the Javan and Sumatran tigers on the other.

3.5. As regards the external measurements of tigers of the Greater Sunda Islands there is no doubt they reach somewhat smaller size than any of the continental tiger subspecies. The exact dimensions that could be accepted as really authentic and scientifically valuable are however very scarce. It would, indeed, be possible to find some records on weights and body measurements in the literature dealing with tiger hunting but such data are very difficult to compare because of different ways in which the measurements might have been taken. Moreover, not all of these measurements and weights can be regarded as really reliable and exact (cf. Locke, 1954 : 10—11; quoted also in Mazák, 1967 : 551).

Sody (1949 : 169) tried to summarize different data on body measurements of island tigers extracted "from more 'popular' literature", and though he justifiably affirmed that such data seem not quite worthless he had to admit that they appeared rather to defy his own results.

As far as I know there are no data on body measurements of Balinese tigers, taken either "between pegs" or "over curves", that concern animals measured in the flesh. I am fully aware that the dimensions of dressed skins are not of great scientific value, but owing to the lack of any other reliable data I think it is not quite useless to quote them in Tab. 4.*)

The fact that the Bali Tiger is the smallest of the three Sunda Island subspecies of tiger (and at the same time of *all* the tiger subspecies as well), which is clearly demonstrated by a comparison of skull measurements, is once again confirmed by measurements of dressed skins.

As for the actual dimensions of Bali tigers measured "between pegs" in the flesh I estimate, according to the measurements of skulls and dressed skins, that an average fullgrown male would be about 2200 to 2250 mm (i.e. approximately 7 ft. 4 ins. to 7 ft. 6 ins.) in total length, whilst an average fullgrown female would have its total length about 1900 to 2000 mm (approximately 6 ft. 4 ins. to 6 ft. 8 ins.).

3.6. In spite of the fact that occurrence of the Tiger on the Bali island was several times confirmed by experienced authors as well as well-known hunters (e.g. Weber, 1904; Schwarz, 1912, 1913; Sody, 1932, 1933, 1949; Heynsius-Viruly & Van Heurn, 1936; Donker van Heel, 1937; Gresser, 1938; Tate, 1944; Pohle, 1950) some twenty years ago Meissner

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*) I did not measure all the skins I studied, this being the reason why the number of specimens listed in Table 4. is smaller than the total number of 24 skins seen by me as indicated in Section 2. of this paper.

Table 4. Measurements of dressed skins of tigers from Sumatra, Java and Bali

	Sex	Head & body	Tail
Sumatra	♂ ad.	1750 mm	810 mm
	♂ ad.	1650 mm	800 mm
	♂ ad.	1620 mm	750 mm
	♂ ad.	1600 mm	700 mm
	♀ ad.	1590 mm	670 mm
	♀ ad.	1560 mm	670 mm
	♀	1500 mm	650 mm
Java	♂ ad.	1900 mm	800 mm
	♂ ad.	1790 mm	825 mm
	♀ ad.	1580 mm	700 mm
	♀ ad.	1560 mm	770 mm
Bali	♂ ad.	1660 mm	620 mm
	♂ ad.	1640 mm	660 mm
	♀ sad. (holotype)	1530 mm	580 mm

Note: Skins are housed in the Zoölogisch Museum, Amsterdam; Museum für Naturkunde, Berlin; Senckenberg-Museum, Frankfurt a. M.; Rijksmuseum van Natuurlijke Historie, Leiden; British Museum (Natural History), London; National Museum, Prague

(1958) threw doubt on the existence of the Balinese Tiger, saying that this carnivore had very probably never inhabited the island in question. This rather unfortunate statement has then for several years been accepted by some authors as a proved fact. I tried already once (Mazák, 1965) to show that the occurrence of tigers in Bali was never a fiction but an indubitable reality, which was emphasized quite conclusively also by van Bemmel (*in* Simon, 1969) and Hemmer (1969).

As to the present occurrence of tigers in Bali there is not much hope that the species has survived on this island. Though some experts, such as Ir. C. H. J. Maliepaard (*in* Simon, 1969), quite recently believed that tigers might still have existed on the island of Bali, there are others who seem to be sure that the Bali Tiger is entirely extinct by now (cf. van Bemmel *in* Simon, 1969; Sinaga *in* Simon, 1969; Somberg-Honig 1970 : 7). It is therefore very interesting to quote here an information given at my disposal by Dr. Colin P. Groves who made in 1975 a several months' trip to Indonesia. In a letter written on July 31, 1975 in Jakarta he states: "We also met a Balinese Wildlife Officer, Mr. J. Made Taman, who knows Sulawesi as well as Java and Bali. He says that people still insist to him that there are tigers in the Bali Barat Reserve (a 20,000 ha reserve) on the N. W. tip of Bali . . .".

Although van Bemmel (*in* Simon, 1969) believes that the last Bali Tiger was a female, shot by Mr. Wehlburg in Sumber Kima, West Bali, on Sept. 27, 1937, there is a certain evidence that before the World War II tigers were still rather numerous on the island of Bali and that they survived at least into the early 1950's. This can be attested by the following data:

A certain Mr. Zimmermann of German origin, who was living on Bali as a planter from 1933 till 1941, when he became interned, and who was an experienced hunter wrote in a letter dated Sendang, Bali, November 3, 1937 (quoted by A. Hoogerwerf in a letter addressed to Ir. C. H. J. Maliepaard and dated Bakkum, NH, May 13, 1965): "During the years 1933 till now, as far as known to me, not less than 14 tigers were shot in the region spreading from Poelakie to Teloktrima . . . At this moment [i.e. in November, 1937] again about 6 tigers are known to me to be living in the same region." It should be added that of the 14 tigers shot in the mentioned period seven were killed by Mr. Zimmermann himself.

Ir. C. H. J. Maliepaard then states (*in* Simon, 1969). "The last reliable news I received about this rare, if not extinct, animal came from one of the last Dutch forest officers, Mr. Florenstijn Mulder, now forrest officer on the Crown lands in the Netherlands, who told me that the Balinese tiger still occurred in 1952. The northeastern part of Bali is so densely wooded and so lonely and remote that some specimens may have survived up till the present time."

Note. A list of actual localities of the Bali Tiger, as known to me, is as follows: *Arimaus* (Dreesen, 1937 : 30), *Denpasar Region* (Schwarz, 1913 : 73), *Medevi* (Hemmer, 1969 : 217), *Pegamatan* (Gresser, 1938 : 241), *Poelakie* (Zimmermann, quoted in a letter of A. Hoogerwerf to C. H. J. Maliepaard), *Poeloekan* (Hemmer l.c.), *Prapat Agoeng* (sf. Section 3.1. of this paper), *Sendang Region* (cf. Section 3.1. of this paper), *Sumber Kima* (Sody, 1949 : 166; van Bemmel in Simon, 1969), *Teloktrima* (Zimmermann l.c.).

4. DISCUSSION

In his 1969 paper Hemmer claimed he could not find any demonstration that the Bali Tiger differed from the Javan specimens. It has been however shown in Sections 3.2, 3.3., and 3.4. of this paper there are several characteristical features, both cranial and external, that distinguish tigers of Bali from those of Java. One of the most important Hemmer's arguments seems to be the fact that the shape of the occipital plane of skull is similar in the Bali and Java tigers. Nevertheless, as demonstrated in Section 3.3., a certain difference in the shape of the occiput *does* exist, viz. the occipital region of the Javan skulls is more elongated than that of the Balinese specimens. In addition, there are other tiger subspecies, such as *Panthera tigris tigris* (Linnaeus, 1758), *Panthera tigris corbetti* Mazák, 1968, *Panthera tigris altaica* (Temminck, 1844), and *Panthera tigris amoyensis* (Hilzheimer, 1905), which do not significantly differ one from the other in certain cranial features (and sometime even not in certain skull measurements), yet there is no doubt about their separate subspecific status.

As to the statement that skull and teeth measurements of the Bali Tiger fall within the variation limits of the Java Tiger and that no significant difference may be found between them, Hemmer does not give any positive statistical proof of this and the graphs published by him (1969, Figs. 5 and 6) show that his statement might be not founded with enough evidence, at least as far as *some* skull and teeth dimensions are concerned. Besides, neither separation of males and females, nor that of young and adult animals, nor that of his own data and the data from the literature has been made by

Hemmer, which is, perhaps, the main reason why he came to the conclusion that the Balinese Tiger is consubspecific with the Javan Tiger, ***Panthera tigris sondaica*** (Temminck, 1844), and why his results seem to be different from those obtained by myself.

In Section 3.3. I have shown that the Bali Tiger skulls differ quite significantly in several measurements from skulls of the Javan Tiger, the differences in females being however somewhat less expressed than in males. Sody (1949, Tab. XIII) gives skull measurements of 12 males and 11 females of the Javan Tiger. The greatest length is indicated in all the males and females, while the condylobasal length only in 8 males and in 8 females. Though Sody's data contain his own measurements as well as those collected from the literature I did not hold it as useless to calculate the mean values of the respective measurements and compare them with my own results.

According to Sody's (l.c.) data the average values and the limits of individual variation of the greatest length and the condylobasal length are in skulls of the Javan Tiger as follows:

males	324.91 mm (309.0—349.0 mm), n = 12
	287.93 mm (272.0—303,0 mm), n = 8
females	279.45 mm (264.0—290.0 mm), n = 11
	250.12 mm (236.0—259.0 mm), n = 8

Among the females Sody lists two exceptionally small skulls, the greatest length of which is, respectively, 265 and 264 mm. These two specimens fall, indeed, into the variation limits of the Bali female skulls (cf. Tab. 3) but it is difficult to say whether or not they belonged to really adult and fullgrown animals since, though in the table of measurements Sody quotes all the specimens as "adult", in the text he mentions that some of them were "clearly *young* adult". In addition we have also to bear in mind that the difference in skull measurements is, as already mentioned above, less expressed in females than in males.

The above given mean values of skull measurements of the Javan Tiger calculated on the basis of Sody's (l.c.) data agree nonetheless very well with the figures obtained by me and summarized in Table 3.

5. CONCLUSION

All the available data on the Bali Tiger shown in the previous sections of this paper indicate that this form of tiger may be awarded the status of a separate and rather well-characterized subspecies of the species ***Panthera tigris*** (Linnaeus, 1758).

The basic systematic and taxonomic particulars of the Bali Tiger can thus be summed up as follows:

Panthera tigris balica (Schwarz, 1912)

1895. *Felis tigris sondaica*, Grevé (*in part*). Nova Acta Ac. Caes. Leop. Carol., **63** : 53. Bali.
1912. *Felis tigris balica* Schwarz. Ann. Mag. Nat. Hist. London, Ser. 8, **10** : 325. Bali, Denpasar.
1969. *Panthera tigris sondaica*, Hemmer (*in part*). Zs. f. Saugetierk., **34**(4) : 219. Bali.

Type specimen: Skin and skull of a subadult to young adult female; housed in the Senckenberg Museum in Frankfurt a.M., No. 2576; "purchased from Dr. J. Elbert" (Schwarz, 1912 : 325), „Das typische Exemplar von *Felis tigris balica* wurde 1909 von K. Gründler in Den Pasar, Süd Bali, geschossen und von Dr. Eugen Wertheimber dem Senckenbergischen Museum als Geschenk überwiesen" (Schwarz, 1913 : 73).

Type locality: Denpasar Region, South Bali.

Description: The Bali Tiger is the smallest of all the tiger subspecies, the total length being in males generally under 2400 mm (ca. 8 ft.) and in females under 2100—2200 mm (ca. 7 ft. to 7 ft. 4 ins.). In both males and females, the greatest length and condylobasal length of skull are significantly smaller than in any other subspecies of the Tiger, the average measurements being, respectively, about 300 mm and 270 mm in males and about 265 to 270 mm and 240 mm in females. Nasal bones long and narrow; occipital plane of skull narrow, in shape similar to that of *Panthera tigris sondaica* (Temminck, 1844) but somewhat less elongated. Auditory bullae slightly flatter than in other Sunda tigers. Ground coloration very dark, being a deep shade between "Tawny" and "Xanthine Orange" or even "Cinnamon-Brown" (Ridgway 1912, pls. III & XV). Light coloured areas very limited and almost purely white. Black stripes numerous, somewhat broader and frequently duplicated, more reminescent of the black stripe pattern of a Sumatra Tiger than of that of a Javan. Distinct marking of short duplicated transversal stripes on the front of head. Hair short and smooth; relatively long and fine whiskers and somewhat longer hair on the nape of neck in males.

Distribution: The island of Bali; formerly most numerous in mountain regions of northern, northeastern and northwestern parts of the island, being however also known from other areas of Bali. At the present time almost certainly completely extinct.

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

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STUDIES ON THE FRESHWATER CERCARIAE OF KERALA
V. PARAMPHISTOMATOID AND OPISTHORCHIOID CERCARIAE

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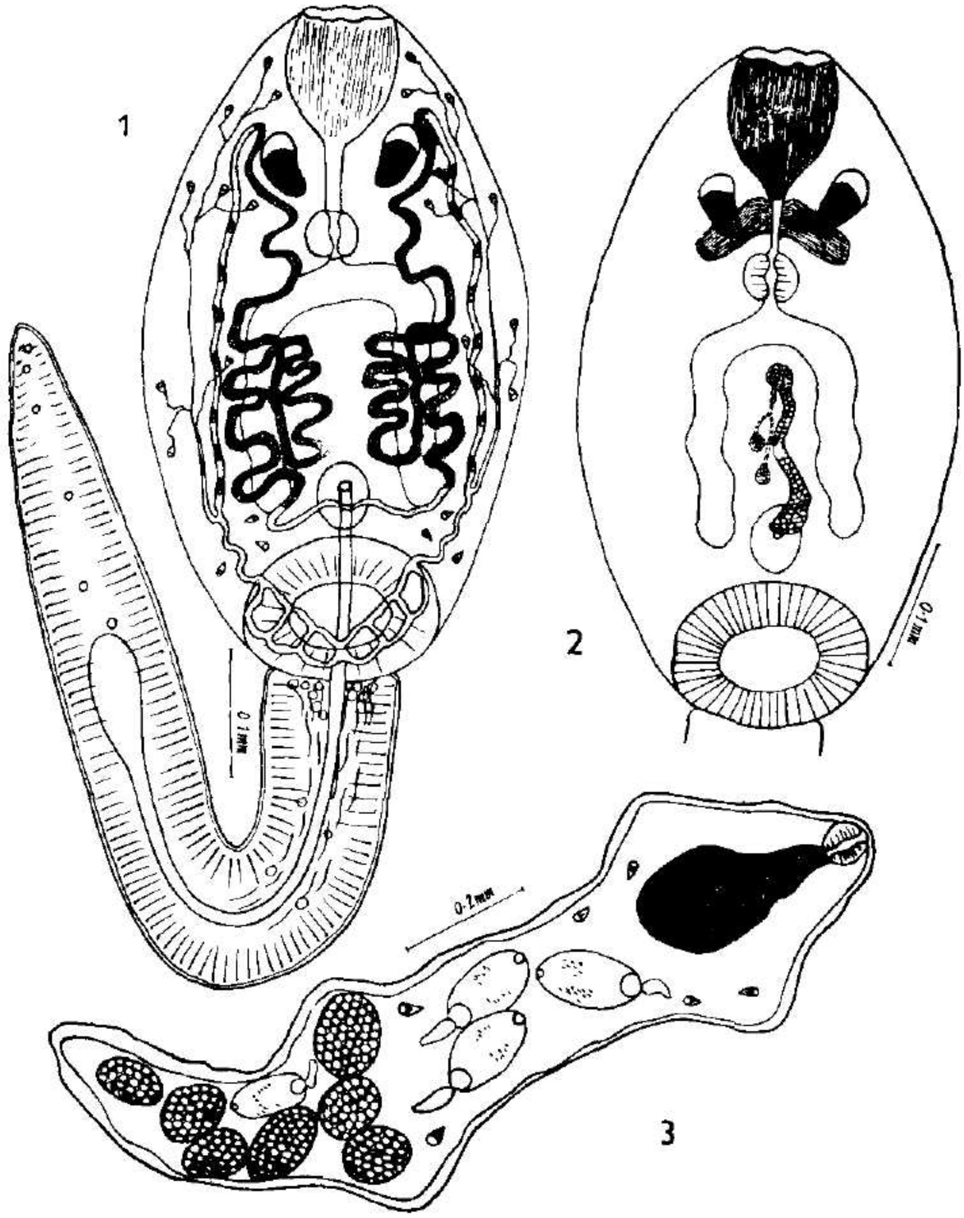
Abstract: A survey of the freshwater gastropods in Kerala for larval trematodes revealed the occurrence of Paramphistomatoid and Opisthorchioid cercariae. One species of paramphistomatoid cercaria — *Cercaria* sp. I Kerala — and two species of opisthorchioid cercariae — *Cercaria* sp. III Kerala and *Cercaria* sp. IV Kerala — were identified as new species. Detailed descriptions are furnished on these cercariae and their validity justified. Other species of cercariae recorded from Kerala but already reported from elsewhere were *Cercariae indicae* XXVI, *Cercariae indicae* XXIX and *Cercariae indicae* VIII. *Indoplanorbis exustus* acted as the intermediate host for *C. indicae* XXVI and *Cercaria* sp. I Kerala with an incidence of infection of 109/1500 and 6/68 respectively and *Lymnaea luteola* f. *typica* for *C. indicae* XXIX (13/125). *C. indicae* VIII was found in *Melania tuberculata* (80/825) but *Cercaria* sp. III Kerala was recorded from *M. tuberculata* and *M. scabra* with an incidence of infection of 25/410 and 6/75 respectively. *Digoniostoma pulchella* harboured *Cercaria* sp. IV Kerala and 22/280 snails were found infected.

Preliminary studies revealed that larval trematode infection was common in the freshwater molluscs of Kerala and a survey was prompted by the lack of literature concerning larval trematodes in this State. Quite often a knowledge of the cercariae serves as a clue to the digenetic trematode fauna of a region. As more and more life histories are known it has been possible now to relate cercariae to the adult group and in the present study, the cercariae have been categorised under families or super-families, based on comparison with cercariae the life cycle of which are known completely or in part. In doing so, I have followed almost completely the new scheme of classification propounded by Cable (1956), LaRue (1957) and Holliman (1961). However, certain morphological terms introduced by earlier workers like Lühe and Sewell, have been used in a descriptive sense. The present communication deals with Paramphistomatoid and Opisthorchioid cercariae encountered in the freshwater molluscs of Kerala.

