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Lehrstuhl für systematische Zoologie der Karlsuniversität, **Praha**
Institut für Zoologie der Universität, Innsbruck

EINE ZWEITE DIAEA-ART IN MITTELEUROPA: DIAEA PICTILIS (ARANEIDA, THOMISIDAE)

Jan BUCHAR, Konrad THALER

Eingegangen am 2. Juni 1982

Abstract: A second species of *Diaea* in Middle Europe: *Diaea pictilis* (Banks) (Araneida, Thomisidae). 26 specimens of *Diaea pictilis* from the West Palearctic (Czechoslovakia, Austria, Switzerland, Turkey) and 4 specimens from the Nearctic region (California) are examined. Middle European specimens are redescribed, their genitalia (epigynes, vulves, palps), abdomen and femora I illustrated. Relationship of this little known species to *Diaea dorsata*, its synonymy, variability and distribution are discussed.

Beiden Autoren liegen seit langem und aus einem weiten geographischen Bereich (ČSSR, Třeboň-Gebiet 1961, Nordtirol 1962, Türkei 1967) einzelne Männchen einer Art des Genus *Diaea* vor, die der kommunen Art der Westpaläarktis *D. dorsata* (Fabricius) (beste Abb. bei Tullgren 1944) nicht angehören. Doch gelang es erst 1975, in Südmähren (ČSSR) neben vielen Männchen auch drei Weibchen zu erbeuten. Seither kamen weitere Funde in der ČSSR, in Österreich und in der Westschweiz zu unserer Kenntnis, ohne daß es schon möglich wäre, die Verbreitung der Form näher zu charakterisieren. — Wir freuen uns, diesen Versuch, die Identität und die taxonomischen Beziehungen der verkannten Form festzustellen, dem ausgezeichneten tschechoslowakischen Arachnologen Prof. Dr. František Miller, DrSc. (Landwirtschaftliche Hochschule, Brno) anläßlich seines 80. Geburtstages am 27. Januar 1982 widmen zu können.

Diaea pictilis (Banks)

Abb. 1 A—D, 2 G, H, K, L, 3 M—O, S—U; zum Vergleich *D. dorsata* (Fabricius), Abb. 1 E, F, 2 I, J, 3 P, R)

?1876 *Diaea livens* Simon, Ann. Soc. ent. Fr. *(5)* **6**, Bull., *p.* CLXXXII. Frankreich, Var.
1896 *Misumena pictilis* Banks, Journ. N. Y. Ent. Soc., **4**: **91**. USA, California.
1909 *Misumessus munieri* Coolidge, Ent. News **20**: **243** (fide Schick 1965).
1939 *Diaea pictilis*; Gertsch, Bull. Amer. Mus. Nat. Hist., **76**: 332–333, Fig. 70, 74, 75, 91.
1965 *Diaea pictilis;* Schick, Bull. Amer. Mus. Nat. Hist., **129**: 103–105, Fig. 144–146. USA, California.
Roewer (1954: 872), Bonnet (1956: 1415)

Fundorte und Material: Westpaläarktis – ČSSR: Branná bei Třeboň (Südböhmen) (7054), Quercetum 450 m (1♂ 30. VI. 1961; leg. J. Martínek, Kätscherfang). Třeboň (6954), an Eichenast (1♂ 29. V. 1973, leg. Buchar). Lednice (südl. Brno) (7166) 150 m, von tiefen Ästen einzelner Eichen in einer Auwiese (12♂ 3♀ 16 V. 1975; leg. Buchar, Hrdlička, Tonner, Kätscherfang. 1♂ 1. VI. 1978; leg. Hotská, Zacharda). Lednice, Mlýnský-Teich (7266), an Eiche (1♂ 25. V. 1981; leg. Buchar, Kätscherfang) — Österreich, Nordtirol. Stams 670 m, an Eiche (1♂ 27 V 1962; 1♂ NMW 19 V. 1976, leg. Thaler, Kätscherfänge) — Schweiz, Kanton Vaud, in Futterbündeln von Wald — und Berglaubsänger (*Phylloscopus bonelli* (Vieill.), *Ph. sibilatrix* (Bechst.)), exakter Fundort nicht mehr eruierbar (4♀ 1970—1975 je 1♀ NMW, MHNG, leg Charpie) — Türkei· Amasya 1000 m, in Obstgärten gestreift (1♂ MHNG 31. V 1967, leg Aspöck)

Nearktis — USA: California, Tapia Park, Los Angeles county (1♂ 1♀ AMNH 24 III 1957, 1♂ 1♀ AMNH 15. — 31. V. 1954; leg Schick)

Material in den Arbeitssammlungen Buchar und Thaler, ferner Naturhistorisches Museum Wien (NMW), Museum d'Histoire Naturelle Genève (MHNG), American Museum of Natural History, New York (AMNH).

♀-Beschreibung: Gesamtlänge 5,8; Länge (Breite) des Ceph. Th. 2,5 (2,5), des Abdomens 3,4 (2,7) mm. — Färbung im Leben: Ceph. Th. und Beine rötlich, Augenhügel weiß, Abdomen cremegelb, dorsal-lateral mit charakteristisch rötlichbrauner, hinten geschlossener Rückenzeichnung. Bei lange (7 Jahre) konservierten Ex. sind Carapax, Cheliceren und Spinnwarzen gelblich-braun, die Tarsen I—IV und Metatarsen I, II bräunlich, die Augenhügel weiß. Die Unterseite ist weißlich-grau, die Rückenzeichnung des Abdomens nahezu verschwunden.

Augen: VA-Reihe (Länge 1,00 mm) stärker procurv als HA-Reihe (Länge 1,27 mm). VMA (HSA) : VSA : HMA wie 1 : 1,5 : 0,9; VMA (HMA) voneinander um 3 (4), von den VSA (HSA) um 2,5 (5), von den HMA um 4 Augen-Durchmesser getrennt. — Höhe des Clypeus 0,30 mm. Cheliceren· Grundglied 0,77 (0,53) mm lang (breit), Klauenfurche unbewehrt, die Klaue stark, nahezu rechtwinkelig gekrümmt, 0,31 mm lang. — Pedipalpus: 2,25 (0,65 + 0,45 + 0,40 + 0,75) mm.

Beine: I/II/IV/III. Fe I mit 6 Stacheln (Abb. 3 N), Fe II—IV mit je 1 Dorsalstachel (DS) (an IV nur schwach ausgebildet). Pt und Ti I—IV mit je 2 DS. Ferner Ti I, II mit 5 Paar Ventral- (VS), 3 Paar Lateral- (LS), 1 Paar ventraler Apicalstacheln (AS) Ti II unterscheidet sich durch Ausfall einzelner VS und AS. Mt I, II mit 5 (3) Paar VS (LS). Die Hinterbeine sind schwächer bewehrt: Ti III, IV pro- (retrolateral) mit 1—2 (0—1) LS, außerdem prolateral/ventral 1 VS. Mt III mit 1—2 (1) pro- (retrolateralen) LS und 1 Paar VS. Mt IV mit 2 prolateralen und 1 prolateral-ventralen Stachel. Distalende von Mt III, IV mit Scopula.

Absolute Maße der Beinglieder (mm)·

	Fe	Pt	Ti	Mt	Ta	Ges. L.
I	2,95	1,30	2,50	2,45	1,00	10,20
II	2,95	1,30	2,45	2,30	1,00	10,00
III	1,85	0,85	1,30	1,10	0,60	5,70
IV	2,00	0,80	1,50	1,25	0,60	6,15

Epigyne-Vulva: Abb. 1A—D. Details sind and frischtoten Ex. wegen der schwachen Sklerotisierung wenig deutlich und heben sich erst nach längerer Konservierung ab. Epigyne ohne markante Begrenzung, vorn mit zungenförmiger, stärker als bei *D. dorsata* vorspringender Führungstasche, seitlich davon die Einführungsöffnungen, dahinter die Ansatzstelle der Receptacularapophyse. Einführungsgänge weitlumig, membranös, zunächst (Abschnitt 1) parallel steil dorsad steigend, dann hufeisenförmig ventrad gekrümmt, von wo sie sich laterad kehren und in die undeutlich abgesetzten, mediad/ventrad gekrümmten Receptacula (Abschnitt 2) münden. Die Befruchtungskanäle entspringen innen//aboral neben der Receptacularapophyse (Struktur 3, nicht weiter differenziert).

♂-Beschreibung: Gesamtlänge 4,2; Lange (Breite) des Ceph. Th. 1,9 (1,5) mm. Färbung kontrastreicher als beim ♀. Ceph. Th. mit zwei von den HSA ausgehenden, aborad konvergierenden dunklen Linien. Abdomen mit deutlicher Dorsalzeichnung, Abb. 3 M. Beine I, II dunkel geringelt, ihre einzelnen Abschnitte *jeweils distal verdunkelt, ebenso die Vorderseite der* Fe I *und der proximale* Bereich der Ti I. Verdunkelt ist auch das Cymbium, lediglich seine Spitze bleibt hell. — Augen wie beim ♀, VA-(HA) Reihe 0,85 (1,00) mm. — Basalglied der Cheliceren 0,73 (0,46) mm lang (breit), Klaue 0,27 mm. — Pedipalpus: 1,95 (0,70 + 0,35 + 0,25 + 0,65) mm.