MATERIALS AND METHODS

Different species of freshwater molluscs were collected from a variety of places in Kerala (Mohandas, 1974) and were brought to the laboratory alive. They were kept in groups of 5—10 in beakers and after one or two days those which shed cercariae were isolated individually and kept in separate beakers. Water in the container was changed on alternate days. Water plants and powdered biscuits were given as food for the molluscs. Only those cercariae which emerged spontaneously were used for detailed study and later these molluscs were crushed and examined for other larval stages. Cercariae were studied alive using physiological saline and 0.1% neutral red as vital stain and for the study of reproductive structures acetocarmine was used. Refrigeration for 30—60 minutes facilitated the study of excretory system. Sporocyst, redia and meta-



Figs 1—3. Cercaria sp. I Kerala: 1 — General organisation of the cercaria: 2 — Diagram showing reproductive and nervous system of the cercaria; 3 — Redia.

cercaria were studied alive, stained or unstained. Measurements were taken from materials fixed in hot 5% formalin but those of metacercariae were based on live specimens. Measurements of at least 25 specimens were taken and drawings made to scale from fixed materials with the aid of a camera-lucida. The drawings were free-hand and details added from observations on live specimens or temporary stained preparations. Measurements in millimicrons or otherwise mentioned.

RESULTS

The three species of Paramphistomatoid cercariae recorded from Kerala were *Cercariae indicae* XXVI Sewell, 1922; *Cercariae indicae* XXIX Sewell, 1922 and *Cercaria* sp. I Kerala.

Cercariae indicae XXVI: — Snail host — *Indoplanorbis exustus* (Deshayes), Location — Hepatopancreas, Locality — Palghat, Trichur, Calicut, Ernakulum, Aleppey and Trivandrum Districts. Incidence of infection — 109/1500. Season — Throughout the year.

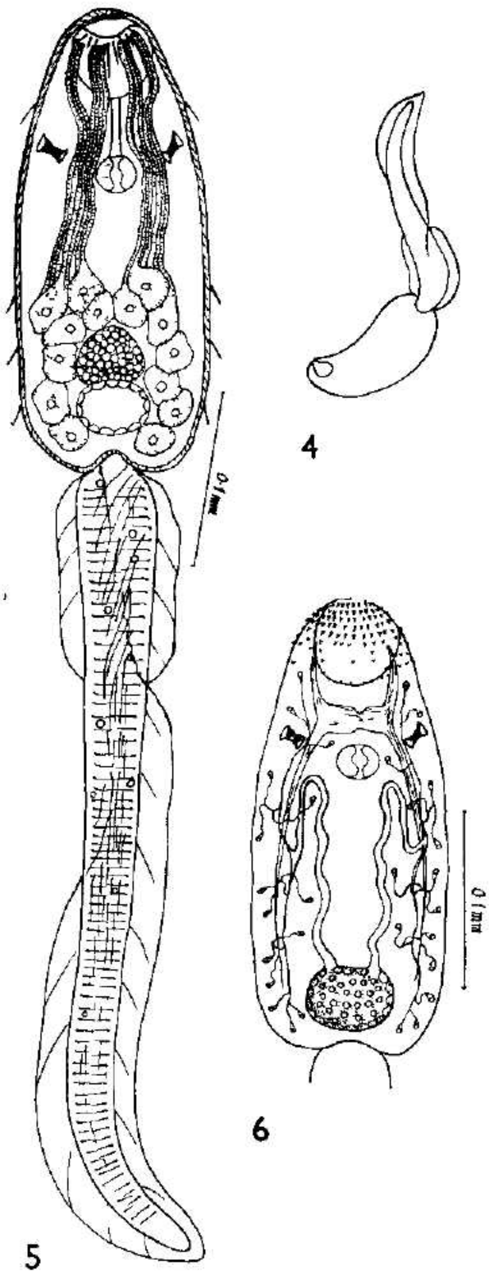
Measurements: — Body — 350—600 × 300—420, Tail — 300—625 × 50 to 75, Oral sucker — 50—60, Acetabulum — 95—130. Development of the cercaria takes place in redia. Redial generations two, mother redia contains 1—3 daughter rediae and measures 450—550 × 150—200, and daughter redia 1010—1635 × 230—295. Metacercariae found attached to the wall of the container or on other hard objects in water. Metacercaria has a diameter of 270—300 and the thickness of the cyst wall varies between 26 and 36.

Cercariae indicae XXIX· — Snail host — *Lymnaea luteola* f. *typica* (Lamarck), Location — Hepatopancreas, Locality — Palghat, Aleppey and Trivandrum Districts, Incidence of infection — 13/125, Season — September and October.

Measurements: — Body — 350—720 × 300—430, Tail — 450—630 × 75 to 120, Oral sucker — 70—120 × 50—85, Acetabulum — 75—100 × 125—150, Flame cell formula: 2(3+3+3+3+3). Development takes place in redia. Redial generations two, mother redia measures 540—820 × 210—275 and daughter redia 740—1650 × 240—400. Cercaria encysts on hard objects and on the wall of the container. Metacercaria has a diameter of 250—300.

Cercaria sp. I Kerala (Fig. 1): — Snail host — *Indoplanorbis exustus* (Deshayes), Location — Hepatopancreas, Locality — Palghat and Trivandrum Districts, Incidence of infection — 6/68, Season — January, April, August and December.

Swimming activities of the cercaria are slow because of its large size. While swimming, the body is contracted and bent ventrally. Swimming aided by lashing movements of the tail. Also capable of leech-like movements on a thin film of water. Body measures 400—690 × 225—400. Pigmentation in irregular patches and scattered all over the body except at the region anterior to the level of eye-spots. Cystogenous material rod-shaped. Pigmented eye-spots with conspicuous non-pigmented lens. Oral sucker 90—125 × 75—110. Acetabulum broader than long and measures 125—170 × 100—125. Tail measures 420—650 × 70—110. Mouth terminal or sub-terminal. Oesophagus narrow and short with a well developed oesophageal bulb measuring 25—45 × 35—50. Excretory bladder small and oval-shaped. Main excretory tubes highly coiled around the caeca and without connections and diverticula. Main duct runs anteriorly and at level with eye-spots bends and takes a descending course. This ciliated descending duct at level with the excretory bladder divides into two, one running anteriorly and the other posteriorly. This posterior branch runs into the acetabulum and ends in a series of branching tubules, all interwoven. Flame cell formula — 2(3+3+3+3). Caudal excretory duct originating from the bladder runs to about 4/5th length of the tail and ends as a slightly dilated sac. Presumptive ovary seen as a mass of cells in front of acetabulum and testes in between the ovary and the genital orifice. The band of cells representing the uterus takes a zig-zag course and



Figs 4—6: Cercaria sp. III Kerala: 4 — Floating posture, 5 — General organisation; 6 — Diagram showing excretory and nervous system of the cercaria.

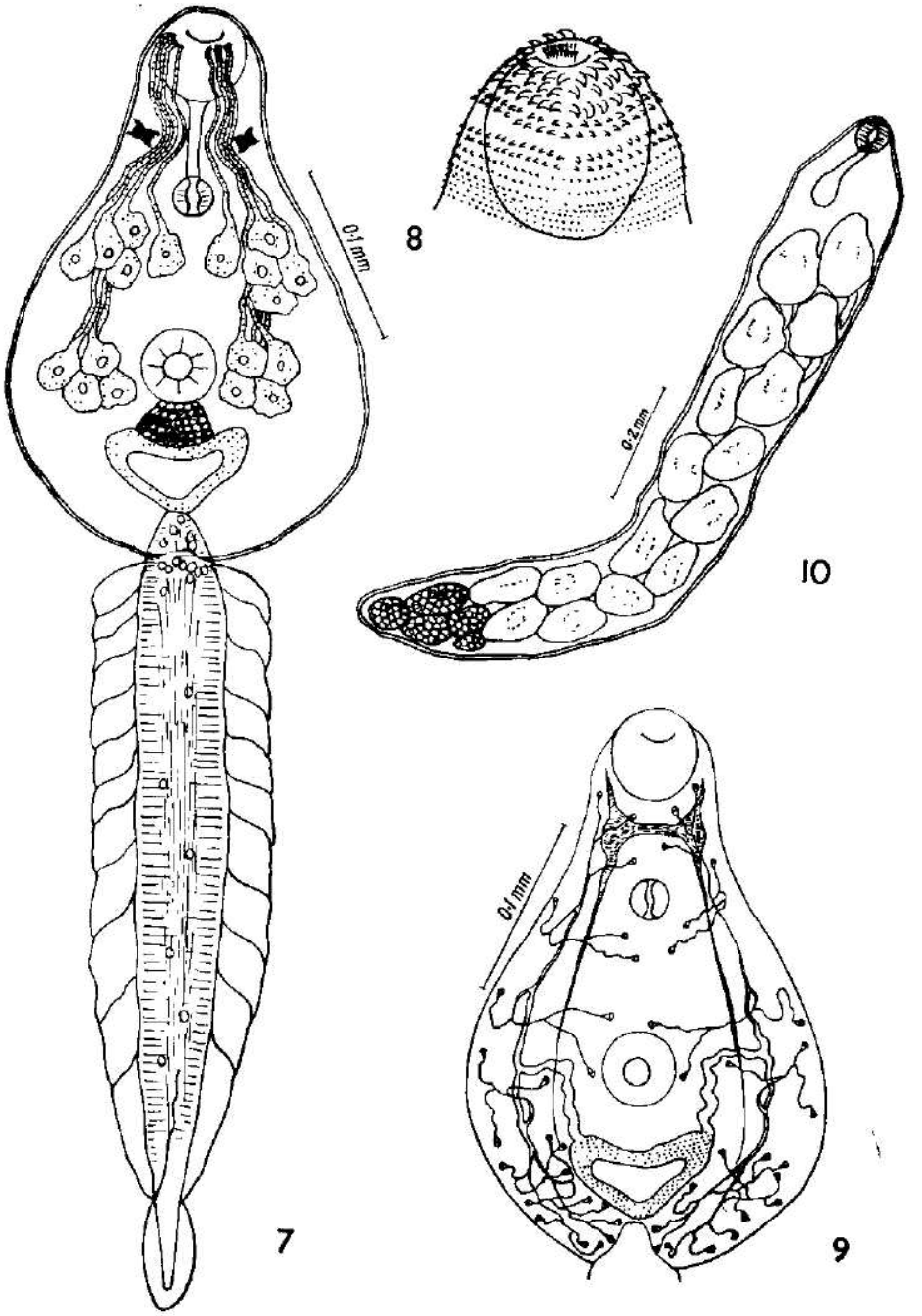
joins another mass presumed to be rudiments of genital orifice. The vasa efferentia and the vas deferens also make their appearance in cercaria. Nervous system represented by two masses of tissues situated on either side of the oesophagus and connected by nerve fibres (Fig. 2). Redia 1050—1910 long (Fig. 3) and pharynx measures 50—75. Appendages two pairs. Excretory system with three pairs of flame cells. Fully matured redia contains as many as 12 developing cercariae. They leave the redia at an early stage of development and complete further development in the tissues of the snail. Metacercaria found attached to the walls of the glass container. The cyst has a diameter of 400—430 and the cyst wall varies in thickness between 10 and 15.

Opisthorchioid cercariae: — Three species of this group were recorded from Kerala, *Cercariae indicae* VIII Sewell, 1922; *Cercaria* sp. III Kerala and *Cercaria* sp. IV Kerala.

Cercariae indicae VIII: — Snail host — *Melania tuberculata* (Müller), Location — Hepatopancreas, Locality — Palghat, Ernakulum and Trivandrum Districts, Incidence of infection — 80/825, Season — January to July, September and November.

Body measures 320—430 × 125—180 and tail 425—530 × 50—70. Diameter of the oral sucker 40—65, pharynx well developed, oesophagus and caeca apparently absent, penetration glands seven pairs, cuticle spinose, cystogenous cells contain granular protoplasm, refractile globules and brown pigments scattered all over the body. Ten pairs of setae on the body, one pair at level of the oral sucker and the remaining in the post-equatorial region. Pre-oral spines 18 (14+4). Excretory bladder triradiate and flame cell formula $2(3+3+3+3+3+3)$. Genital rudiments seen as an oval shaped mass just in front of the excretory bladder. Nervous system represented by two nerve masses connected by nerve fibres and paired anterior and posterior nerve cords. Development takes place in redia. Redial generations two and daughter redia measures 1050—1750 × 150—225. Diameter of the pharynx 40—50. Fully matured redia contains as many as 30 developing cercariae. Development completed outside redia, in the tissues of the snail.

Cercaria sp. III Kerala (Fig. 5). — Snail hosts — *Melania tuberculata* (Müller) and *M. scabra* (Müller), Location — Hepatopancreas, Locality — Palghat, Ernakulum and Trivandrum Districts, Incidence of infection — 25/410 and 6/75 respectively, Season — February, July, October and December. This cercaria is comparatively smaller than *C. indicae* VIII and swims intermittently in all directions with sudden jerks and then floats for sometime with tail bent in a characteristic pattern (Fig. 4). Any slight disturbance stimulates the cercaria to rapid reaction and it starts its vigorous swimming movements and then takes up the resting posture. Larval body capable of considerable degree of extension and contraction. Body measures 175—300 × 75—125. Cuticle with rows of spines and the first 4—5 rows of spines slightly larger. Cystogenous cells with granular material, refractile globules very few, pigmentation mild and pigmented granules aggregated in longitudinal rows. Paired eye-spots with non-pigmented lens. Four pairs of setae on the body, the first pair situated a little above the level of eye-spots and the remaining three pairs in the posterior half of the body. Tail set in a pocket and measures 350—500 × 35—65. Dorsal, ventral and lateral finfolds present.



Figs 7—10. Cercaria sp. IV Kerala: 7 — General organisation; 8 — Diagram showing spination at the anterior end of the cercarial body; 9 — Diagram showing exretory and nervous system; 10 — Redia.

Oral sucker with a diameter of 32—50. Penetration glands seven pairs, completely occupying the mid portion of the body and encircling the genital rudiments and excretory bladder. Gland cells contain granular protoplasm and the ducts of these glands are grouped into four bundles of 3, 4, 4, 3 pattern and open at the oral sucker. Pre-oral spines in three rows consisting of 4,5 and 7 spines. Acetabulum absent, mouth sub-terminal and the digestive tract consists of a prepharynx and pharynx. Excretory bladder thick-walled and transversely oval. The cells constituting the wall have granular protoplasm and the lumen of the bladder contains 20—30 vacuoles. Flame cell formula 2(3+3+3+3+3) (Fig. 6). No trace of a caudal excretory duct. Genital system represented by a mass of cells situated anterior to the excretory bladder. Nervous system consists of two masses of cells on either side of the prepharynx and connected by nerve fibres and the anterior and posterior nerve cords (Fig. 6). Early development of the cercariae takes place in palebrown redia measuring 875—1250 × 135—190.

Cercaria sp. IV Kerala (Fig. 7). Snail host — *Digoniostoma pulchella* (Benson), Location — Hepatopancreas, Locality — Trivandrum District, Incidence of infection — 22/380, Season — October.
Cercaria not very active, fairly large and visible to naked eye. It stops suddenly while swimming and keeping the tail upwards floats freely in water. During locomotion, the tail moves first and the body is drawn behind. In this locomotory behaviour, this species resembles most of the furcocercous cercariae. Body capable of independent contraction and extension and during contraction the body assumes a triangle shape. Body pyriform in normal state with the maximum width at level of or slightly posterior to acetabulum. Cercariae emerge in large numbers at noon between 1 and 3. Larvae do not exhibit geotaxism and are found at all depths in water.
Body measures 250—375 × 175—225. Brown pigments sparsely distributed in the posterior half of the body. Spination restricted to the level of the posterior margin of the oral sucker (Fig. 8). First three rows of spines very large. Parrot-beak shaped spines measure 10—12 in length. Below this are seen two rows of slightly smaller spines and after a gap the third set of spines is seen consisting of 10—11 rows. The size of the spines decreases as they run posteriorly. Eighteen pre-oral spines in double rows. Setae absent on the body. Cystogenous cells numerous with granular material. Paired eye-spots with conspicuous lens and each eye has two identical units.

Oral sucker circular or slightly oval shaped with a measurement of 50—62 × × 40—50. Acetabulum equatorial or slightly post-equatorial and has a diameter of 37—50. Tail with well developed finfolds measures 325—425 × × 87—105. Lateral finfolds extend the whole length of the body but the dorso-ventral finfold is restricted to a small portion at the posterior end. Mouth sub-terminal and prepharynx long and narrow. Globular pharynx has a diameter of 20—25. No trace of oesophagus and intestinal caeca. Nine pairs of penetration glands arranged in three groups — one group of four gland cells at level and on either side of the acetabulum, two groups of four gland cells between the pharynx and acetabulum and the remaining two gland cells situated medially just below the pharynx. Gland cells with well defined nuclei and coarsely granular protoplasm. The triradiate excretory bladder is thick-walled. The main excretory duct runs anteriorly to the level of acetabulum, divides into two, one running anteriorly and the other posteriorly. Flame cell formula — $2(3+3+3+3+3+3+3+3) = 48$. Nervous system represented by two masses of cells situated on either side of the prepharynx and connected by transverse nerve fibres and, paired antero-lateral and postero-lateral nerve cords (Fig. 9). Rudimentary reproductive system seen as a mass of cells situated in between the acetabulum and excretory bladder.

Redia pale-white coloured and measures 525—1450 × 125—225 (Fig. 10). Appendages absent. Pharynx has a diameter of 45—70. Digestive tract very short. Development of the cercariae completed outside redia in the tissues of the snail.