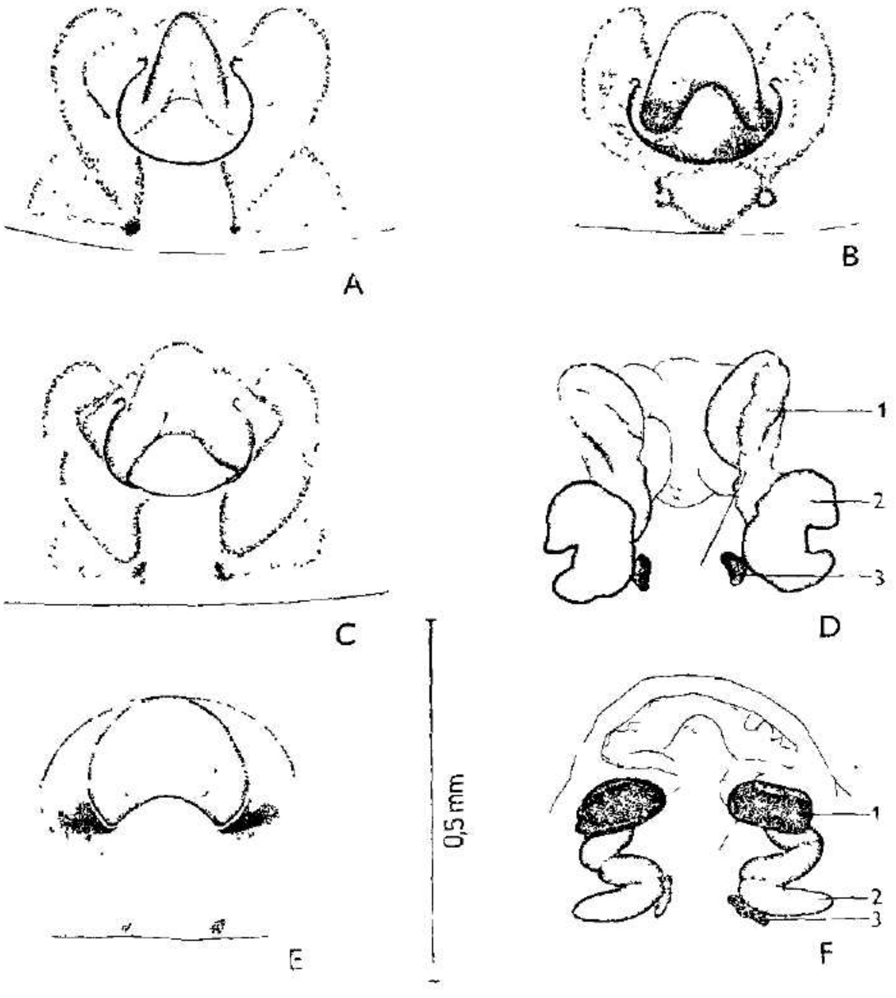

Abb 1. – *Diaea pictilis* (Banks): A–D (ČSSR, Lednice). – *D. dorsata* (Fabricius) **E–F** (ČSSR, Jeseníky). – Epigyne: A–C,E Vulva von dorsal: *D* (zu Abb. 1 C), F (zu Abb 1 E). Erläuterung 1 Einfuhrungsgang, 2 Receptaculum, 3 Befruchtungsgang und Receptacularapophyse (*Alle Abbildungen von E. Laštovková gezeichnet*).

Beine: I/II/IV/III. Fe I mit 10—11 Stacheln in zwei unregelmäßigen Reihen (Pro-LS, DS), Fe II—IV mit je 5 DS. Pt I, II zusätzlich zum ♀ mit 1 Paar LS, Pt (III), IV mit 1 Retro-LS. Ti I (II) mit 3 Paar LS, 3 (2) Paar VS und 1 Paar ventraler AS, Ti III, IV mit 2 (1) Paar LS (VS). Mt I—IV mit 2 Paar LS, zusätzlich I, II mit 3 Paar VS, III mit 1 Paar VS, IV mit 1 prolateralen VS.

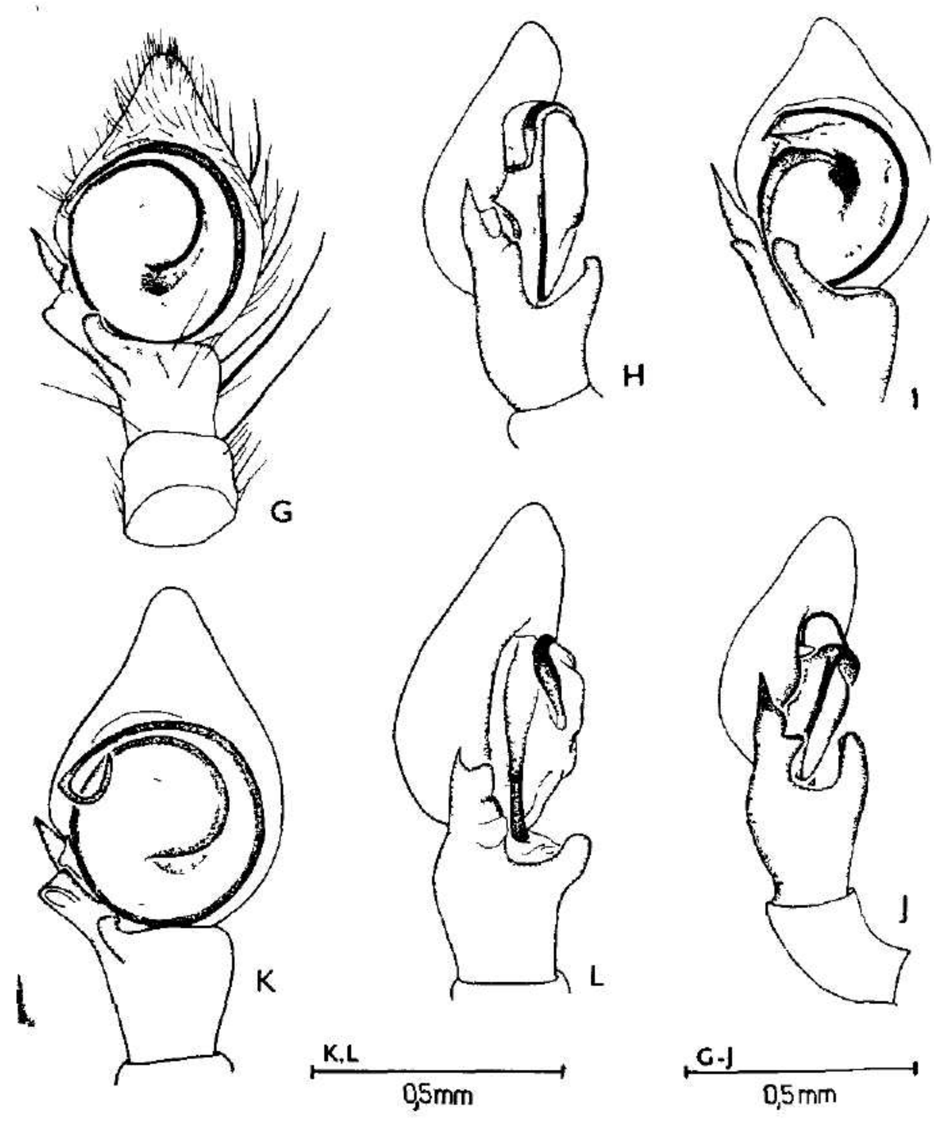

Abb 2 — *Diaea pictilis* **(Banks):** G, H (ČSSR, Lednice), **K, L, (Türkei,** Amasya). — *D dorsata* (Fabricius): **I, J (ČSSR,** Kamenice). — ♂-**Palpus ventral** (G, I, K) **und** retrolateral (H, L, J).

Absolute Maße der Beinglieder (mm):

	Fe	Pat	Ti	Mt	Ta	Ges. L.
I	3,55	1,10	3,30	3,50	1,30	12,75
II	3,45	1,10	3,15	3,25	1,25	12,20
III	1,80	0,75	1,40	1,25	0,75	5,95
IV	1,85	0,75	1,50	1,30	0,65	6,05

Pedipalpus: Tibia mit zwei Apophysen; die retrolaterale Hauptapophyse gerade, mit scharfer Spitze endend, mit zwei ventralen Vorsprüngen; ventrale Nebenapohyse schräg retrolaterad verlaufend, stumpfkegelig, mit eingekrümmtem Ende. Cymbium ohne Tutaculum, Bulbus rund, scheibenförmig, ohne Apophyse, Embolus median-proximal entspringend, zunächst mit breitem, membranosem Innensaum, etwa 3/4 des Tegulum umrundend und riemenförmig endend, Embolus-Ende abgewinkelt, im Ruhezustand im Alveolus geborgen, Abb. 2 G-K. *D dorsata* unterscheidet sich in der Form der Tibialapophysen, markant bezüglich des Embolus, Abb. 2 I—J.

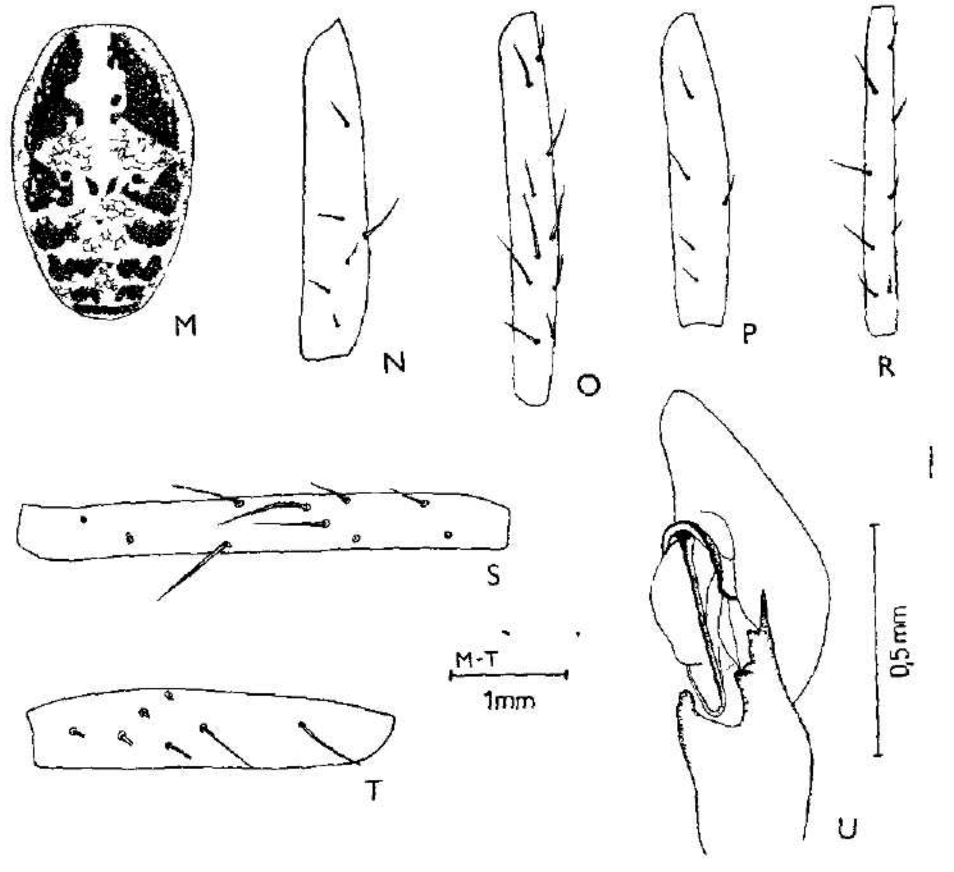

Abb 3. — *Diaea pictilis* (Banks) M—O (ČSSR, Lednice), S—U (USA, California). — ***D. dorsata*** (Fabricius) P—R (ČSSR, Kamenice). — ♂-Abdomen dorsal M. ♀/♂-**Femur** I von **vorn**: N,P,T/O,R,S. ♂-Palpus retrolateral U

Variabilität: Die Größenvariation ist unbeträchtlich, Ceph. Th. Länge ♀ 2,3—2,6 (n=7), ♂ 1,9—2,0 (n=19). Die Dorsalzeichnung des Abdomens ist bei allen ♂ nahezu identisch (Abb. 3 M), bei den ♀ weitgehend reduziert und nur durch ihre seitliche und rückwärtige Begrenzung angedeutet. Variabel ist die Ausdehnung der Prosoma-Zeichnung des ♂, die dunklen Linien fehlen dem Ex. aus der Türkei, und die Ringelung der Beine. Die Ringflecken der Ta fehlen einigen ♂ aus Lednice und dem türkischen Ex. Variabel ist auch die Bewehrung der Beine: angegeben ist die volle Stachel-Garnitur, der Ausfall einzelner Stacheln ist häufig. — ♂-Pedipalpus: Das türkische ♂ weist eine auffällig kurze Endspitze der Hauptapophyse der Tibia auf, Abb. 2 L.

Bemerkungen zur kalifornischen Population: Die Körpermaße der uns vorliegenden Ex. (2♂ 2♀) liegen im Randbereich der Variationsbreite der westpaläarktischen Ex., Ceph. Th.-Länge ♂ 1,4; 2,3; ♀ 2,0; 2,5 mm. Genitalmorphologisch herrscht Übereinstimmung. Vulva und Embolus wirken geradezu identisch. Das belegen die Fig. von Schick (Ventralansicht des Palpus, Epigyne und Vulva) und unsere Abb. des Palpus von retrolateral (Abb. 3 U). — Bestachelung der Fe I: Bei beiden ♀ asymmetrisch, jeweils nur einseitig unserer Abb. 3 N entsprechend, das andere Femur mit 7 Stacheln bewehrt (Abb. 3 T). Die Beinbewehrung der 2♂ ist ärmer, nur eines stimmt einseitig mit den mitteleuropäischen Ex. (Abb. 3 S) überein.