DISCUSSION

Except for slight difference in size, the descriptions of *Cercariae indicae* XXVI and *Cercariae indicae* XXIX agree with those given by Sewell (1922). *Cercaria* sp. I Kerala is compared with other amphistome cercariae characterised by the presence of coiled exretory ducts around the caeca. *Cercaria diastropha* (Cort, 1915) differs from *Cercaria* sp. I Kerala in the following characters: oral sucker provided with two pouches and the margin of the sucker lacks papillae, the descending ducts of the excretory system bifurcate slightly below the level of the eye-spots and the testes tandem but situated apart. *Cercaria corti* (O'Roke, 1917) is comparatively larger measuring 940 in length; papillae absent on the oral sucker and a constriction present between the oral cavity and oesophagus. Descending limbs absent in the excretory system and genital anlagen represented by two masses of cells situated closely. In *Cercariae indicae* XXI (Sewell, 1922) pharyngeal pouches are present but oesophageal bulb absent. Intestinal caeca terminate on either side of the acetabulum in a spirally coiled manner. *Cercaria kylasami* (Rao, 1932) lacks an oesophageal bulb but the distal part of the oesophagus is muscular and the ducts of the two intestinal glands open into a common atrium at the centre of the muscular portion of the oesophagus. The retrograde excretory tubules filled with excretory granules. In *Cercaria bareillyi* (Peter and Srivastava, 1960), oral pouches and gland cells associated with oesophageal bulb present. Retrograde excretory duct divides immediately after its origin and testes though tandem are situated apart on either side of the uterus. The diffetences that are noticed in *Cercaria mathurapurensis* (Mukherjee, 1968) are the presence of pharyngeal pouches and the stright course of the intestinal caeca. Pigmentation is restricted mostly to the region in between the caeca at the anterior half of the body and a major part of the posterior portion of the main excretory tubes is devoid of excretory granules.

From the comparative study it is obvious that the cercaria in question is hitherto unrecorded and hence it is treated as a new species.

The measurements and description of *Cercariae indicae* VIII agree with those given by Sewell (1922). The excretory system has been worked out in detail and the presence of setae on the body noticed.

Cercaria sp. III Kerala is compared with *Cercariae indicae* VIII Sewell (1922), *Cercariae indicae* VII Sewell (1922), *Cercaria gomtiensis* Premvati (1956), cercaria *Stellantchasmus falcatus* Martin (1958), cercaria *Haplorchis yokogawai* Martin (1958), cercaria *Haplorchis taichui* Martin (1958), *Heterophyes cercaria* I Martin (1959), *Heterophyes cercaria* II Martin (1959), *Hetero-*

phyes cercaria III Martin (1959) and *Cercaria pinjorensis* Gupta and Taneja (1969).

In *C. indicae* VII, eye-spots are conical and 17 pairs of penetration glands are present. A caudal excretory duct passes into the tail, sensory hairs absent on the body and genital organs already differentiated. *C. indicae* VIII is comparatively larger and heavily pigmented. Ten pairs of setae on the body, flame cell formula different and the genital rudiments spherical in shape. In *C. gomtiensis*, the lateral finfolds and the dorso-ventral finfolds clearly demarkated and the structure of the eyes and position of the penetration glands different. Excretory bladder fairly large occupying the posterior third of the body. Flame cells six pairs and the redia characterised by the presence of lateral appendages. In the cercaria *S. falcatus*, the left eye-spot is double and the right single. The number of pre-oral spines varies. Rudimentary acetabulum and intestine present. Both cercaria *H. yokogawai* and cercaria *H. taichui* have caudal finfolds but different in disposition from that of *Cercaria* sp. III Kerala. Cercaria *H. yokogawai* is very small but cercaria *H. taichui* is considerably larger than the present form. These two cercariae differ further in the structure of eye-spots, presence of rudimentary acetabulum and gut. Each of these cercariae has twenty four flame cells in groups of two and a caudal excretory duct which bifurcates a short distance from its origin and opens laterally. *Heterophyes cercaria* I, II and III have caudal finfolds almost similar to those of *Cercaria* sp. III Kerala, but in the structure of eye-spots, excretory bladder and in the disposition of penetration glands, these forms differ from *Cercaria* sp. III Kerala. *Cercaria pinjorensis* though it resembles with the present form in the number and position of penetration glands, shows difference in size of the body and in having 27—30 spines surrounding the mouth. Further it is characterised by the possession of a solid dome-shaped structure bearing 15 spines in two rows and a typically rounded excretory vesicle.

It is evident from the discussion that the present form is different from those already described and hence it is considered as a new species.

When *Cercaria* sp. IV Kerala is compared with *Cercariae indicae* XXXI Sewell (1922), *Cercariae indicae* L Sewell (1922), *Cercaria parvomelaniae* Tubangui (1928) and cercaria *Centrocestus formosanus* Martin (1958), it becomes clear that the present species shows marked differences although there is overall resemblance in the shape of the body and in the presence of a caudal finfold.

Cercariae indicae XXXI is slightly smaller and the anterior half of the body is armed with spines. Refractile globules scattered all over the body. Lateral finfold extends the whole length of the body but a dorso-ventral finfold is absent. The eight pairs of penetration glands are arranged in two groups on either side of the acetabulum, the anterior group of cells being smaller. Excretory bladder has its long axis set transversely to the body length and there are only two pairs of flame cells. A caudal duct is present in *C. indicae* XXXI. *Cercariae indicae* L is also smaller than the present form. Pigmented eye spots are conical and the whole body is covered with backwardly directed spines. Penetration glands fifteen pairs. Excretory bladder broader than long and the sides thrown into folds. A caudal excretory duct present and there are only six pairs of flame cells. Redia characterised by the possession of salivary glands. *Cercaria parvomelaniae* differs in the structure of the eyes, in the absence of prepharynx and in the number and disposition of penetration glands. Acetabulum absent and the shape of the excretory bladder different. Cercaria *C. formosanus* though biocellate, left eye is double and right one single. Light-brown granules scattered throughout the body. Lateral finfold absent and the dorso-ventral finfold poorly developed. Acetabulum absent but a short oesophagus and rudimentary intestine present. There are only seven penetration glands on each side forming a single group and the excretory system is totally different.

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THE EFFECT OF LARVAL STARVATION ON THE DEVELOPMENT OF METASYRPHUS COROLLAE (DIPTERA)

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Abstract: Feeding by larvae of *Metasyrphus corollae* (Fabricius) of different age on the adult aphids *Acyrthosiphon pisum* Harris is described. Prey handling time and the length of periods without feeding are compared during the larval development. The effects of short term starvation on the larval and pupal development are studied in larvae of various age. The developmental characteristics of the syrphid larvae on the food consumption reduced in the second and third instars are given.

The polyphagous larvae of *Metasyrphus corollae* (Fabr.) are voracious feeders of many aphid species (Okuno, 1967; Růžička, 1975). The females for which the main oviposition stimulus are aphids (Volk, 1964) lay eggs close to or directly into aphid colonies (Chandler, 1968) thus providing the young larvae with sufficient food. The aphid colony where the egg is laid does not always enable the larvae to complete the whole development, because it is often destroyed by older syrphid larvae, other predators (Pollard, 1969) or parasites. The larvae forced to search for other aphids may either find dense colonies in which they complete the development or their food supply is permanently limited by low aphid infestation. There is still unsufficient knowledge of how such food shortages can affect these predators. The present study was conducted to bring more information about their food requirements as well as their feeding behaviour.

MATERIALS AND METHODS

The laboratory culture of *Metasyrphus corollae* (Fabricius) was established in 1971 from adults collected near Prague. Wing amputated flies were reared on *Corylus avellana* pollen, fructose solution and water, the larvae fed on *Acyrthosiphon pisum* Harris from *Vicia faba*. The culture was maintained at 20 °C, 55—70 % r.h. and 16 hours photophase for several generations before the experiment started. In the experiments which were conducted under the same abiotic conditions *A. pisum* was also provided as prey for the larvae.

Prey handling time and duration of the periods without food consumption were registered in singly reared larvae. On the fourth day (2nd instar larvae) and every following day (3rd instar larvae) ten larvae were transferred from rearing cells into Petri dishes (5 cm diam.) with moist filter paper and size selected aphids (each 1.8 mg). The succesfully captured aphids were replaced by new ones. Tarsi of captured aphids had to be cut off if the larva did not succeed to lift the prey above the surface. This was mainly the case in four days old larvae which would otherwise loose their prey.

The effects of short term starvation in the larval stage on the development of *M. corollae* were investigated in series of 20 larvae from a stock culture of individually reared larvae. At the age of 24, 72, 120 and 168 hrs the larvae were left in their cells without aphids for 20 hours. Before and after the period without food they were provided with freshly collected aphids in surplus. The age difference between the larvae in the whole experiment was less than two hours.

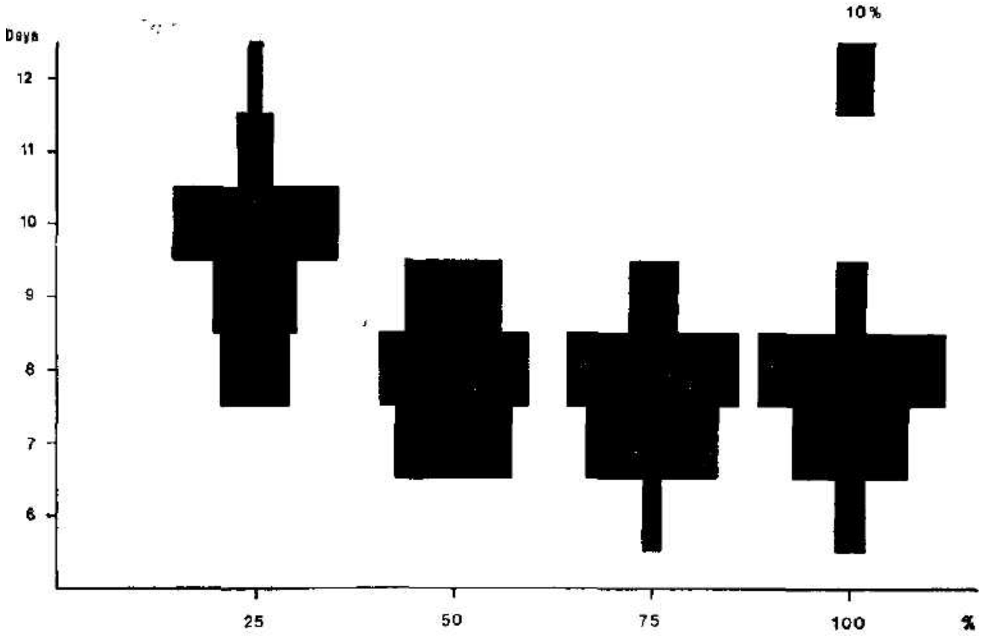

Fig. 1. Occurrence of defecations in relation to food reduction degree.

The influence of permanent food reduction during the second half of the larval period was studied in series of 30 larvae from a similarly bred stock culture. Four days after hatching the larvaes of each series were transferred into the rearing units in which during the further development their daily food supply represented approximately 25, 50 and 75 % of the optimum consumption found in 15 larvae reared on *A. pisum* in surplus (adult aphids of the same size, mean weight 1.89 mg). The age difference between the larvae in each series of this experiment was less than two hours. The daily amount of aphids given to the larvae is given in Table 1.

RESULTS AND DISCUSSION

Larval age and predation

In the stock culture the newly enclosed larvae of *M. corollae* preyed sometimes on aphids considerably exceeding the predator in size. The larvae

Table 1. The reduction of daily food supply for *Metasyrphus corollae* larvae during the second half of the development

Day	No. of adult aphids *Acyrthosiphon pisum* Offer when food reduced to approx. 25 %	50 %	75 %	Mean optimum consumption
5th	3	6	9	10.7
6th	6	12	20	26.2
7th	6	12	20	25.9

On the 8th and every following day the quantity was given as on the 7th day

Table 2. Variation of preying activity in relation to the age of *Metasyrphus corollae* larvae

Age of the larvae (days)	No. of handled aphids	% of aphids sucked out from				Mean time needed for sucking the prey from 1/2		Mean interval between two feedings
		1/3	1/2	2/3	completely		completely	
4	24	58.3	20.8	12.5	8.3	46′33″	39′40″[1]	43′49″
5	20	25.0	20.0	10.0	45.0	12′27″	16′07″	35′00″
6	30	0	16.6	6.6	76.6	3′24″	8′19″	54′49″
7	30	6.7	16.7	3.3	73.3	4′52″	7′38″	52′14″
8	22	0	27.3	0	72.7	4′29″	8′47″	40′33″

[1] Mean time needed for sucking the prey completely affected by low n of the aphids.

Table 5. Changes in the development of *Metasyrphus corollae* from the day of food reduction

Daily amount of aphids offered (% of optimum consumption)	Occurrence of the second moult (day)	Aphids consumed from the 4th day			Mean weight increase after the 4th day		Average No. of defecations from the 4th day
		No.	weight (mg)	(%)	(mg)	(%)	
100	4.9	65.0 ± 12.2	122.9	100	26.6	100	2.3
75	5.3	49.7 ± 6.3	93.9	76.4	23.9	89.8	2.1
50	5.3	39.9 ± 6.5	75.4	61.3	20.7	77.8	2.5
25	5.2	29.9 ± 3.6	56.5	46.0	12.1	45.5	1.3

penetrated the cuticle of these aphids regularly on the ventral side near the coxas. The resulting colour of the gut and growth of the larvae indicated *that ingestion had occurred. Feeding on a single aphid lasted usually few* hours. Some larvae preyed in intervals, resting between them under the prey. On each occasion they renewed the contact with the aphid. The aphids were often not sufficiently disturbed by the presence of the predator and continued sucking on the plant. Some of them were sucked out almost completely but did *not* escape. *Dissappearance of habitual response to predation and* consequent lack of mobility seem to be results of an intoxication by a substance injected into their body by young larvae. Prey paralysing substances are used by 1st instar larvae of some Coccinellidae (Brown, 1972).

Four days old larvae of the 2nd instar often contacted and seized the aphids *on their leggs or antennae. Thereupon the larvae slowly advanced their* mouthpart on the surface to thorax or abdomen of the aphid which lasted 10—40 seconds in spite of prey resistance. The reaction of the older larvae changed in similar situations. If the contact was made on prey extremities the larvae repeated as a rule food searching movements in the near vicinity *of the first encounter until they reached a suitable part of the aphid body.* Larvae in the age of five and more days (3rd instar) usually lifted easily and preyed the captured aphids above the surface. Table 2 illustrates the main results of the tests. According to Láska (1959) predation in syrphid larvae is resumed soon after the defecation. Also our observations prove, that larvae *of M. corollae which defecated are able to attack aphids almost immediately* after it. In accordance with it the longest period without food intake was not in the larvae which during this time emptied their gut.

Effect of temporary starvation at different age

The starvation which lasted 1/10 of the normal larval period influenced the development of *M. corollae* in every age category tested in the present experiment (Table 3). Bombosch (1962) recorded unaffected length of the larval development and contemporary decrease of the total food intake to 57 % in larvae of *M. corollae* deprived of aphids on the third day after the second moult. Larvae deprived of food immediately after the second moult lenghtened their development. He reared the larvae on a mixture of aphids *Aphis fabae* Scop. and *Myzus persicae* Sulz. at 22 °C and 55 % r.h.

We observed significantly longer larval development in all treatments ($P < 0.001$). The puparial weight of the larvae deprived of food on the 2nd, 4th, 6th and 8th day decreased to 96.9 %, 91.9 %, 92.8 % and 76.9 % of the normal weight. The differences were significant on the fourth ($P < 0.02$), sixth ($P < 0.05$) and eighth ($P < 0.001$) day. The length of pupal development did not seem to be affected. The mortality rate of the larvae at the time when food was absent was not higher than in the following period when larvae were returned to their diet. The total mortality during the whole development increased most when food was not available around the second moult.

Effects of daily food reduction

In our experiments, food intake was not reduced on the 1st—4th day when larvae of *M. corollae* ate an average of 0.09, 0.45, 1.45 and 4 aphids. In the

Table 3. The effects of 20 hrs starvation on larval and pupal development of *Metasyrphus corollae*

Larvae deprived of food on day	No. of larvae of M. corollae	Mortality No. of indiv.		% total	Mean time of development in days		total	Mean weight and S.D. of puparia in mg	Sex ratio males : females
		larvae	pupae		larva	pupa			
–	20	2	3	25.0	8.1	7.9	16.0	32.0 ± 1.8	1.5
2	20	6	2	45.3[1]	10.3	7.9	18.2	31.0 ± 3.1	0.7
4	20	10	2	65.9[1]	10.6	8.0	18.6	29.4 ± 3.0	0.3
6	20	4	7	63.0[1]	10.3	7.6	17.9	29.7 ± 3.0	0.8
8	20	3	2	40.7[1]	8.9	7.7	16.6	24.6 ± 2.4	0.5

[1] In the calculations of the total mortality values the following formula has been employed:

$$M = \frac{(t + a)\,100}{t + n} \quad \text{where} \quad t = \frac{n\,m}{100 - m}$$

M – total mortality (in %)
m – mortality of the larvae (in %) before the starvation period started – in our experiment represented by mortality of 100 individually reared larvae at corresponding time (24, 72, 120 and 168 hrs)
t – theoretical number of the larvae which died before the starvation period started
a – No. of individuals which died after the starvation period started
n – No. of larvae when the starvation period started

nature, the food intake of syrphid larvae is probably most often restricted by the quantity of available food in the second half of the development when food demands increase considerably. The larval food consumption in the first four days was 6.0 ± 1.7 aphids which represents only 8.5 % of the total amount of the aphids eaten during the whole larval development (71.0 ± 12.5 aphids). The weight of the four days old larvae was 5.0 ± 1.1 mg. This corresponds to 15.4 % of the puparial weight. Extensive weight losses in the 3rd instar, when the larva empties the gut before the puparium is formed and unnoted feeding on the aphids during the first days of the larval development explain the seeming contradiction between the percentages mentioned above. In addition the puparium looses 7 % of its weight during the first day (Benestad, 1970). In our experiments two days old puparia were weighed.

A positive correlation was observed between the degree of daily food reduction and the larval prey searching activity. On the seventh and eighth day of development the hungry larvae which had food reduced to 25 % captured all aphids offered. This applies also to the correlation between the degree of food reduction and the extent to which the prey was sucked out. The larvae always sucked out the aphids thoroughly in the series where the food was limited to 25 % and 50 %.

In the cells with larvae reared on unlimited food we found occassionally mobile aphids bearing signs of the larval attack. These aphids were even able to survive for several days in spite of the fact that some of them were noticably sucked out. In addition we observed during the experiment that larvae preyed also on already dead aphids though living prey was available. If more than 1/3 was sucked out the aphid was considered as eaten.