Differenzierung von *D. dorsata* (Fabricius): Zur sicheren Unterscheidung der beiden Formen verhelfen die Kopulationsorgane. Das Augenfeld der uns vorliegenden ♂ ist bei *D. dorsata* in der Regel verdunkelt, bei *Diaea pictilis* (Banks) hell; die Dorsalzeichnung des ♀ Abdomen bei *dorsata* in der Regel kompakt dunkelbraun, bei *pictilis* aufgelöst, besonders randlich und rückwärts erhalten. Fe I scheinen bei *pictilis* reicher bestachelt, ♀ (♂) mit 6 (10) LS und DS (Abb. 3 N, O) gegenüber 5 (9) (Abb. 3 P, R) bei *dorsata*, doch ist auch dieses Merkmal nicht ohne Überschneidung.

	D. pictilis	*D. dorsata*
Führungstasche	vorspringend	flach
Anfangsabschnitt der Einführungsgänge	hufeisenförmig, den Vorderrand der Epigyne erreichend, Abb. 1 D	mit kugeligem Atrium hinter der Führungstasche, Abb. 1 F
Tastertibia — Ventralapophyse	ventrad laterad abstehend, Abb. 2 H	parallel zur Hauptapophyse verlaufend, Abb. 2 J
Embolus	riemenförmig endend, mit abgewinkelter Spitze, Abb. 2 G, K	breit endend, mit schnabelförmigem Spitzchen, Abb. 2 I

Diskussion: Aufgrund der verschiedenen Ausbildung der Kopulationsorgane scheint uns unzweifelhaft, daß in der West-Paläarktis (bisherige Fundgebiete ČSSR, Österreich, Schweiz, Türkei) eine weitere Art der Gattung *Diaea* vorkommt. Ein vollständiger Formenvergleich ist bei dieser mit circa 80 Arten weltweit, besonders in Afrika, in der orientalischen und australischen Region auftretenden Gattung nicht möglich (Roewer 1954, Bonnet 1956). Leider stehen gerade die wenigen nominellen Taxa der Paläarktis für einen Vergleich nur in sehr eingeschränktem Maße zur Verfügung: fünf ohne Abb. aus Yarkand beschriebene Arten (Cambridge 1885), *D. subadulta* Bösenberg & Strand (nach Yaginuma 1977 möglicherweise ein *Philodromus*); lediglich *D. kochi* Thorell, ebenfalls aus Japan, ist genitalmorphologisch distinkt (Koch 1878).

— Doch wurden aus Europa weitere fünf *Diaea*-Formen benannt, deren Kopulationsorgane nicht bekannt sind und die, *D. formosa* ausgenommen, gegenwärtig als Synonyme von *D. dorsata* gelten. Eine Re-Interpretation ist schwierig, auch ist uns das alte Schrifttum nur teilweise zugänglich. Nach den Angaben der Autoren über die Zeichnung ihrer Arten glauben wir, diese Synonymisierung für *Thomisus capparinus* C. L. Koch (Patria: „Ungarn. Banat", Koch 1845: 58, fig. 993—995) und *D. devoniensis* O. P. Cambridge (Patria: Devon, Torquay, Cambridge 1881) akzeptieren zu müssen. Die Typen von *Th. floricolens* (Walckenaer) und von *Th. formosus* Blackwall (Patria: London, Southgate, Walker leg. 1848) müssen wohl als verloren gelten, eine zwingende Interpretation allein nach den Angaben über Färbung und Zeichnung (Blackwall 1861, Walckenaer 1837) ist wohl nicht möglich, ebensowenig für *D. livens* Simon (1876, Patria: Frankreich, Var, Sainte-Baum, Belon leg.). Wir möchten nicht ausschließen, daß ein Studium der Verbreitung von *Diaea* in Frankreich und England dazu führen wird, eines dieser alter Taxa als valide anzuerkennen. — Die Übereinstimmung der Kopulationsorgane zur einzigen nearktischen, in Kalifornien beheimateten Art *D. pictilis* veranlaßt uns, unsere Ex. derart zu identifizieren. Die Beinbewehrung von zwei Pärchen aus Kalifornien (AMNH) scheint ebenfalls in den Variationsbereich der europäischen Form zu fallen. Auch die Habitat-Ansprüche sind ähnlich, „*pictilis* has been collected only on the coast live oak ... and principally in Coastal Oak Woodland". In Anbetracht der Distanz der Fundgebiete ist eine befriedigende Deutung dieses Verbreitungsbildes wohl erst nach besserer Kenntnis der Gesamtverbreitung und Beziehungen der verschiedenen *Diaea*-Arten möglich, auch der Verdacht auf eine künstliche Erweiterung des Areals durch Verschleppung sollte besonders berücksichtigt werden.

Dank: Für Vergleichsex. danken wir dem American Museum of Natural History, New York (Dr. N. I. Platnick) und dem Museum d'Histoire naturelle, Genève (Dr. B. Hauser), für die Mitteilung von Funden und sonstige Unterstützung den Herren Prof. Dr. H. Aspöck (Wien), D. Charpie (Lausanne), Dr. V. Mahnert (Genève).

Nachtrag

Dank dem Entgegenkommen von Herrn Dr. M. Hubert (Paris) lag uns die Typenserie von *Diaea livens* Simon (t. 1588, 6 Ex., Patriaangabe „Gallia meridionalis") zur Nachuntersuchung vor. Zu unserem Bedauern mußten wir erkennen, daß es sich durchwegs um in- bis subadulte Ex. handelt. Die ‚peripheren' Merkmale dieser Ex. sprechen für ihre Identität mit *D. pictilis:* Abdomen mit einem Paar weißer Dorsalflecke, Femora I mit (3) 2+1+1 Stacheln, endlich das Größenverhältnis der Mittelaugen. HMA auffallend kleiner als VMA. Leider kann die Beurteilung nicht nach genitalmorphologischen Merkmalen erfolgen. Wir können daher nur unsere Erwartung aussprechen, ein Studium der Verbreitung von *Diaea in Frankreich* werde zu einer Neubewertung von *D. livens* Simon führen.