Prolongation of larval development was found to be positively correlated with the degree of food reduction. Similar correlation was found also between the puparial weight and the amount of offered aphids (Table 4). It is surprising that in the groups where the daily offer was reduced to 25 % the mortality of the larvae was nil and the pupal mortality did not increase though the weight of the puparia in this series decreased distinctly (54.1 % of the weight of the normal puparia).

The comparison of the results illustrated in Tables 4 and 5 shows that the larvae of *M. corollae* were partly able to compensate for negative effect of increasing food shortages by gradual prolongation of their 3rd instar which enabled them to gain additional food. The individuals which died before reaching the adult stage were not included in the calculations of the mean values for they would blind some of the results. E.g. in the series of the larvae for which the food was reduced to 75 % only the heaviest pupae died, while in the group reared on 25 % food only the lightest pupae did not complete their development.

According to Benestad (1970) larvae of *M. corollae* are not able to complete their development on 2 aphids *M. persicae* per day (at 8–28 °C; unlimited food consumption throughout the development was 307 aphids). Exceptionally, they are able to survive under such conditions to the 3rd instar and produce even an extra 4th instar which is never found under adequate food conditions.

Fig. 1 illustrates the time distribution in defecations of the larvae reared on various quantities of food. The individuals which died are not included.

Table 4. The effect of food reduction from the 4th day of larval stage on the development of *Metasyrphus corollae*

Daily amount of aphids offered (% of optimum consumption)	No. of larvae of *M. corollae*	Mortality No. of indiv.		%	Mean time of development in days			Mean weight and S.D. of puparia in mg
		larvae	pupae	total	larva	pupa	total	
> 100	15	2	2	26.6	8.1	8.0	16.1	31.6 ± 1.7
75	30	5	3	37.6[1]	8.3	8.0	16.3	28.9 ± 3.1
50	30	3	6	40.4[1]	8.7	7.8	16.5	25.7 ± 2.3
25	30	0	6	31.9[1]	10.3	7.8	18.1	17.1 ± 0.9

[1] Corrected mortality (see the text below the Table 3)

Their larvae either did not empty the gut at all or defecated with abnormal delay.

SUMMARY

All age categories of the larvae of *Metasyrphus corollae* (Fabricius) are able to attack succesfully adult aphids *Acyrthosiphon pisum* Harris. The manner of capturing and handling prey depends on the age of larvae. Handling time in the larvae at the end of the 2nd instar is about five times longer than at the end of the 3rd instar. Resting intervals from 2nd to 3rd instar varies slightly between two successful encounters. The larvae are capable of feeding immediately after the defecation.

Temporary food absence lasting 1/10 of the normal development significantly prolongs larval development, decreases the weight of the puparia and increases the mortality. The weight of puparia is the lowest when food is not available at the end of 3rd instar, but at this time the mortality increase is the smallest.

The more the daily food supply at the end of the 2nd and during the 3rd instar is restricted the longer is the larval development and the lighter are puparia. Daily restriction of food supply to 25 % of the optimum consumption does not result in an increase of the mortality though after such treatment the pupal weight declines substantially. The permanent reduction of food supply at the end of the 2nd and in the 3rd instar seems to be less harmful to the development than the complete absence of aphids lasting only 1/10 of the normal development at any time of the larval period. The utmost reduction, 6 aphids *A. pisum* (1.9 mg each) per day, enable satisfactory development of the larvae of *M. corollae*.

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SITEROPTES PROKOPIUS SP. N. (ACARI, PYEMOTIDAE), A MITE FROM FODDER DEVELOPED FOR LARGE-SCALE CATTLE REARING

KAREL SAMŠIŇÁK

Received September 10, 1975

Abstract: *Siteroptes prokopius* sp. n. is described from a new plant-produced proteinic cattle feeding substance. Notes on the taxonomy of the genus *Siteroptes* Amerling, 1861 are given.

New forms introduced to agricultural management have brought forth new problems concerning theoretically various scientific fields. The situation is particularly marked in the field of large-scale meat production in view of an evident lack of classical food which, under these new conditions, will hardly be available in the quantities required. This calls for the development of new, untraditional substances. Since the composition of new cattle fodder differs from that of classical fodder to a considerably degree, we shall have to anticipate the incidence of as yet unknown pests. This assumption has been confirmed by the finding of a large number of mites in a new, plant-produced proteinic feeding substance.

Siteroptes prokopius sp. n.

Ungravid female: Body elongate, spindle-shaped, opaque, length 260 μm (without gnathosoma), width 126 μm.

Dorsal side: Anterior margin of propodosoma almost semispherically raised, margin moderately convex. Hysterosoma narrow, posteriorly attenuated, posterior body margin widely rounded. Vertical setae hardly shorter than setae scapulares internae (19 μm). Scapulares externae 45 μm. Pseudostigma 22 μm, with a droplike extension at its tip. Stigmata small, in dense arrangement. Setae humerales internae 22 μm, externae 45 μm, dorsales 27 μm, lumbales internae 30 μm, externae 22 μm, sacrales internae 29 μm, externae 20 μm.

Ventral side: All coxal fields closed. Both fields I and II and fields III and IV closely adjoining one another. Interval between field II and III of considerable width, roughly equal to length of field III. Coxal setae of similar length (12 μm). Fields I and IV armed with two each of these setae, fields II and III with three each. One pair of setae poststernales externae (14 μm) situated in first quarter of opisthosoma. Three pairs of setae caudales on tip of opisthosoma; of these setae caudales externae are longer (20 μm), the remaining two pairs are microchaetae.

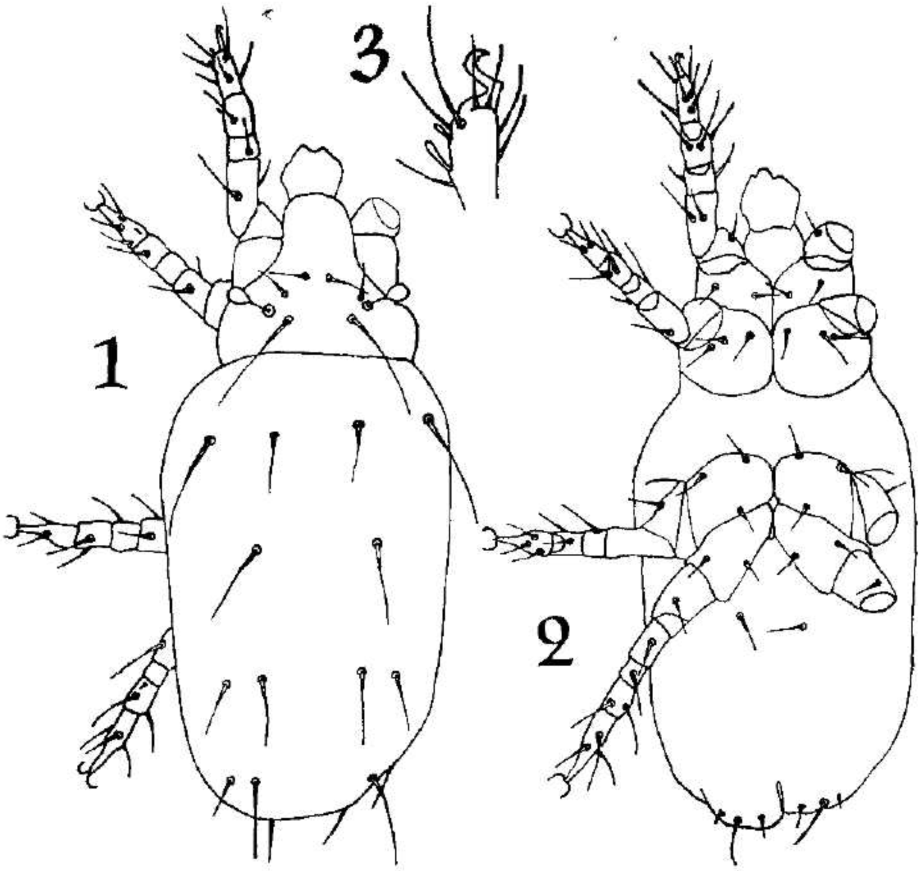

Fig. 1. *Siteroptes prokopius* sp. n. — Ungravid female: 1 — dorsal view, 2 — ventral view, 3 — tarsus I.

Legs I composed of five movable segments. Tarsus terminated in a single, normally formed hook. Lateral side of tarsus armed with two club-shaped solenidia, *of which the apical solenidium attains half the length of the distal* solenidium. Femur with four setae. Tarsi of remaining legs terminate in a pair of claws, trochanters of legs I—III triangular, trochanter IV quadrangular.

Locality. Brno-Medlánky. Veterinary Research Institute. Large numbers of this mite were present on crushed straw saturated with a nutritive soluation containing mainly urea. Lgt. ing. Jílek — Dr. Lauterer 1975.

Holotypus: Female deposited in the collection of the Institute of Parasitology, Czechoslovak Academy of Sciences, Prague, Coll. Samšiňák, no. 1581 A. Paratypes dto. Larval stages and male unknown. In addition to the new species, the substrate harboured *Pediculaster mesembrinae* (R. Canestrini, 1881) (Pyemotidae) and *Sancassania michaeli* (Oudemans, 1924)

(Acaridae). The typical site of incidence of the two species is mouldering vegetation (manure, compost).

Differential diagnosis: According to the revision by Crosse (1965) and Mahunka (1970, 1972), the new species has been listed to the genus *Siteroptes* Amerling, 1861. It belongs to a small group of species arranged by Krczal (1959) to the genus *Pygmephorus* Kramer, 1877. The species concerned are mainly *Siteroptes priscus* (Krczal, 1959), *S. absidatus* Crosse, 1965 and *S. soliter* Mahunka, 1969. Our species differs from the first species in the length of the dorsal setae and particularly in a marked difference of the humeral setae. In addition to minute differences in the chaetotaxis of the dorsal side, the remaining two species differ from our new species in a different length ratio of the setae caudales.

What is the taxonomic position of *Siteroptes cerealium* Kirchner, 1864?

The description of the new species appears to be a proper occasion for discussions on the validity of the species *Siteroptes cerealium* Kirchner, 1964. In spite of the fact that it represents a typus generis, it is generally referred to as a nomen nudum.

The problem of the validity of this species has not received a unanimous opinion in the literature. Differences in views expressed by the various authors have to be ascribed to the fact that recently introduced rules on the validity of generic and specific names have been applied to description from the last century although these rules should be applied to species described after the year 1930.

Amerling (1861) gave a valid description of the genus *Siteroptes.* It is excellent for its time, particularly the part concerned with diseases of cereals caused by this mite. Amerling collected his mite material from the area of today's Great Prague, but these lots were covered half a century ago. In spite of that the mite can still be found in the surrounding of Prague. Although the typus generis has not been given in Amerling's description, this has not affected the validity of the species. The species was named by Kirchner in 1864, who called it *Siteroptes cerealium.* He referred to Amerling as to the author of the species, but according to Article 50 of the International Code of Zoological Nomenclature. "The author of a scientific name is the person who first publishes it".

A comparison of the mite material from the vicinity of Prague with descriptions and materials from Oudemans' collection indicated that the former is identical to the species *Siteroptes graminum* (Reuter, 1900).

Valid data:

Siteroptes Amerling, 1861

Typus generis: *Siteroptes cerealium* Kirchner, 1864

Syn. *Pediculoides graminum* Reuter, 1900 syn. nov.

This means that the most accurately described and longest known species with considerable economic importance becomes the typus generis.

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A COMPARATIVE STUDY ON THE TONGUE OF SOME INDIAN FRESHWATER TELEOSTS

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Received October 25, 1974

Abstract: A small tongue is present in *Xenethodon cancila, Botia dario, Colisa fasciata* and *Chatoessus manminna*. The tongue in all the above fishes consists of mucosa, submucosa and skeletal support. The mucosa is made up of stratified epithelial cells. The taste buds are present in the tongue mucosa of *Xenentodon cancila, Botia dario* and *Chatoessus manminna* but absent in that of *Colisa fasciata*.

The tongue of the fish is a most primitive structure as compared with the tongue of other higher animals. Contradictory opinions exist about the tongue in fishes. It may be quite distinct, rudimentary or absent.

Countless accounts on the anatomy and histology of the digestive tracts of fishes inhabiting different waters are available, but there is paucity of information on the morphology and histology of the tongue. Some of the important contributions on the study of tongue are of Haller (1904), Wiedersheim (1907), Bridge (1932), Marcus (1934), Matui (1936), Suyehiro (1942), Kapoor (1957) and Khanna (1962).

This study has been attempted to extend the range of observations on this topic with a view to enrich the existing information. Here, the observations on the tongue of some freshwater teleosts, namely, *Xenentodon cancila* (Ham.) — Belonidae, *Botia dario* (Ham.) — Cobitidae, *Colisa fasciata* (Bl. & Schn.) — Anabantidae and *Chatoessus manminna* (Ham.) — Dorosomidae are presented.

The reported histological examination, in each case, is based on the fixation of the living tissue in Bouin's fluid and 5% formalin and on the 7 µm sections stained with Delafield's haematoxylin and eosin.

OBSERVATIONS

The tongue in *Xenentodon cancila* is elongated. The whole structure is attached with the floor of the buccal cavity. The tongue in *Botia dario* is a thick, small and triangular structure. Only the anterior tip of the tongue is free. In *Colisa fasciata* the tongue is small and rudimentary. The tongue freely projects in the buccal cavity. In *Chatoessus manminna* the tongue is thin and is partially covered over by the mandibular valve.

Histologically, the tongue of all the fishes studied is composed of mucosa and submucosa which is backed up by a cartilaginous plate. The thickeness of the mucosa varies in different fishes. It is about 50 µm thick in *Xenentodon cancila* (Fig. 1), 56 µm in *Botia dario* (Fig. 2, 3) and 35 µm in *Colisa fasciata*

(Fig. 4) and *Chatoessus manminna* (Fig. 5). The mucosa is made up of stratified epithelial cells in all the fishes studied. The upper layers of mucosal cells are polygonal, while the basal one is columnar in form. The form of middle layers of mucosal cells may be either elongated (*Xenentodon cancila* and *Botia dario*) or round (*Colisa fasciata*). The mucosa is destitute of the mucous cells and club cells in *Xenentodon cancila*, *Botia dario* and *Colisa fasciata*. The mucous cells are sparse in the mucosa of *Chatoessus manminna*. The taste buds are present in small numbers in the mucosa of *Xenentodon cancila*, *Botia dario* and *Chatoessus manminna*. It is entirely absent in *Colisa fasciata*. The taste buds in *Chatoessus manminna* rest on submucosal eminences, and flush with the outer margin. The taste buds in Botia dario are approximately 35 μm long and 21 μm wide, while those of *Chatoessus manminna* are 14 μm long and 7 μm wide. A few eosinophilic granular cells are found in *Chatoessus manminna*. The basal membrane is not distinct in any fish. The submucosa, in all the fishes examined, is composed of connective tissue fibres. It is thin and densely disposed in *Xenentodon cancila* and *Chatoessus manminna* and thick and loosely arranged in *Botia dario* and *Colisa fasciata*.

DISCUSSION

On comparison with the oro-pharyngeal lining, one tends to believe that the tongue, wherever present, has generally almost an identical structure.

The tongue mucosa of *Xenentodon cancila* and *Botia dario* possesses taste buds but lack in mucous cells and club cells. The mucous cells and taste buds are entirely lacking in the mucosa of the tongue of *Colisa fasciata*. The tongue mucosa of *Chatoessus manminna* has scanty mucous cells and taste buds.

The occurrence of the mucous cells and the taste buds are recorded in the mucosa of the tongue in *Cyprinus carpio* (Curry, 1939), *Ophicephalus gachua* (Islam, 1951), *Clarias lazera* (Al-Hussain and Kholy, 1953),*Glossogobius giuris* (Mohsin, 1962), *Catla catla*, *Barbus stigma* and *Gudusia chapra* (Kapoor, 1957). In addition to the mucous cells and the taste buds, Kapoor (1957) also observed the club cells in the tongue of *Wallago attu*.

The occurrence of taste buds in the tongue of fishes has led me to conclude that they have a gustatory significance.

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

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STUDIES ON THE MORPHO-HISTOLOGY OF THE ALIMENTARY CANAL OF FRESHWATER FISHES OF INDIA

PART I. THE ALIMENTARY CANAL OF YOUNG CIRRHINUS REBA (HAM.) WITH A COMPARISON WITH THAT OF THE ADULT IN RELATION TO FOOD

G. M. SINHA & S. K. MOITRA

Received January 15, 1975

Abstract: Adult *Cirrhinus reba* (Ham.) is a herbivorous, common minor carp of Indian freshwaters. Freshwater adult carps of India are herbivorous as adults and zooplankton feeders (carnivorous) in the young condition. The alimentary canal is adapted in its morpho-histology to the food in fishes and undergoes changes in *Cirrhinus reba* during the different stages of its life history. The morpho-histology of young *Cirrhinus reba* is described and compared with that of the adult.