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MORPHOLOGY OF THE MIDDLE AND INNER EAR IN TWO PANTHERA SPECIES — P. TIGRIS AND P. ONCA (FELIDAE, CARNIVORA, MAMMALIA)

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Received May 31, 1982

Abstract: The authors describe the morphological structure and present some morphometrical characteristics of the peripheral auditory organ (bulla tympanica, eardrum, and auditory ossicles of the middle ear; basilar membrane, spiral ligament, and the population of hair cells of the organ of Corti of the inner ear) in two Panthera species — the tiger and the jaguar. It is for the first time that the inner ear of any felid other than the domestic cat has been studied by means of the method of total surface specimens. The morphological findings are discussed also in terms of hearing capabilities of the examined species.

Within the framework of the morphological and morphometrical studies on the auditory apparatus in mammals we have been given opportunity to examine also the ears of two *Panthera* species: the tiger and the jaguar. With regard to the fact that the ears (and especially their actual sensory parts — the organs of Corti) of these (nor of any other *Panthera* or wild cat) species have been based on examination of two ears of both two studied animals only. our findings. They may be worth mentioning in spite of the fact that they have been based on examination of two ears both two studied animals only. Since the variation in morphological (and morphometrical) parametres of the auditory organ structures may be considered rather insignificant among individuals of the particular mammalian species, we may hold the data presented, to a great extent as representative.

MATERIAL AND METHODS

Both ears of the Sumatrean tiger, *Panthera tigris sumatrae* (14 years old male named Raduz) and of the jaguar, *Panthera onca* (17 years old female) were examined. The animals were killed according to the decision of their keepers of the Zoological Garden of Prague. The reason for this euthanasia was the senility and the associated functional and organ changes in both animals. Neither the tiger nor the jaguar had been treated with any drugs that could be considered as ototoxic (like aminoglycosydics, some of the diuretics, cytostatics).

Within 15 minutes post mortem the caudal part of the base of the skull, including both otic regions, was isolated, the eardrum perforated, and neutral solution of 10 % formaldehyde injected into the middle ear cavity. Then the bones contaning the auditory organs were immersed into the fixative of 10 % formaldehyde solution for several weeks.

The middle ear was examined under a stereomicroscope. The petrosal bone forming the bony shell of the cochlea was worn off by means of an electric dentist's drilling machine to such an extent that the cochlear wall could be entirely removed by means of fine surgical instruments. After being stained by toluidin blue and Ehrlich's haematoxylin "in toto" the cochlear partition was (under control of the stereomicroscope) prepared, mounted in glycerine, and examined under the light microscope. For measuring the ocular micrometre was used.

One ear of the tiger was processed by a standard histological technique (after being decalcified by Chelaton — EDTA) to serial 10–20 μm thick paraffin sections.

RESULTS AND DISCUSSION

Comparing our observations with the fragmentary data that may be found in the literature (e. g. Werner, 1960; Fleischer, 1973) we may conclude that the middle ear of both tiger and jaguar does not differ from the common structural plan of the middle ear in the Felidae.

The most conspicuous structure is the voluminous external bulla which resembles the proper tympanic bulla but being filled with air only it does not contain any structures. It is formed by the endotympanic part of the temporal bone and it communicates via a narrow slit with the tympanic bulla proper which is relatively small and is made by pars tympanica, petrosa et squamosa of the temporal bone. While the volume of the "external' endotympanic bulla in the tiger was estimated to be 13.2 ml, the volume of the actual bulla tympanica (s. bulla ossea) was only 0.3 ml. The situation in the jaguar (though not quantitatively assessed in this study) is very similar.

The area of the tympanic membrane (eardrum) accounts to 61 mm^2 in the tiger and 58 mm^2 in the jaguar.

The middle ear ossicles are of the same shape and roughly of the same size in both species under study. They are pictured in Figure 1 (the stirrup was destroyed during the preparation).

There are at least two ways in which the effective transmission of sound energy from air to cochlear fluids is accomplished by the middle ear. One of them is due to the condensation of pressure energy from the larger eardrum to the smaller footplate of the stapes, the other is determined by the mechanical performance of the auditory ossicles. The former way may be expressed by the so-called area ratio (i. e. the ratio of the area of the eardrum to that of the stapedial base). Since the area of the stapedial base was counted to be 3.5 mm^2 in the tiger and 2.1 mm^2 in the jaguar the value of the area ratio is about 17 in the tiger and 27 in the jaguar. The mechanical performance of the ossicles is determined by the so-called lever ratio (i. e. the ratio between the length of the lever of the manubrium and the collum of the malleus and the lever of the incus). The lever ratio in the studied ossicles of the *Panthera* species was estimated to be about 2.8 : 1. The final decrease in the impedance of the cochlear fluid is determined by the so-called final transformation ratio which has been defined as the product of both the above-mentioned ratios. The value of this ratio is 48. Though it is well known that the middle ear does not work in such an ideal way and the effective transformer power may be reduced (or increased) also by other factors such as the mass and stiffness of the ossicular chain, we may nevertheless consider the middle ear of both the tiger and the jaguar to be more effective for transmission of acoustic energy than, e. g., the ear of man, the final ratio of which is (according to Møller, 1974) 18 : 1.