INTRODUCTION

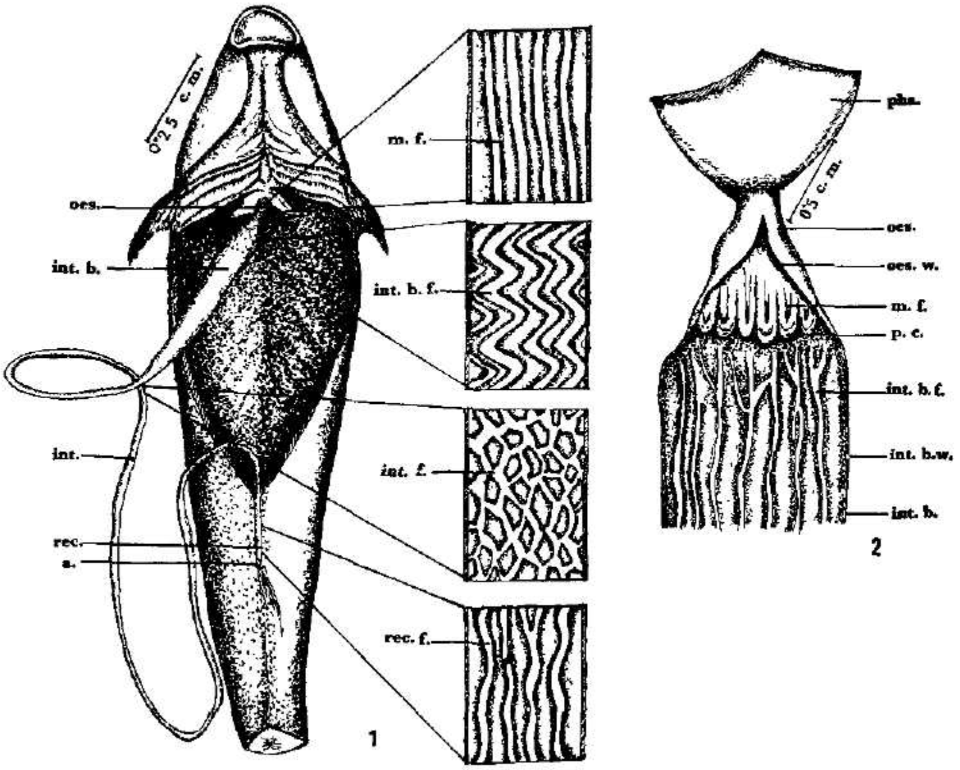
Studies on the morpho-histology of the digestive system of the adults of several fishes are on record (Sarbahi, 1940; Islam, 1951; Khanna, 1962, 1968; Khanna and Pant, 1964; Khanna and Mehrotra, 1970, 1971; Kapoor, 1953, 1957a, b; Pasha, 1964; Sehgal, 1966; and Moitra and Sinha, 1971a, b), but the changes brought about in the alimentary canal as a result of adaptation to feeding habits during the life history of fishes have not been studied so far in a comprehensive way (Sinha and Moitra, 1974).

It has been established by various workers (Mookerjee and Das, 1945; Islam, 1951; and Das and Moitra, 1963) that in herbivorous fishes the relative length of the gut (R.L.G.) is high while in carnivorous fishes it is low with intermediate values in the omnivorous ones. The same sequence of changes is possible in fishes which change their food habits in the different stages of their life history. Preliminary studies on young *Catla catla* have been made by Moitra and Bhowmik (1967) and some freshwater carps by Sinha (1973).

The present communication relates to detailed observations on the morpho-histology of the young C. reba with a comparative account of that of the adult.

MATERIAL AND METHODS

50 young *C. reba* (2.5 to 3.0 Cms.) were collected from the Damodar river near Sadarghat, Burdwan, during the period June to October, 1969. The fishes were dissected and the entire alimentary canal fixed in alcoholic Bouin's for 18 to 24 hours. Transverse serial sections at 4 to 6 µm were made from the lip to the rectal regions. Sections were stained in Delafield's Haematoxylin and counterstained with Eosin. A few sections were stained with Mallory's triple stain. Sketches were drawn with the help of a mirror type camera lucida. The wall of the alimentary canal was cut longitudinally, mounted in glycerine and examined under a binocular microscope for studying the mucosal folds.



Figs. 1—2. Morpho-histology of the alimentary tract of *Cirrhinus reba* (young stage): 1 — Ventral view of the alimentary canal (slightly displaced) showing the uncoiled intestine and mucosal folds; 2 — The pyloric valve after making a longitudinal incision at the junction of the oesophagus and intestinal bulb.

ABBREVIATIONS USED IN FIGURES

a — anus, ad.t. — adipose tissue, b.c. — blood corpuscles, b.ca — blood capillary, b.m. — basement membrane, c.c.f. — circular connective tissues, c.ep. — columnar epithelium, c.m. — circular muscle, c.t. — connective tissue, c.w. — common wall, d.c.t. — deep connective tissue, fl. — floor, f.t.b. — formative taste bud, g.p. — gustatory pore, int. — intestine, int.b. — intestinal bulb, int.f. — intestinal fold, int.w. — intestinal wall, l.int.b. — lumen of intestinal bulb, l.m. — longitudinal muscle, l.oes. — lumen of oesophagus, l.p. — lamina propria, l.s. — lower surface, m. — mucosa, m.b. — muscle bundles, m.c. — mucous cell, m.f. — mucosal fold, nu. — nucleus, n.c. — neuroepithelial cell, oes. — oesophagus, oes.v. — oesophageal villus, oes.w. — oesophageal wall, pha. — pharynx, p.c. — pigment cell, pe.. — projecting end, r. — roof, rec. — *rectum, rec.f. — rectal folds, rect.M. — rete mucosum of Malpighii, s.c. — sustentacular cell,* ser. — serosa, s.m. — sub-mucosa, st.ep. — stratified epithelium, str.M. — stratum Malpighii, t.b. — taste bud, t.p. — top plate, t.pro. — tunica propria, u.s. — upper surface, v.int. b. — villus of intestinal bulb, w.c. — wandering cell.

OBSERVATIONS

Morphology and anatomy

The mouth is short, crecentric and bounded by the dorsal and ventral lips, the former being larger and partly covering the latter.

The tongue, a muscular diverticulum, is 0.01 mm in length and situated between the dorsal and ventral lips. The free end of the tongue measures 60 µm and is attached to the ventral lip. The attached portion measures 40 µm in length.

The alimentary canal comprises the buccal cavity, pharynx, oesophagus, intestinal bulb, intestine and rectum (Fig. 1). The mouth leads into a dorso-ventrally compressed buccal cavity. The pharynx is a posterior continuation of the buccal cavity and is laterally perforated by gill-slits. The anterior pharynx is respiratory while the posterior pharynx is masticatory in function. Two sets of horny, pointed pharyngeal teeth present on the interior pharyngeal bones are masticatory in function. The pharynx leads into a short, thick-walled *oesophagus and is 1 mm in length. This continues into* an intestinal bulb in the form of a distinct valve known as the pyloric valve which projects into the lumen of intestinal bulb (Fig. 2). The free end of the pyloric valve is produced into finger-like projections which are unequal in length. The valve is 170 µm in length while the projections of the distal free end measures 60 µm and remain protruded into the intestinal bulb. The lumen of the oesophagus is provided with longitudinal mucosal folds (Fig. 1).

The intestinal bulb, which is 3 to 4 times longer than the oesophagus and measures 4 mm in length is provided with zigzag mucosal folds (Fig. 1).

The region succeeding the intestinal bulb with a uniform but smaller calibre is the intestine proper and measures 6 mm in length. The intestine is distinguished by being provided with honeycomb shaped mucosal folds (Fig. 1). There appears to be no other morphological landmark to distinguish the intestinal bulb from the intestine.

The intestine leads into the rectum which is 3 mm in length. It is a very short tube and its lumen is almost of the same calibre as that of the intestine but possesses wavy mucosal folds (Fig. 1).

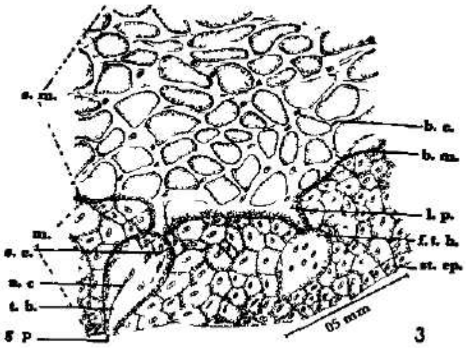
Histology

Lip:

The lip consists of an outer layer of epidermis or mucosa and an inner layer of dermis or sub-mucosa (Fig. 3). The epidermis is formed of a many layered stratified epithelium provided with a few formative and functional

Table 1. Showing the number, dimension and distribution of taste buds in different histological regions of the alimentary tract of young *Cirrhinus reba* (Ham.).

Regions	Number	Length in µm	Breadth in µm
Dorsal lip	few	37.5 – 45.0	7.5 – 15.0
Ventral lip	many	52.5 – 67.5	37.5 – 45.0
Skin of lip	few	67.5 – 75.0	37.5 – 45.0
Tongue	few	45.0 – 67.5	30.0 – 45.0
Roof of buccal cavity	*few*	37.5 – 45.0	22.5 – 30.0
Floor of buccal cavity	many	67.5 – 85.5	45.0 – 60.
Skin of buccal region	many	52.5 – 67.5	30.0 – 37.5
Roof of pharynx	few	52.5 – 60.0	22.5 – 30.0
Floor of pharynx	(–)	–	–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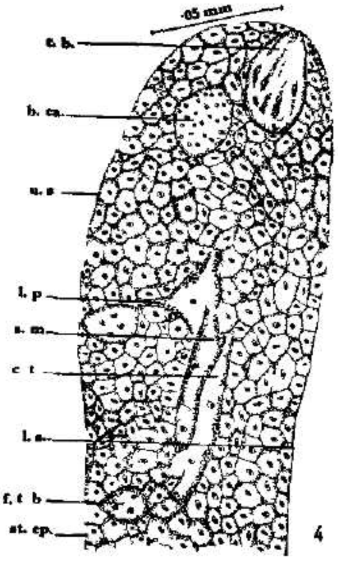
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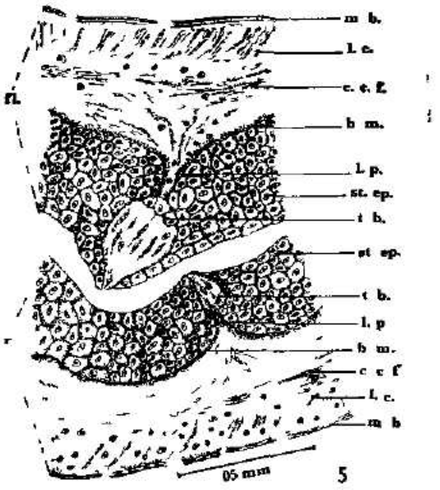
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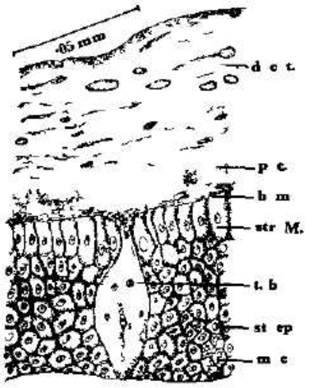
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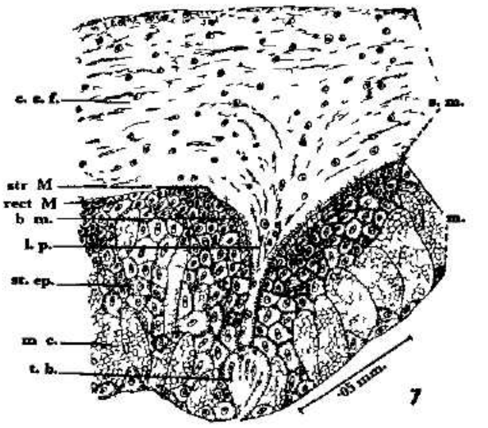
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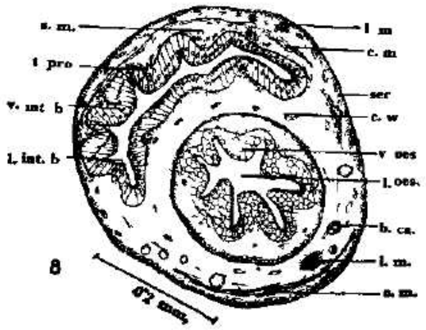
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8

taste buds and mucous cells. Taste buds are absent at the extreme anterior end which is richly supplied with blood capillaries. The number of taste buds increases towards the buccal region. The dorsal lip taste buds measure 37.5 to 45.0 μm in length and 7.5 to 15.0 μm in breadth while the ventral lip taste buds measure 52.5—67.5 × 37.5—45 μm (Table 1). The taste buds in the skin of the lip region measure 67.5—75 × 30—45 μm. The epidermis of the skin is provided with club cells. The dermis or sub-mucosa is separated from the epidermis or mucosa by a basement membrane.

Tongue:

The tongue consists of mucosa and sub-mucosa (Fig. 4). The epithelial cells are flat at the surface and contain a few formative and functional taste buds varying in length (45—67.5 × 30—45 μm). The epithelium of the ventral free region is devoid of taste buds which are, however, more abundant at the posterior end of the tongue.

Buccal cavity:

The histology of the buccal cavity is almost similar in nature to that of the lip (Fig. 5). Formative and functional taste buds are numerous. They vary in size in the roof of the buccal cavity being 37.5—45.0 × 22.5—30.0 μm in size while on the floor of the buccal cavity they are 67.5—85.5 × 45—60.0 μm in size. Taste buds are also present in the skin of the buccal region (Fig. 6). They are 52.5—67.5 × 30—37.5 μm in size. In addition to the ordinary epithelial cells, the epidermis is also provided with club cells.

Pharynx:

The wall of the pharynx consists of mucosa and sub-mucosa (Fig. 7). The mucosa is made up of simple epithelial cells. Mucous cells are so abundant in the epithelium that in certain areas they occupy the entire epithelial surface. A few formative and functional taste buds are also present in this region and are 52.5 — 60.6 × 22.5 — 30.0 μm in size. Below the epithelium the rete-mucosum of Malpighii is present, a thin layer of rounded cells followed by the stratum Malpighii consisting of a single layer of columnar cells. Below the stratum Malpighii the basement membrane is present.

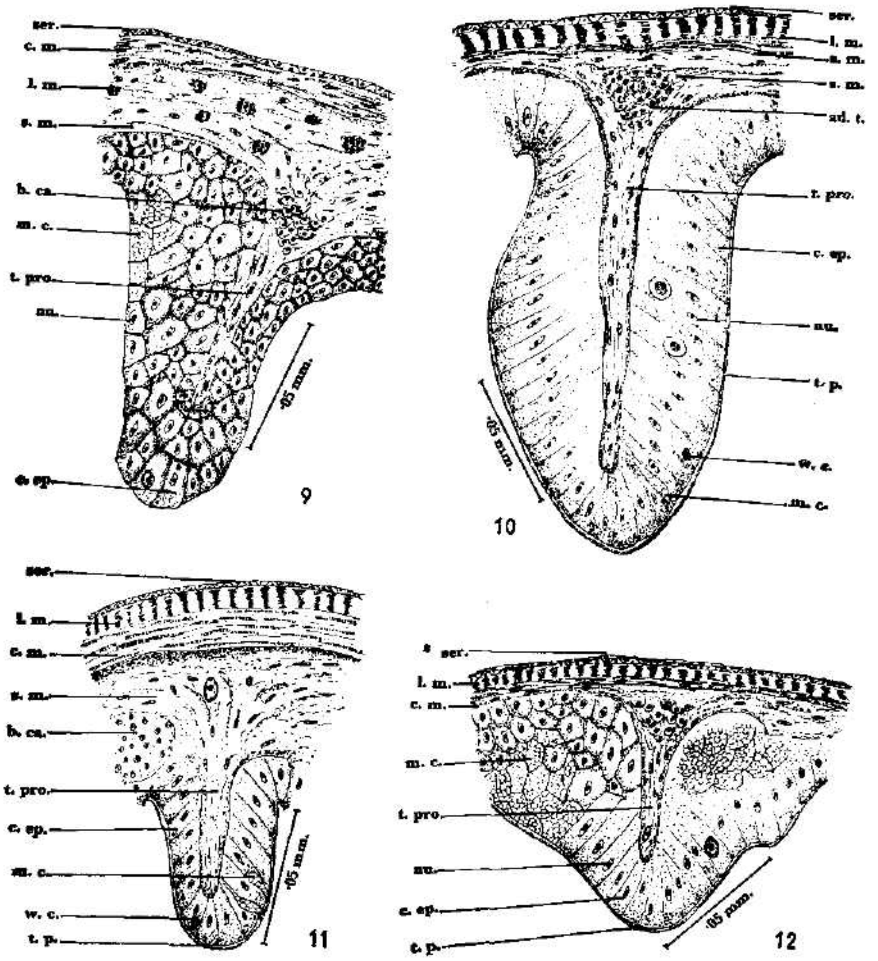
Oesophagus:

The oesophagus is made up of mucosa, sub-mucosa, muscularis and serosa (Fig. 9). The epithelium of the oesophageal mucosa is considerably folded and provided with narrow crypts. It is stratified in nature and comprised of polygonal and a few columnar cells. A few mucous cells are also present but taste buds are entirely absent. The sub-mucosa is well developed and comprised of collagenous connective tissue projecting into the mucosal folds forming the tunica propria which is comparatively narrower. The muscularis is made up of an outer circular and an inner thick longitudinal layer of muscle fibres. The muscular layer is the thickest in this region. The serosa is a thin layer and consists of a single layer of fibrous connective tissue.

Figs. 3—8. Histology of the different regions of the alimentary canal of *Cirrhinus reba* (young stage, transverse section): 3 — Lip; 4 — Tongue; 5 — Buccal cavity; 6 — Skin; 7 — Pharynx; 8 — Junction of the oesophagus and intestinal bulb.

Pyloric valve:

The histological picture of the region where the oesophagus enters into the intestinal bulb is characteristic due to the presence of a pyloric valve. At the posterior end of the oesophagus there are two lumina, (a) the lumen of the oesophagus proper and (b) the lumen of the intestinal bulb. The two lumina are separated by a common wall formed of muscularis (Fig. 8). On one side of this common wall there is the lumen of the oesophagus bearing typical oesophageal villi. On the opposite end of this common wall there is the lumen of the intestinal bulb which bears typical intestinal bulb villi.



Figs. 9—12. Histology of the different regions of the alimentary canal of *Cirrhinus reba* (young stage, transverse section): 9 — Oesophagus; 10 — Intestinal bulb; 11 — Intestine; 12 — Rectum

Table 2. Relative length of the alimentary canal of *Cirrhinus reba* (Ham.).

No of specimens dissected.	Body length in Cms.	Gut length in Cms.	R.L.G.
10	**2.5**	5.0	**2.0**
8	**2.7**	6 0	**2.2**
6	**3.0**	7.5	**2.5**

Intestinal bulb:

The wall of the intestinal bulb comprises four layers, viz., mucosa, sub-mucosa, muscularis and serosa (Fig. 10). The epithelial cells of mucosa are slender, typically columnar with a very thin top plate which is discontinuous in the region of mucous cells. The mucous cells are few in number while wandering cells abundant. The tunica propria is thin. The sub-mucosa is made up of connective tissue fibres richly supplied with blood vessels. The muscularis consists of a thick inner circular muscle layer and an outer layer of longitudinal muscles. The serosa is comparatively thicker than any other region of the alimentary canal.