The area of the fenestra vestibuli corresponds to that of the stapedial base and as such it has been given above. The fenestra cochleae is somewhat larger — its area in the tiger accounts to 10.7 mm^2. The cochlea of both *Panthera* species coils into a rising spiral which has 2 3/4 turns in both. The length of the spiral (better to say, the length of the organ of Corti) was counted to be *35.5 mm in the tiger and 33.3 mm in the jaguar.*

The cochlear duct is built in an identical way as in all placental mammals studied so far. Examining the histological sections through the tiger cochlea we paid attention to the ratio between the width of the spiral ligament and the width of the basilar membrane since in Burda's previous papers (1980, 1982) it has been shown that there exists a correlation between the value of that ratio and the tonotopy of the mammalian cochlea (the fact which indicates functional unity of both structures and the importance of the spiral ligament for cochlear mechanics — cf. Voldřich and Úlehlová, 1982). The value of the ratio *increases from about 0.6 at the base to about 5.5 at the apex. Comparing these* values with the previously found and described correlations (Burda, 1980 a, b) we may assume the hearing range (frequency range of the audible field) in the tiger to cover frequencies from about 200 Hz up to 20—60 kHz. Neff and Hind (1955) stated the high frequency cut-off in the domestic cat to be 60 kHz and this is — as far as we know — the only felid which has been audiologically examined.

Examining the total surface specimens of the cochlear partitions we have evaluated especially the population of sensory hair cells of the organ of Corti. *The surface pattern of the organ of Corti (its reticular lamina) is very regular* (Figs. 2—4) and though not so regularly geometrically arranged as in e. g. shrews or bats it is more regular than in primates (cf. Burda, 1979). In both Panthera species, the cochlear duct and its organ of Corti are subject to the same relative current intracochlear changes along the spiral from apex to base as known in most of other mammalian species (these changes involve, e. g., reduction in the majority of the radial basilar membrane parametres, opening of the "W" formation of outer hair cells, etc. — cf. Burda, 1979).

Since both animals under study were rather old we were able to find besides the *normal morphological structure,* also the specific features of the involution of the auditory papilla as caused by senility. These particular findings in both *Panthera* species are described and dealt with in a separate paper (Úlehlová et al., 1983).

We counted the number of sensory cells as well as that of scars from sensory cells which had become extinct during life. Thus we could determine the ideal number of sensory hair cells — i. e., the animal's life outfit of hair cells.

In the tiger, the total "ideal" number of outer hair cells was counted to be 12,936 and the number of inner hair cells 3,414 — hence there were 16,350 auditory hair cells altogether in the tiger. The total number of outer hair cells in the jaguar accounted to 13,076, that of his inner hair cells 3,354, i. e., altogether 16.430 auditory hair cells were found in the jaguar.

The mean density of outer hair cells and inner hair cells per one millimetre of the organ of Corti is thus 364 + 96 (460 altogether) and 393 + 101 (494 altogether) in the tiger and the jaguar, respectively. Neither in the tiger nor in the jaguar any significant intracochlear current changes in the hair cell densities could be found. Though the jaguar has a higher density of hair cells (having the organ of Corti shorter, however) than the tiger it is still a question whether this difference can be considered as significant (due to the fact that only one animal of either species was examined). Comparing the hair cell density found in both panthers with values estimated in other mammalian species (cf. Burda and Voldřich, 1983) we may consider it to be within the range of the "normal" mammalian ear. Having in mind the relatively long Corti organ and thus the relatively high total number of hair cells (i. e. the proper sensory cells) we may conclude that both tiger and jaguar are provided with fair hearing resolution capabilities.

CONCLUSSIONS AND SUMMARY

The middle and inner ear in the tiger (*Panthera tigris sumatrae*) and the jaguar (*Panthera onca*) was examined. Special attention was paid to the middle ear structures involved in transmission of sound energy and in the population of sensory hair cells of the organ of Corti of the inner ear. The latter was studied especially by means of the total surface specimen technique. Values of some functionally important morphometrical parametres are presented and discussed.

The middle ear transformer chain: eardrum (61 mm^2 in tiger and 58 mm^2 in jaguar) — auditory ossicles lever performance ratio (2.8 : 1) — stapedial footplate (3.5 mm^2 in tiger and 2.1 mm^2 in jaguar), seems to be rather effective for transmission of acoustic energy and for matching the impedance of cochlear fluids against that of air.

The cochlea has 2 3/4 turns. The length of the cochlear duct (namely the organ of Corti) was estimated to be 35.5 mm in the tiger and 33.3 mm in the jaguar. The cochlear duct is built in the same way as in other placental mammals studied so far.

The analysis of the ratios between the radial widths of the basilar membrane and the spiral ligament in the course of the cochlear duct of the tiger indicates that in tiger the hearing range should approximately cover frequencies from at least 200 Hz up to 20 (to 60) kHz.

The total "ideal' number of hair cells ("life outfit") in both animals under study was counted. The numbers are as follows (outer hair cells; inner hair cells; hair cells altogether): tiger — 12,936; 3,414; 16,350; jaguar — 13,076; 3,354; 16,430. The density of hair cells does not change significantly in the course of the organ of Corti. Though the mean hair cell density in the jaguar is higher than in the tiger we are not allowed to consider this difference to be significant since only one animal of either species was examined. The hair cell density is within the range of the "normal" mammalian ear. The high total number of sensory hair cells indicates fair hearing (intensity and/or frequency) resolution capabilities.

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The figures 1–4 will be found at the end of this issue.