Intestine:

The intestine is similar in structure to the intestinal bulb but is characterised by well developed muscular layers (Fig. 11). The villi are short, blunt, and tend to be more slender towards the posterior end. Mucous cells are few in number.

Rectum.

The rectum is provided with the usual layers (Fig. 12). The mucous cells are abundant and aggregated.

The differences in the morpho-histology between the alimentary canal of young and adult *C. reba* is given in Table 3.

DISCUSSION

Young *C. reba* is a zooplankton feeder and, accordingly, it has a low R.L.G. (2 to 3) as observed from the present study (Table 2). The adults *C. reba*, however, is a typical herbivorous fish (Das and Moitra, 1963 and Sinha and Moitra, 1971b) and its R.L.G. has been found to be high. In the young, the intestine is neither as much coiled as in the adult nor is the R.L.G. as high, obviously due to the differences in the food habits (Sinha and Moitra, 1975). Herbivorous fishes require much longer intestine for digestion than the carnivorous ones.

The mucosal folds in different regions of the alimentary canal are specialised accordingly for conduction, retention and absorption of the ingested food (Moitra and Sinha, 1971a). The oesophagus and rectal region have longitudinal mucosal folds in both the young and adult *C. reba*, an adaptation for facilitating conduction of the food and undigested food matter progressively onwards. In the adult *C. reba*, the mucosal folds are larger in number and longer, an adaptation for better production of mucus for the lubrication

Table 3. Comparative morpho histology of the alimentary canal of young and adult *Cirrhinus reba* (Ham.).

	Young Stage (2.5 to 3.0 Cms.)	Adult Stage (10 to 20 Cms.)
Food habit	Carnivores (Zooplankton feeders)	Herbivores
R.L.G.	2 to 2.5	5 to 10
Nature and number of coils of intestine	Anticlockwise coiling of the intestine. Forms 1 to 2 coils.	Anticlockwise coiling of the intestine. Enormously coiled intestine.
Histology: Lip:	Few-layered stratified epithelium. Few formative and functional taste buds. Mucous cells absent.	Many-layered stratified epithelium. Many functional taste buds. Mucous cells few.
Buccopharynx	3- to 4-layered stratified epithelium. Few formative taste buds. Many functional taste buds and mucous cells.	Many layered stratified epithelium. Taste buds abundant. Mucous cells profusely present.
Tongue	A few formative and functional taste buds. Mucous cells absent.	Many fully formed functional taste buds. Mucous cells few.
Oesophagus	Villi short. Taste buds absent. Mucous cells few.	Villi long. Taste buds present. Mucous cells many.
Intestinal bulb and intestine	Villi short. Mucous cells few. Top plate and tunica propria thin.	Villi comparatively elongated. Mucous cells many. Top plate and tunica propria relatively thicker.
Rectum	Villi flat. Mucous cells aggregated in certain regions.	Villi conical. Mucous cells profusely abundant.

of coarser food particles which the fish generally ingests. Moreover, the intestinal bulb and the intestine have irregular and zigzag mucosal folds developed for partially retarding the motion of food so as to retain it for longer periods for facilitating digestion, absorption and assimilation. In young *C. reba*, the intestinal bulb is provided with honeycomb-shaped mucosal folds for prolonged retardation of the motion of the food (Kapoor, 1953). Retardation of food for shorter periods in the intestinal bulb and intestine in the adult is compensated by the relatively longer intestinal bulb and intestine.

In the young stage, the villi of the oesophagus are unbranched and provided with stratified and columnar epithelial cells. In the adults, however, the oesophageal villi are much branched and are usually stratified in nature. As a result, the mucosal surface area increases greatly for copious secretion of mucus. The presence of abudant mucous cells and strong musculature in the oesophagus of the adult *C. reba* appears to be related to adequate lubrication of food for subsequent conduction posteriorly along the alimentary canal. In the young *C. reba*, however, the presence of a comparatively thinner musculature and few mucous cells indicates that the fish ingests very simple food particles. According to Barrington (1957) the presence of taste buds and striped muscle fibres in the oesophagus suggests their importance in the selection and rejection of food.

The presence of a valve between the oesophagus and the intestinal bulb has been observed in young as well as the adult *C. reba*. The pyloric valve is the landmark between the oesophagus and intestine or between the stomach and intestine of certain teleosts of Northern Red Sea (Al-Hussaini, 1951). Sarbahi (1940) described the pyloric valve as a valve-like structure in the adult *L. rohita* lying between the oesophagus and the intestinal bulb.

In adult *C. reba*, the villi are very long in the intestinal bulb region. Consequently, the absorptive surface is greatly increased. This is obviously an adaptation to the herbivorous type of food it ingests. In the younger stages, however, the villi are not as long as in the adult.

It has been observed in the present study that the lip of young *C. reba* is provided with a few formative and functional taste buds. It may be concluded, therefore, that the lip of young *C. reba* may be concerned with gustation to some extent. The presence of a few well developed functional taste buds in the lip region of the adult confirms its gustatory nature. The presence of a few mucous cells in the young and adult *C. reba* indicates that the secretion of mucus is not essential in the lip as it is concerned with primary selection of food only and has no role in food conduction.

It has been observed that the young *C. reba* have comparatively smaller and fewer formative and functional taste buds in the bucco-pharynx region while the adult have many well developed taste buds. Variations in the number, nature and distribution of taste buds in the different stages of *C. reba* thus appear to be related to the change in feeding habits. In fishes feeding by sight only, taste buds have been reported to be rare or absent, a few taste buds are present in those which feed by sight and taste, while in fishes feeding by gustation only abundant taste buds are present (Khanna 1968). According to Alikunhi (1952), "carp fry" are able to identify their food mainly by the organs of sight. Accordingly, young *C. reba* depend primarily on sight while feeding rather than on taste. Obviously, the function of the taste buds is to discriminate the ingested food and to accept for passage posteriorly only those which are suitable. This feature is well marked in adult carp since they also have little ability in selection of their food by sight, and consequently final selection is made inside the bucco-pharyngeal region and oesophagus (Sarbahi, 1940; Islam, 1951; Kapoor, 1957a, b; Khanna, 1968; Pasha, 1964; Moitra and Sinha, 1971a, b, 1972; Sinha, 1974). In the young *C. reba*, taste buds are absent in the oesophageal region. This clearly indicates that the gustatory sense extends up to the oesophageal region in the case of adult *C. reba* where the final selection of food is made. Young *C. reba* does not require any gustatory sense in the oesophageal region probably because of their sight feeding habit.

Taste buds present on the floor of the lip and bucco-pharynx are larger in size than those located on the roof of the corresponding regions (Table 1). These variations may probably be due to the fact that the food particles come into contact with the floor directly which has, therefore, a greater ability in food selection.

The taste buds and mucous cells are few in the lip and the buccal cavity in adult *C. reba*, but their number greatly incraeses in the posterior part of the bucco-pharyngeal cavity in the adult. Hence, the gustatory sense is *highly developed in the adult and extends up to the anterior oesophagus.* The arrangement presumably helps the fish in the matter of selection of food. The food is selected by the organ of sight which is well developed in the young (Alikunhi, 1952). Consequently, the carp fry or young carp does not appear to need a keen gustatory sense. But in the adult *C. reba*, after the food is selected with the help of the sense of smell, the real sampling of food takes place in the bucco-pharynx and anterior oesophagus. Consequently, the adult *C. reba* possesses well developed functional taste buds in this region. These functional taste buds originate from the formative taste buds present in the young and as the fish grows in length they change with the change in their feeding habits (Sinha and Moitra, 1974a).

SUMMARY

Young *Cirrhinus reba* (Ham.) ranging from 2.5 to 3.0 Cms. in length were dissected for morphological, anatomical and histological studies on the alimentary canal with a view to comparing them with that of the adult.

1) The intestine forms a loop in the young and it is enormously coiled in the adult.

2) In the young, the mucous folds throughout the alimentary canal have a great resemblance to those of carnivorous fishes, while in the adult they are of the herbivorous type.

3) The lip, anterior part of the skin, tongue and bucco-pharynx are gustatory in both young and adult. But the gustatory sense is extremely strong in the latter due to the presence of large number of taste buds.

4) The pharyngeal lining is formed of a large number of mucous cells and a few taste buds and the gustatory function is extremely reduced in the young.

5) Taste buds present on the ventral side of the lip, buccal lining and pharynx are larger than those present on the dorsal side of the corresponding regions in both young and adult.

6) The oesophagus is devoid of taste buds and has no gustatory function in the young. In the adult, however, taste buds are present. The presence of a valve between the oesophagus and intestinal bulb is being reported here for the first time.

7) The tunica propria and top plate in the intestinal bulb and intestine are thinner in the young in comparison with those of the adult.

8) Mucous cells are isolated in small groups in the villi of the rectum, a characteristic feature in young. In the adult, however, mucous cells are abundant throughout the rectum.

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ON THE POSSIBILITY OF USING ANNUAL BONE LAYERS OF ALPINE NEWTS, TRITURUS ALPESTRIS (AMPHIBIA: URODELA), FOR THEIR AGE DETERMINATION

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Abstract: In the paper there is an account of the age analysis of the population sample of the Alpine newts (*Triturus alpestris* Laurenti, 1768), from the locality of Mladé Buky (NE Bohemia) by means of the method of stating the annual bone layers number. The results of this analysis are completed by ecological and bionomical characteristics of the population and they are also discussed from this point of view. The authors have come to the conclusion that it is possible to determine the age by bone layers in the Alpine newts with the accuracy of ± 1 year.

INTRODUCTION

The first attempt at the age determination of amphibians according to the bone layers was made by Senning (1940) who also found out the layers in the clarified bones of the *Necturus maculosus* skull. Although the layers were visible in many bones the observing was restricted to parasphenoid as to the most low-laying bone. Senning has disclosed the fact that in young animals the bone layers are spread out in long distances while in adult individuals the distances between layers become much shorter on and after the eight and the layers on and after the 15th—16th were very closely adjacent to one another so that it was no more possible to count them.

It is perceptible after the size curve given by Senning that the growth in the *Necturus maculosus* goes considerably fast up to the attainment of sexual maturity which comes at the age of the seventh to the eighth year of their life. Then the growth becomes considerably slow. The number of layers in parasphenoids of five specimens of the mentioned species with known age was in accordance with the number of years lived through.

On the basis of the results obtained by studying Senning has come to the conclusion that it is possible to determine the ages of *Necturus maculosus* specimens with the exception of the oldest in which the layers corresponding to the last years of their life are so narrow and closely adjacent to one another that counting them is simply not possible.

Schroeder and Baskett (1968), studying the possibility of age determination of the Bullfrog (*Rana catesbeiana*), observed flat bones which were clarified by the light running through and found out annual layers in many of them. The most outstanding picture was shown in the back wing of the os pterygoideum. During the checking on the frogs marked with individual marks both authors have stated that it is possible to determine the age after the number of these layers. In spite of it both Senning and Schroeder & Baskett consider as impossible to carry out determining the age by using this method in the oldest animals because in these specimens the latter annual layers are narrow and very closely adjacent to one another and counting them is considerably difficult.

The investigations carried out on Common frogs (*Rana temporaria*) and Common toads (*Bufo bufo*) have shown that it is more advisable to count annual layers in the bones on the transversal sections in the middle of the diaphysis of the tubular bones (including the toes phalangs) stained with Ehrlich's haematoxylin (Klejnenberg and Smirina, 1969; Smirina, 1972, 1974b). In this case layers can be seen much more clearly and counting them, including the oldest animals, is considerably simplified. The attempts using vital stainings of bones — alizarin red S and oxytetracyclin which both leave a lasting picture in the bones — and also the investigations of sections from toes phalangs of animals marked with individual marks have confirmed that in the bones of amphibians collected in the region of continental climate every year one layer really arises. This layer consists of a broad zone of the usual bone tissue which is formed during the period of activity of the animal and of a narrow compact layer which is formed in the period of winter restriction of growth (Smirina, 1972). It is necessary to take into consideration, however, that along with accruing of new bone tissue layers from the periostal side, the formerly arisen bone tissue from the side of endoost which beds the marrow cavity of the tubular bones is resorbed. When determining the age after bone layers it is necessary to determine and take into consideration the rate of this process of resorption in every species. It usually gets slow or stops completely after the attainment of sexual maturity.

The aim of this paper is to clear up the problem of the existence of layers in the bones of the Alpine newts (*Triturus alpestris*) which could be held after the analogy with other amphibians as annual ones and to determine the age after them.

We wish to thank to Ota Oliva, Ph.D., from the Department of Systematic Zoology, Charles University, Prague, for his valuable comments on the present study.

MATERIAL AND METHODS

For our investigations we had 40 specimens of adult Alpine newts (20 males, 20 females). The body length from the fore end of the head to the cloacal aperture was 43—58 mm in the females and 40—51 mm in the males. We suppose that these specimens were sexually matured (Roček, 1974). There was a shortage of specimens from the first growth groups.

The material was collected on May 5, 1971, in the pond about 1 km NE from the village Mladé Buky (5 km N from the town of Trutnov, NE Bohemia). This locality is situated on the southern foot of the eastern part of the Krkonoše Mts. (Rýchory). The whole region is orographically included into the geographical unit of West Sudeten (Zoubek, Kunský & coll., 1968). The locality itself is an overgrowing pond about 20 by 30 m large and represents by its nature a typical locality of the Alpine newt in this region. It is situated in the elevation of 490 m.

The climatological, precipitation, snow and phenological characteristics were obtained from long-termed averages (mostly from the period 1901—1950) of measurements of the meteorological station of Trutnov. This station is situated in the elevation of 427 m (the geographical position 50°34′, 15°55′) about 5 km SE from the mentioned locality. Some characteristics were completed by the data of the meteorological station of Žacléř which is situated on the eastern foot of the Rýchory Mts. Its elevation is 604 m, the geographical position 50°40′, 15°56′.

For the study of layers the transversal sections from the middle part of diaphysis of femur were made and then they were stained with Ehrlich's haematoxylin. The bones were preliminarily

Tab. 1. Climatological, precipitation, snow and phenological characteristics obtained by measurements of meteorological stations of Trutnov and Žacléř in the period 1901–1950

Station	Climatol. character	Average air temperature annual IV–IX	Average relat. air humidity annual IV–IX	Mean of annual minimums of relat. air humidity
Trutnov	6.8 °C	13 °C	82%	28%
Žacléř	6.1 °C	12.2 °C	—	—

Station	Precipit. and snow character.	Average total of precipitations annual IV–IX X–III	Average number of days with snow-storm	Average number of days with snow cover
Trutnov		778 mm 418 mm 384 mm	53.1	85.4
Žacléř		857 mm 473 mm 384 mm	—	—

Station	Phenolog. character.	Beginning of apple-trees blossom
Trutnov		May 10

decalcified in the 5% solution of nitric acid. The sections were obtained on a freezing microtome. The smallest number of visible layers on the sections was 2—3, the greatest was 9—10 (see Table 2).

Considering that among basic lines of adhesion which correspond to the hibernations it is possible to see more or less clearly the supplementary lines of adhesion (Fig. 1a) or owing to the decomposition of the lines of adhesion it is difficult to count the layers. Therefore we think it is right and more suitable in such cases not to try to count accurately the number of layers, because there could be mistakes, but only to estimate approximately their number: e.g. instead of 3 layers only 3—4 etc. It is possible to state in general that the layers in the bones of Alpine newts are well visible and counting them does not make any particular troubles (Fig. 1).

ECOLOGICAL AND BIONOMICAL CHARACTERISTICS

The locality in which the newts were collected belongs to the mildly cold region with the average number of "summer days" (max. temperature more than 25 °C) 0–10 a year and with the average number of "cold days" (max. temperature less than –0.1 °C) 60–70 a year. The average date of the first "frosty day" (min. temperature –0.1 °C or lower) is Apr. 21 to May 11, the average date of the first day with snow cover is Oct. 21 – Nov. 1, the average date of the last day with snow cover is Apr. 21 – May 1. Further most important characteristics are given in Table 1. The average period of the snow cover duration is a bit longer than it is mentioned in the table because the locality is situated closely to a mountain massif and to large wood complexes. Also other characteristics are influenced in a similar way. It is possible to state that the region considered is situated roughly in the transition between the oceanic climate and the continental one.

The climatological characteristics mentioned also determine the biology of the Alpine newt in this region. The beginning of hibernation comes in approximately towards the end of October (it is difficult to determine it more accurately because the most of Alpine newts act on the land during that period); the hibernation ends approximately in the middle of April. The beginning and the end of the hibernation is strongly influenced by the course of the weather during the year but it can considerably change from year to year. It is necessary, however, to state in general that the period of hibernation takes roughly about 6 months but it can be also shorter. The period of hibernation can be broken by the periods of activity only at the beginning when short time periods of warm weather can come. These short-time changes, however, cannot influence essentially the formation of the bone tissue.

The period of reproduction comes in practically immediately after coming into water with those specimens which hibernated on the land. Some of the newts, however, also hibernate in water which can be seen from the fact that they act in water already when there is still ice and snow on the shores. The nature of the locality is thus very important. The reproduction itself takes no more than 14--21 days. The newts, however, stay further in water and leave it, earlier or later after circumstances uncleared so far. Therefore the length of the stay in water is considerably varied. Sometimes we can even observe, in the region of Czechoslovakia, that the Alpine newts stay during the whole summer period in water and they do not come on the land. It is still necessary to note that under normal circumstances when newts come on the land males leave water earlier than females.

The period of larval development takes about 4 months (June – September). But if the coming of the winter period is accelerated the metamorphosis can come as late as in the spring of the next year. These cases happen especially in the localities of all regions of Czechoslovakia of higher elevation but they are not abundant.

RESULTS AND DISCUSSION

Unfortunately, as it was mentioned above we had at the disposal no specimens from the first age-groups so that we cannot state assuredly the rate of resorption of the bone tissue from the side of endoost, but judging by some indirect indications this rate is not great. So on the sections is some specimens it is possible to see around the marrow cavity one line of adhesion which is more or less resorbed. We cannot state if it is the rest of the resorbing line of adhesion which corresponds to the first hibernation or if it belongs to the second one. But we have never observed two lines of adhesion afflicted by the process of resorption in the newts that we have observed, e.g., in Common frogs or in Common toads. So it is possible that even the first line of adhesion in Alpine newts cannot be resorbed completely by the sexual maturity. This presupposition is also confirmed by the fact that the first from the visible lines of adhesion (which is closely situated to the marrow cavity) is regularly inexpressive, incontrast and it has no clear outlines. This is characteristic of the lines of adhesion to the first hibernation as it was already stated in the case of mammals (Klevezal and Klejnenberg, 1967) and as we also observed in other amphibians and reptiles. It is possible (probably in mammals, too) to clear up this fact so that in the first year (but in some species with the slow growth rate — "in first years") either the seasonal variations of the growth rate of animal as a whole or also the opposition of the bone tissue are less sharp than in the following years. In

Table 2. Number of layers in the middle of diaphysis of femur in the Alpine newts (*Triturus alpestris*)

Number of specimen	Body length in mm	Number of bone layers	Number of specimen	Body length in mm	Number of bone layers
1	51	9—10	21	50	3
2	56	7—8	22	47	3
3	52	4	23	42	3
4	55	5	24	47	3
5	58	9—10	25	47	3
6	50	5	26	47	5
7	50	9—10	27	44	3—4
8	48	5	28	51	5
9	51	8	29	47	3
10	54	6	30	47	6—7
11	49	5	31	44	3
12	52	5	32	47	4
13	50	5—6	33	47	5
14	47	8	34	50	9
15	57	5	35	46	4
16	43	3	36	43	3—4
17	54	6	37	47	3—4
18	50	8	38	46	4
19	45	5	39	42	2—3
20	45	6	40	40	3

this case owing to the partial retarding of the growth in winter the line of adhesion which corresponds to this hibernation is formed less expressive and in the case of discontinued hibernation double, therefold etc. lines of adhesion are formed. The sharper and longer is the suppressing of the growth, the more expressive is the corresponding line of adhesion.

G. A. Klevezal (1973) distinguishes three basic categories of annual additional layers according to the stage of their expressiveness on the stained sections:

(1) Expressive layers. They are in contrast, easily separated from the supplementary lines of adhesion; counting them is without troubles.

(2) Inexpressive layers. With regard to the little contrast of the lines of adhesion or to the numerous supplementary lines it is almost impossible to state the limit of annual layers and count them.

(3) Layers of the medium expression. This is the transient category where it is possible to separate and count the layers only with difficulty.

From the 40 specimens of the Alpine newt investigated 27 ones had expressive layers (67.5%) and 13 ones had the layers of the medium expression (32.5%). We had no specimens with inexpressive layers which would be impossible to count.

It is perceptible from Fig. 2 that even when there is no sharp dependence of the increasing number of bone layers on the increasing length of the body, there is a certain tendency in that regard. The fact that the biggest specimens are not always the oldest as well need not be surprising. This phenomenon was already observed in reptiles (Smirina, 1974a) and it was also stated and cleared up in fishes (Ricker, 1969).

SUMMARY

Although we had no dated material we can state according to the analogy with other species of amphibians and the nature of the distribution of bone layers that these are annual ones and that it is possible to determine the age after them with the accuracy of ± 1 year.. This accuracy could be higher after the determination of the resorption rate.

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The plate (Figs. 1, 2) will be found at the end of this issue.

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THE FIRST THERIOLOGICAL CONGRESS

V. E. Sokolov

President of the 1st International Theriological Congress

The 1st International Theriological Congress ("therion" means "animal" in Greek) took place in Moscow on June 6—12, 1974. Suggestions in favour of convoking an international gathering on theriology were raised at the 2nd All-Union Conference on Theriology. The idea was supported in many other countries; then the proposal came from the mammalogists of the U.S.A., asking officially the Academy of Sciences of the U.S.S.R. to organize the 1st ITC. The Institute of Evolutionary Animal Morphology and Ecology of the Academy of Sciences of the U.S.S.R. took over the organization, and many other institutions, especially the Biological Faculty of the Moscow State University, and individual scientists, helped with preparing the congress.

V. E. Sokolov, Member-Correspondent of the Academy of Sciences of the U.S.S R., became President of the Congress, Vice-Presidents were Professors V. G. Geptner, V. V. Kucheruk, N. P. Naumov and Academician S. S Shwarc, Secretary-General was P. A. Pantoleyev, Dr. Sc.

Specialist in mammals came to Moscow from 29 countries: Australia, Austria, Belgium, Bulgary, Canada, Cuba, Czechoslovakia, Finland, France, German Democratic Republic, German Federal Republic, Great Britain, Hungary, India, Iran, Israel, Italy, Japan, Kenya, Mongolia, Norway, Poland, Roumania, Sweden, Switzerland, Tanzania, Tunisia, the United States, and Yugoslavia.

The most numerous foreign delegations arrived from the United States — 99 delegates, Poland — 31, GDR — 20, Czechoslovakia — 18, Canada — 10, and GFR — 10.

Naturally, the largest was the Soviet delegation — about 600 persons.

In his opening address, President of the Congress pointed out the principal tasks of theriology. In the name of the President of the Soviet Academy of Sciences, the participants of the Congress were greeted by Academician V. A. Kotelnikov, and an address by the Chairman of the State Committee of the Council of Ministers for Science and Technology Academician V. A. Kirillin was read by V. G. Sokolovsky, member of the Commitee. The Congress was also greeted by the representative of the Moscow Council A. K. Melnikov and Prorector of the Moscow State University Professor F. M. Volkov.

On the opening day, two lectures were read — "Rates of evolution in carnivora during the Late Cenozoic" by B. Kurten (Finland) and "Theriology today" by G. A. Novikov (USSR).

Each of the Congress days was organized according to the same scheme: mornings were devoted plenary sessions, afternoons to the work in sections.

At plenary sessions, the following papers were read: those by B. Kurten and G. A. Novikov mentioned above; "Variability in mammals — concepts and complications" by R. Berry (Great Britain), *"Intraspecific variability and species formation" by S. S. Shwarc (USSR), "The Formation* of theriofaunas in the Quaternary on the territory of the USSR" by N. K. Vereschagin and I. M. Gromov (USSR), "On the zoogeography of some Beringian mammals" by R. Rausch (USA), "Ecological organization of population" by K. K. Petrusevich (USSR), "Population regulation in mammals" by D. E. Davis (USA), "Main principles of chemocommunication in terrestrial mammals" by V. E. Sokolov, "Communication in mammals" by G. Tembrock (GDR), "Signal system, signal biological fields and their significance in the life of mammals" by N. P. Naumov (USSR), "Social structure and dynamics of the wild gelada baboon in the mountains of Ethiopia" by J. H. Grook, "Estimation of harmful activity of mammals in countries with highly developed agriculture" by J. Giban (France), "The importance of mammals in the evolution of different groups of parasites on vertebrates" by B. Rosický (Czechoslovakia), "Wild mammals as carriers of diseases dangerous to man" by V. V. Kucheruk (USSR), and "On developmental trends in theriology according to data offered by the analysis of literature" by L. P. Poznanin (USSR).

In the six sections of the Congress about 300 reports were read.

The section of phylogeny and paleotheriology (organized by K. K. Frelov) paid main attention to prehistory and earlier evolution of mammals, development and formation of mammal complexes in the Miocene and Quaternary periods, problems of extinction and change of some mammal groups in Late Pleistocene, former areas of ungulates, origin of domestic animals and original centres of domestication, phylogeny and morphological and ecological peculiarities of various mammal groups in the Neogene and Quaternary periods.

In the systematic and zoogeographic section (organized by V. G. Geptner, I. M. Gromov and N. N. Voroncov) papers were read on the rare occurrence of mammals, mammal faunas of different countries, zoogeography of some special regions on the surface of the earth, and causes of geographical regional differentiation. Other reports were devoted to the application of methods of karyology and biochemical genetics in systematics.

The section of morphology (its organizers were A V Yablokov and Y B Bayevsky) dealt with problems of the structure and function of different organs in mammals Special attention was paid to the blood vessel system, and questions of population morphology were also discussed A special sub section dealt with the problems of embryology, one of the chief questions discussed being the relationship between embryonic and maternal organisms

The section of ecology (organized by N P Naumov and S S Shwarc) was one of the largest The papers read in this section were concerned with improving the methods of the census of rodents and methods of controlling their population structure, working out the methods of population *structure studies of species, and concrete mechanisms of regulation of the numbers of various* species under different environmental conditions

The section of ethology (organized by L V Krushinsky) discussed the problems of formation of various types of behaviour in mammals and the origin and significance of behavioral convergencies

The section of applied theriology (organized by V V Kucheruk and A A Sludsky) devoted its work to medicinal aspects utilization, protection and acclimatisation of mammals and mammals as pests in agriculture

Another form of the Congress acitivity were symposia, to these one day was reserved On the whole, 16 symposia were organized on various questions of theriology Here are their themes history of zoogeographical relations between the Cretaceous and Tertiary Asiatic theriofaunas, *factors of the development of internal organs and its detection in mammals, age an growth,* regulation of number of animals, its prognostics and the definition of the harmful activity of small rodent populations, principles of internal population organization of mammals, orientation and signal systems, systematics, evolution and variability of the voles bears of the world, new studies of sea mammals ecology and behaviour of ungulates, winter ecology of mammals, the role of mammals in the biological circulation and transformation of environment, mammals in tundra ecosystems, parasites and diseases of mammals, nomenclature of mammals, collections of mammals

The publication of syllabi (in Russian and English) of the papers read in sessions and at symposia contributed to the success their work, it helped their participants in a prompt orientation among the papers presented

The participants of the Congress were invited to visits to Moscow biological institutions and museums 160 persons visited the natural reservation of Prioksko-Terrasnoye On the occasion of the Congress, special expositions of the Soviet theriological literature and works of artists devoted to animals were arranged

At the final session of the Congress a resolution was unanimously approved supporting the idea of international theriological congresses

The Congress decided that these congresses would be organized once in four years It consituted the International Theriological Committee to which each of the countries represented at the Congress delegated one member, and its Executive of eleven members, representing all areas of the world The main task of these organs is to organize future congresses As to the next congress, the Czechoslovak Academy of Sciences was asked to organize it in Czechoslovakia

The nomenclatorial committee of nine members prepared the resolution of the Congress It emphasized, among others, the great importance of saving rare species of mammals and appealed to theriologists of all countries to unite their efforts in the protection of these animals

RECENZE — REVIEWS

Wolff E **Experimentelle Embryologie.** Gustav Fischer Verlag, Stuttgart 1971 192 stran

Knizka je tretim svazkem Grasseho edice Obecna biologie a je preložena z francouzskeho *originálu Ve světové literatuře je velmi malo shrnujicich děl o experimentalni embryologii,* hlavně snad proto, ze jde o vědu relativně velmi mladou Jako obor snazici se kausalně vysvětlit pochody vedouci k diferenciaci organismu a jeho casti, stavi na embryologii popisne a metodicky navazuje na radu oboru pro ni vedlejších Proto take vysledky experimentalni embryologie jsou casto daleko obecnějsiho vyznamu než by vyplyvalo z formalniho zařazeni a názvu oboru, velmi casto se dotykaji jedne z hlavnich otazek biologie, regulace diferenciace bunky, pro jejiz řešeni je zarodečná bunka vybornym objektem Vedle teoretickych aspektu maji závěry experimentalni embryologie ovšem take svůj dopad prakticky vysvětleni teratologickych jevu je casto možne jen na základě znalosti mechanismu, ktere jsou předmětem jejiho studia Oba pohledy nachazeji v publikaci svuj odraz

Kniha je příkladně koncisni, nezůstáva vsak v žádném useku na povrchu a je doslova nabita fakty. Na druhé straně poukazuje na nevyřešené problémy ve shrnujících závěrech jednotlivých kapitol. Pro pracovníka v oboru jsou zvláště cenné kapitoly druhá, třetí a čtvrtá (Determinace, Regulace, Morfogenetická pole a gradienty), které vynikajícím a přehledným způsobem shrnují dosavadní znalosti, základní pro pochopení kausality inidividuálního vývoje. Kapitola pojednávající o jaderných transplantacích a heterogenním oplození (VII) poněkud zůstává dlužna současnému stavu problematiky, chybí zde na příklad výsledky chemické embryologie, její stavba však velmi názorně na příkladech ukazuje interakční působení jádra a cytoplasmy v průběhu vývoje. Kapitoly Diferenciace pohlaví, Regenerace a Růst jsou zcela samostatné.

Celkově jde o velmi náročnou publikaci s množstvím vyobrazení, která mají obzvláště didaktickou hodnotu a bezprostředně napomáhají porozumění popisu velmi komplikovaných procesů.

Pro začátečníka je méně vhodná, předpokládá již určitý stupeň biologického vzdělání.

A. Romanovský

Kükenthal-Matthes-Renner: **Leitfaden für das zoologische Praktikum.** 16. vyd. G. Fischer Stuttgart 530 stran, 219 obr. cena DM 44.

Vychází-li některá odborná publikace od r. 1898 nepřetržitě v nových vydáních svědčí to nejen o velké potřebě zmíněného díla, ale především o dobré koncepci, která od prvého vydání nedoznala žádných převratných změn. Jde totiž nejen o návod k provádění anatomických cvičení, ale také o opakování základních dat ze zoologie a uvedení do srovnávací morfologie.

V recenzovaném vydání, které redigoval a přepracoval prof. Renner, byla doplněna některá nová fakta o stavbě bičíků, choanocytů hub a protonefridií ploštěnců. Místo pitvy králíka byla zařazena pitva krysy a byl i rozšířen výběr objektů. Nové vydání má také řadu nových vyobrazení. Didakticky velmi cenné je to, že rozsah knihy přes rozšíření a doplnění nevzrostl, poněvadž na druhé straně byly zkráceny některé méně důležité části.

Praktikum je uvedeno krátkým výčtem a přehledem potřeb nutných pro anatomické a mikroskopické studium, dále stručným přehledem živočišné říše s vyznačením kmenů, jež jsou v praktiku zastoupeny. Každá část má krátký technický úvod, v němž je uvedeno jak získávat a připravovat materiál. V obecné partii pak jsou shrnuty základní údaje o morfologii studovaného objektu, nutné pro lepší chápání vlastního praktika. Na rozdíl od našich praktických cvičení jsou samozřejmě zařazeny v hojné míře i formy mořské a dále jsou probíráni i cizopasníci.

V závěru je důkladný přehled zoologického systému s charakteristikou jednotlivých skupin. Systematické třídění je místy ještě zastaralé (rozdělení prvoků na bezbrvé a obrvené), jinde moderní (korýši). Kniha obsahuje i slovníček odborných výrazů s vysvětlením etymologie latinských nebo řeckých názvů a je zakončena rejstříkem. Tak jako všechny publikace známého nakladatelství Fischerova má i tato vzornou grafickou úpravu.

Toto modernizované vydání zoologického praktika najde plné uplatnění nejen jako vysokoškolská příručka pro studující biologie, ale i jako důležitá pomůcka učitelům středních a odborných škol a pracovníků výzkumných laboratoří a ústavů.

M. Kunst

Krupka I., J. Holčík: On the occurrence of Barbus plebejus in the Poprad river

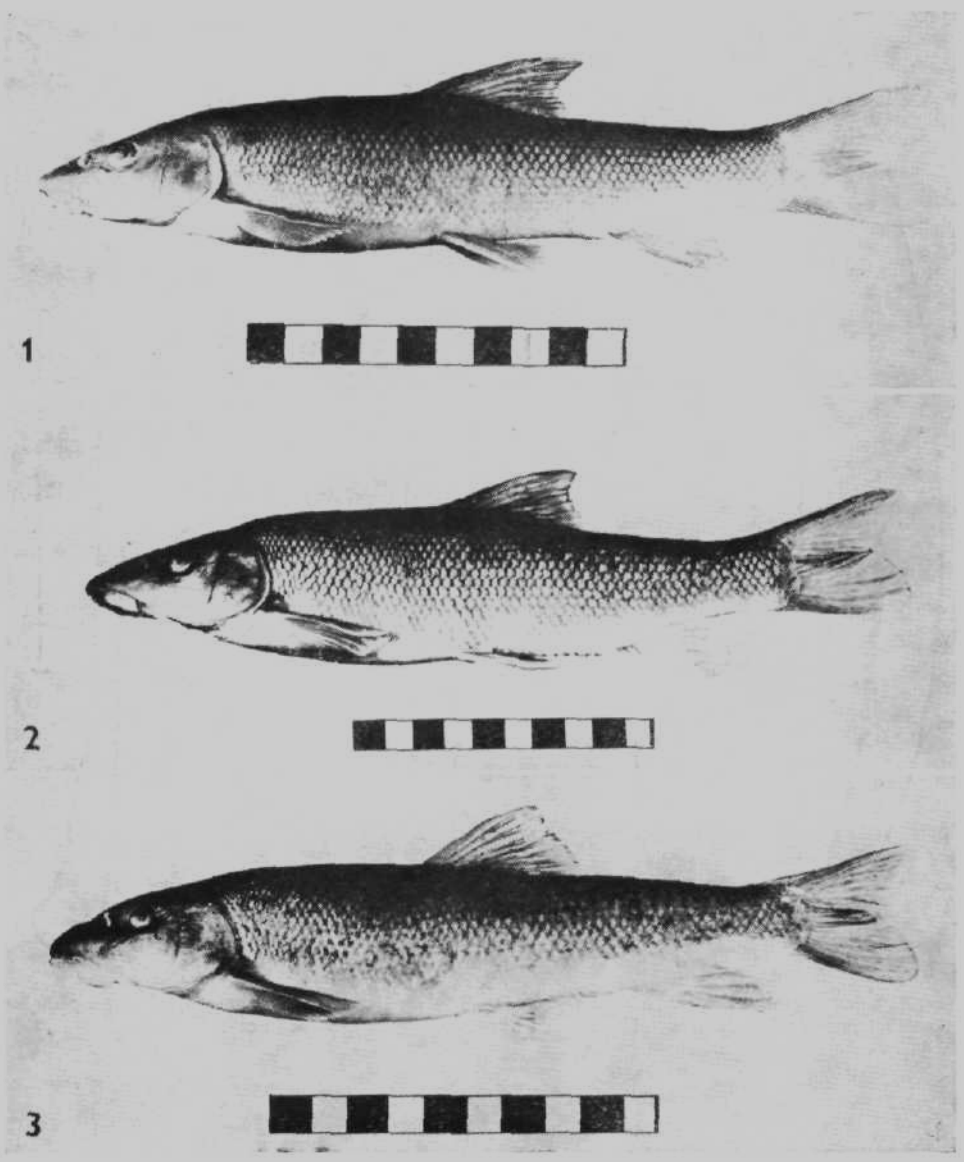


Fig. 1. 1 — *Barbus barbus* (standard length 196 mm), 2 — *Barbus plebejus* (206 mm) and 3 — *Barbus meridionalis petenyi* (181 mm) from the Poprad river. Scale in cm.

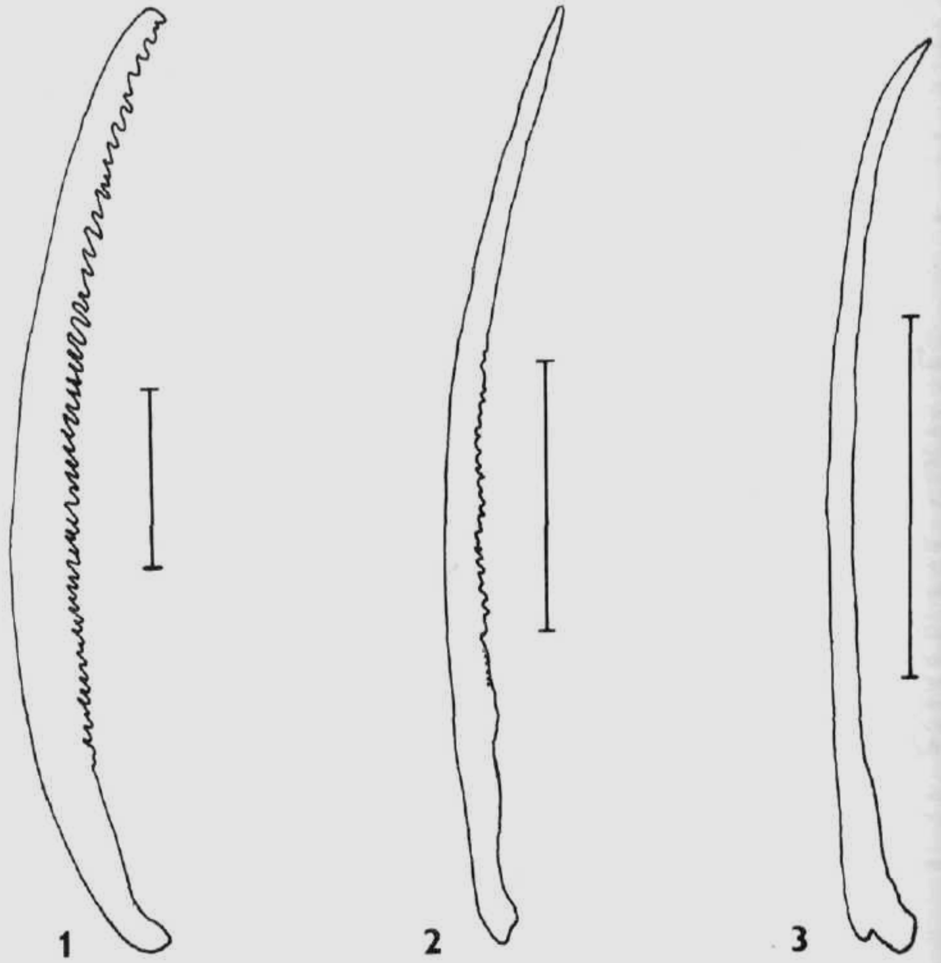
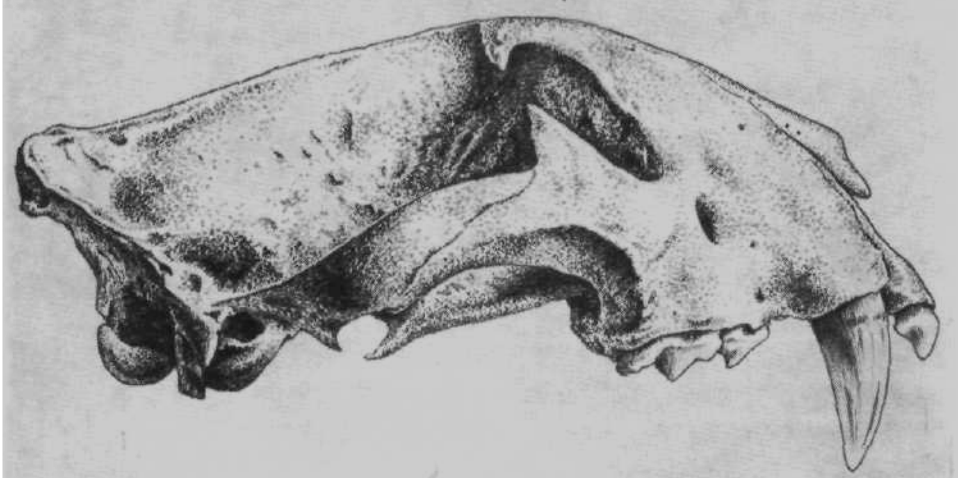


Fig. 2. Last dorsal spine in *Barbus barbus* (1—260 mm of standard length), *Barbus plebejus* (2—212,7 mm) and *Barbus meridionalis petenyi* (3—173 mm). Scale in cm.



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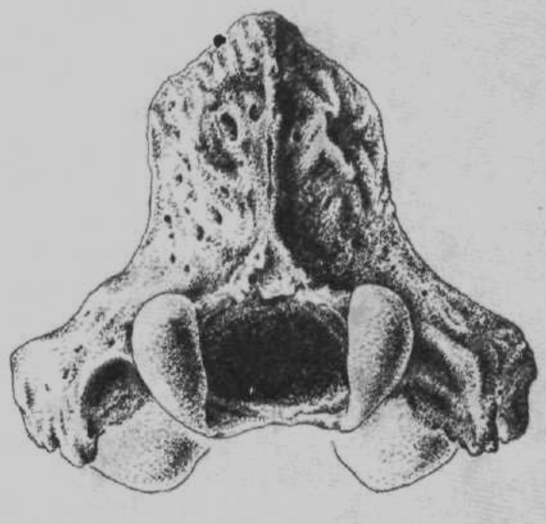


BM(NH) No. 1937.12.1.2

Plate I. Skull of the Bali Tiger, *Panthera tigris balica* (Schwarz, 1912); fullgrown male, Sendang, N. C. Bali; British Museum (Natural History), London, No. 37.12.1.2. Above — side view; below — occipital plane. Del. V. Mazák.

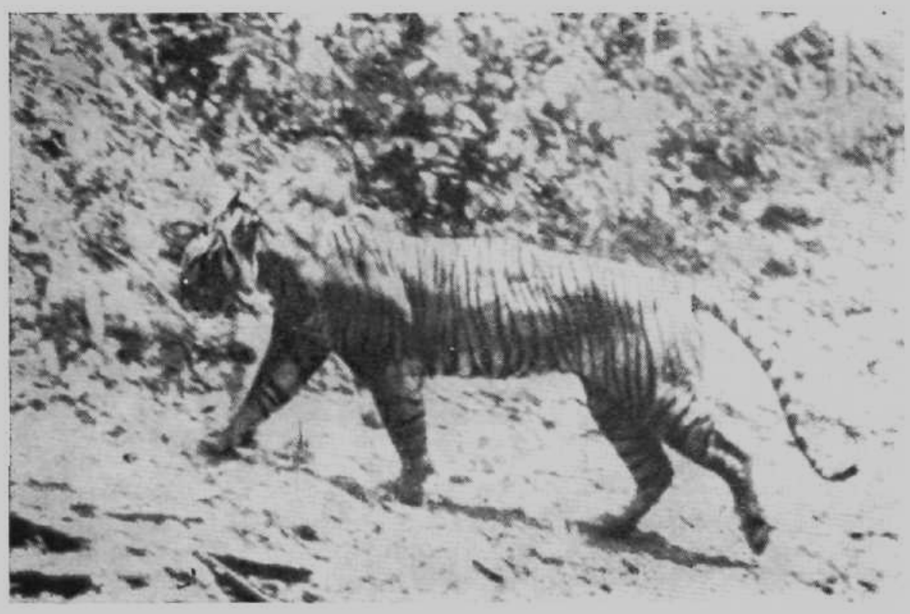
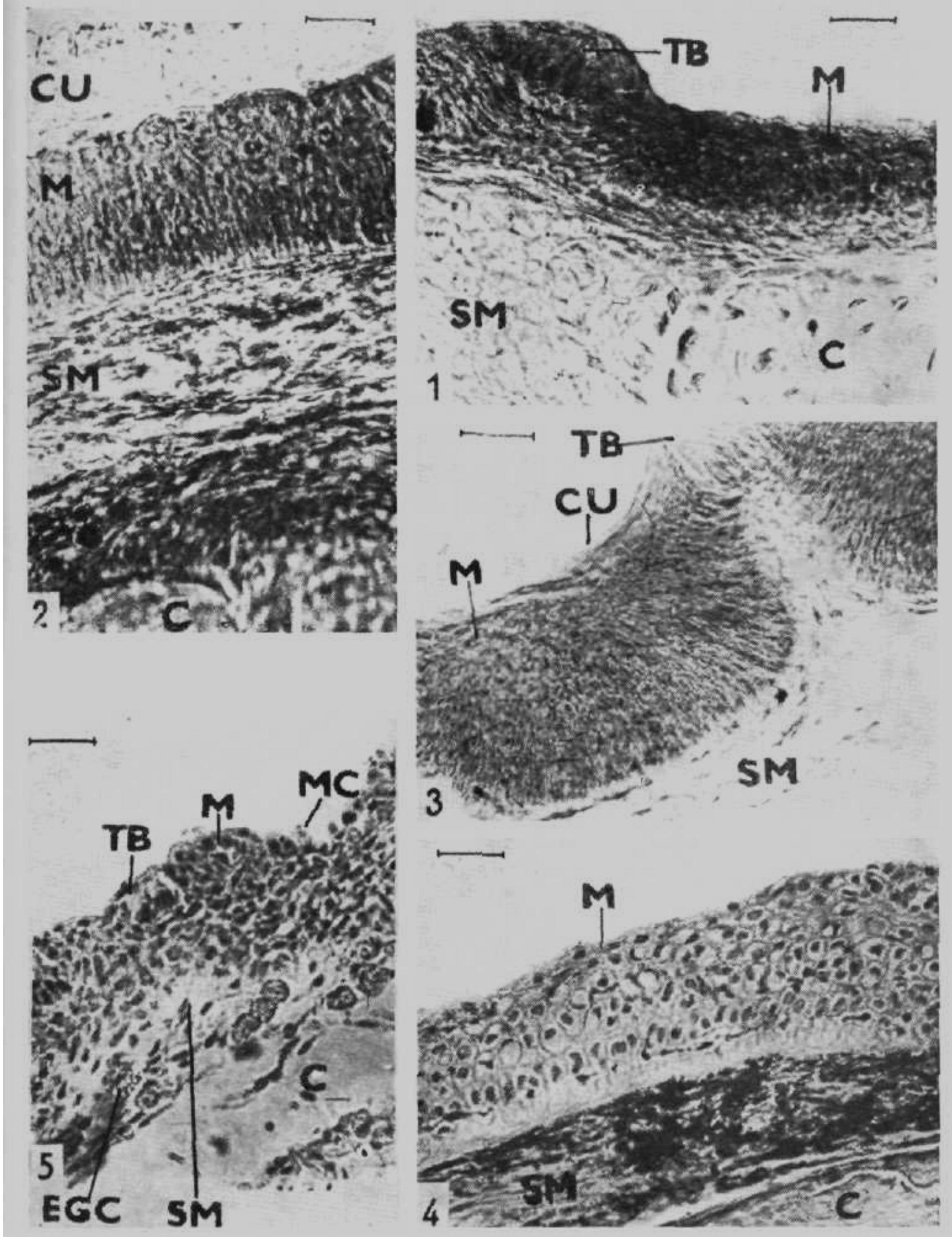


Plate II. An adult male of the Bali Tiger, *Panthera tigris balica* (Schwarz, 1912), shot in 1907 by Mr. Zandveld. The photograph was kept by the family of Mr. Zanveld and was placed at the author's disposal by Ir. C. H. J. Maliepaard and Dr. P. J. H. van Bree (above). A Javan Tiger, *Panthera tigris sondaica* (Temminck, 1844), photographed in the wild by A. Hoogerwerf (below).



Figs. 1—5. A part of T.S. passing through the tongue of: 1 — *Xenentodon cancila*, 2 — *Botia dario*, 3 — *Botia dario* exhibiting taste bud, 4 — *Colisa fasciata*, 5 — *Chatoessus manminna*. C — Cartillage; CU — Cuticle; EGC — Eosinophilic granular cell; M — Mucosa; MC — Mucous cell; SM — Submucosa; SMP — Submucosal papilla; TB — Taste bud. Scale = 0.2mm

Smirna E. M., Z. Roček: On the possibility of using annual bone layers of Alpine newts, Triturus alpestris, for their age determination

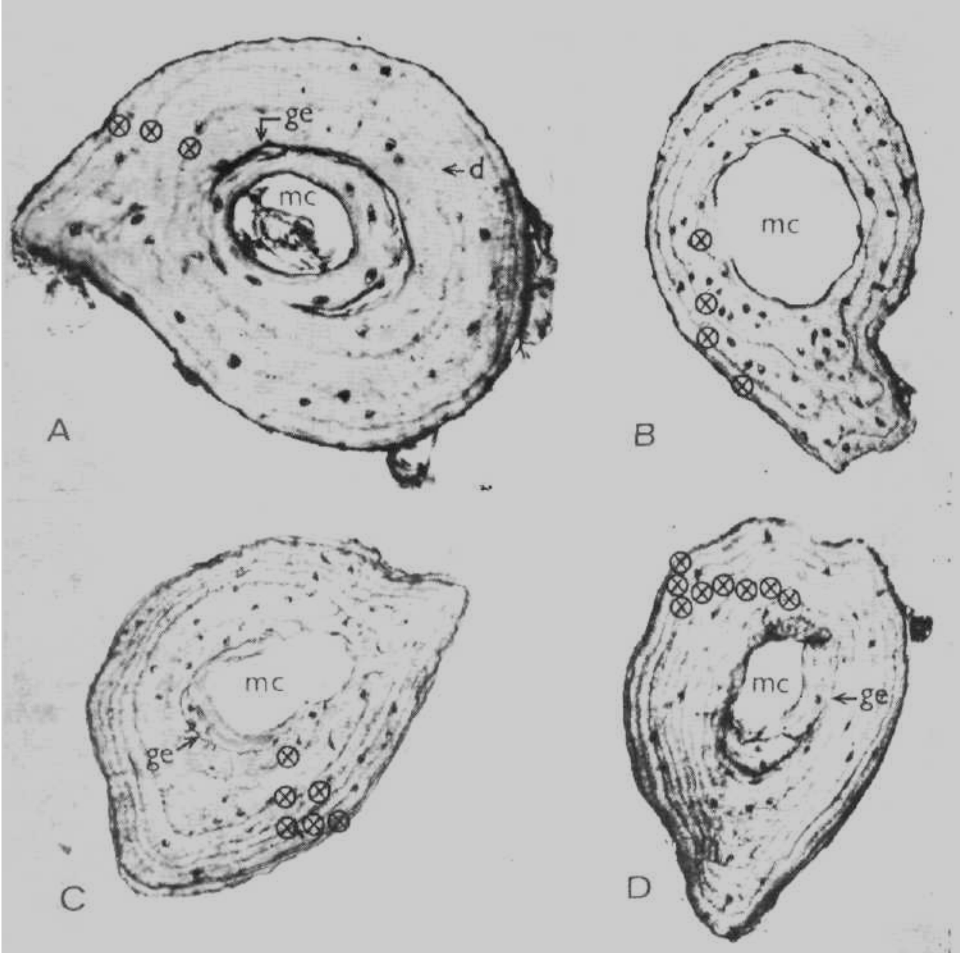


Fig. 1. The transversal sections in the femur of the Alpine newt. A — 3 layers; B — 4 layers: C — 6 layers; E — 8 layers. Abbreviations: ge — the limits of endoostal bone zone; d — supplementary lines; mc — marrow cavity. The layers are marked by crosses.

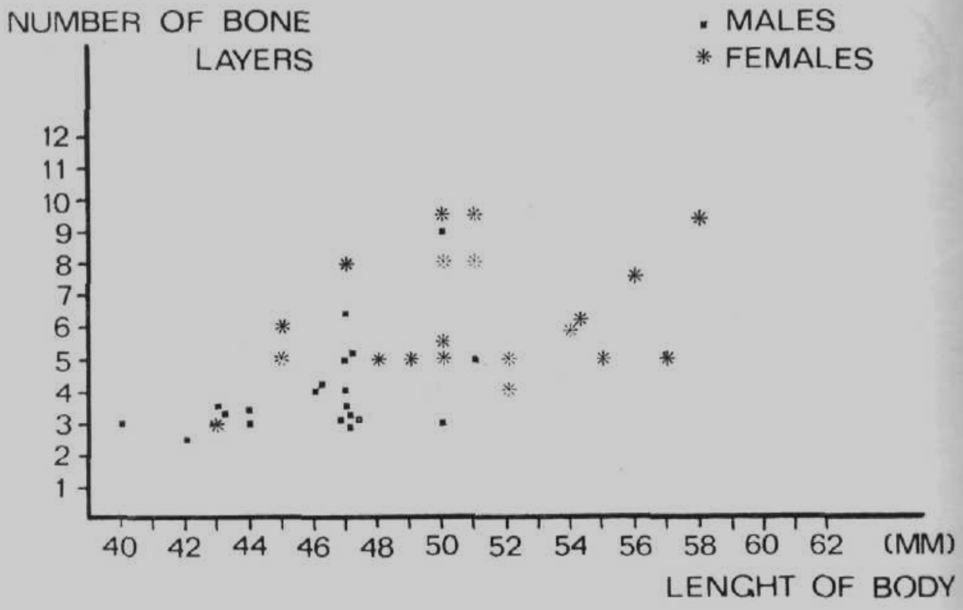


Fig. 2. The dependence of the number of bone layers on the length of the body.