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ANALYSIS OF THE CIRCADIAN RHYTHM OF A SNOWSHOE HARE (LEPUS AMERICANUS, LAGOMORPHA) FROM TELEMETRY DATA

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Abstract: The pattern of rest and activity of an adult male snowshoe hare was monitored over 26 months to illustrate seasonal changes in the circadian pattern. Data were collected in east-central Minnesota, U. S. A. using an automatic radio tracking system. Average daily percentage activity is used to define onset and end of activity in each 24 hour period. Phase-angle differences of onset, end and midpoint of activity and activity time show a strong similarity in successive years suggesting that telemetry data and our method of determining of onset and end are consistent and suitable for studies of rhythms in free-ranging animals. In general, onset followed sunset much more closely than end followed sunrise or midpoint followed darkness midpoint. Highest values of activity time occurred in winter and lowest values in summer. In terms of biological requirements, the large positive phase-angle difference in summer, with a short dark period, may indicate that the hare had to begin activity several hours before sunset to have sufficient time for feeding, grooming and other activities. During long winter nights the hare had ample time to complete required activities. Use of telemetry on free-ranging animals has the advantage of eliminating effects of cages and disturbances caused by human activities. Furthermore, telemetry allows measurement of all locomotor movements, not just activity measured by running wheels, at food or nest boxes or on perches. In addition, telemetry provides an opportunity to determine how factors such as temperature, precipitation, food, cover and reproduction interact with photoperiod in determining the circadian pattern.

INTRODUCTION

Seasonal changes in circadian activity have been studied extensively in caged animals (Aschoff 1969, Daan and Aschoff 1975). Development of radio telemetry techniques has made it possible to investigate the pattern of activity of free-ranging animals living under natural conditions. Examples of such studies include Gerell (1969) on mink (*Mustela vison*), Maxson (1977) on ruffed grouse (*Bonasa umbellus*), Mech et al. (1969) on cottontail rabbits (*Sylvilagus floridanus*) and snowshoe hares (*Lepus americanus*), Rongstad and Tester (1971) on snowshoe hares and Tester (1978) on grey squirrels (*Sciurus carolinensis*).

Comparison of data indicates that activity patterns of free-ranging animals are less precise in terms of the time of onset and end of activity than are patterns of caged animals. As a result, determinations of typical circadian characteristics such as period, phase relationships and $\alpha : \rho$ ratios (see Aschoff 1965 for definitions) are more difficult from telemetry data.

This paper describes the type of information on activity that can be obtained by telemetry and presents a quantitative technique for determining time of onset and end, key circadian characteristics. This technique is applied to observations of a snowshoe hare over a 26 month interval to illustrate seasonal changes in the circadian pattern. This animal was selected because it had been monitored continuously for more than 2 years and data on seasonal changes in activity could be compared from year to year.

METHODS

Field data were collected at the Cedar Creek Natural History Area in east-central Minnesota (93° 12′W., 45° 24′ N.) from March 1966 to April 1968. The hare, an adult male, was captured on 16 March 1966 in a National live trap and was fitted with a radio transmitter in the 53 mHz range. The transmitter was designed as a collar with the broadcasting antenna forming the collar loop. Weight of the transmitter was 35 grams, life was 180 days and range was about 1.6 km. Every six months the hare was recaptured using a drive net and the battery in the radio transmitter was replaced.

Radio signals from the hare monitored by the Cedar Creek automatic radio tracking system (Cochran et al. 1965) and the data were used to determine location and activity. Signals were recorded on microfilm every 45 seconds.

When the hare was motionless the radio signal appeared as a continuous black bar on the microfilm records, whereas when the hare was moving the signal appeared as a broken or interrupted bar. These breaks were caused by modulation of the radio signal due to a change in capacitance of the circuit as the collar changed position on the neck of the mammal. The appearance of the radio signal on the microfilm record provided a means of determining, to the nearest minute, when the hare was active or resting. Specific types of activity, such as running or feeding, could not be differentiated from the radio signal. In our analysis, data were summarized by five minute intervals. The hare was considered "active" if two or more of the signals exhibited the broken pattern. At times, no signal was received due primarily to failure of equipment.

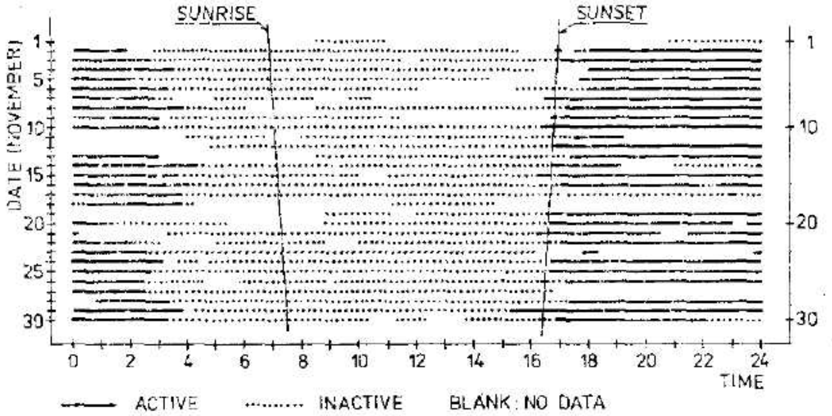

Fig. 1. Daily activity pattern for an adult male snowshoe hare for November 1967 in east-central Minnesota, U. S. A.

Data from the film record were recorded on tabulation sheets and then on computer punch cards for further analysis on a Control Data Cyber 74 system. The analysis program was designed to produce one output showing the daily pattern of rest and activity for an individual animal by months (Fig. 1). These data correspond to the strip chart records of captive animals in running wheels or spring-suspended cages.

The second computer output summarizes data on activity and rest for each month (Fig. 2). These data are presented as a composite 24 hr graph showing the percent of days of the month the hare was active for each 5 minute interval throughout the day.

For every 24 hour monthly composite, we calculated the average daily percentage activity. This is the total minutes active for the month, i. e., the summation of all 5 minute intervals, divided by the total minutes known times 100. This average activity, shown as a horizontal line in Figuere 2, is used for defining onset and end of activity. Periods when percent activity is above this average line are defined as activity time, or "α". Periods below the average line are defined as resting, "ρ". In the evening, for a night active species, the time when the percent activity rises above the average is defined as onset of activity. The time in the morning when the percent activity falls below the average is defined as end of activity. These onset and end of activity times along with the average sunset and sunrise times for each month are used to calculate Ψ onset and Ψ end.

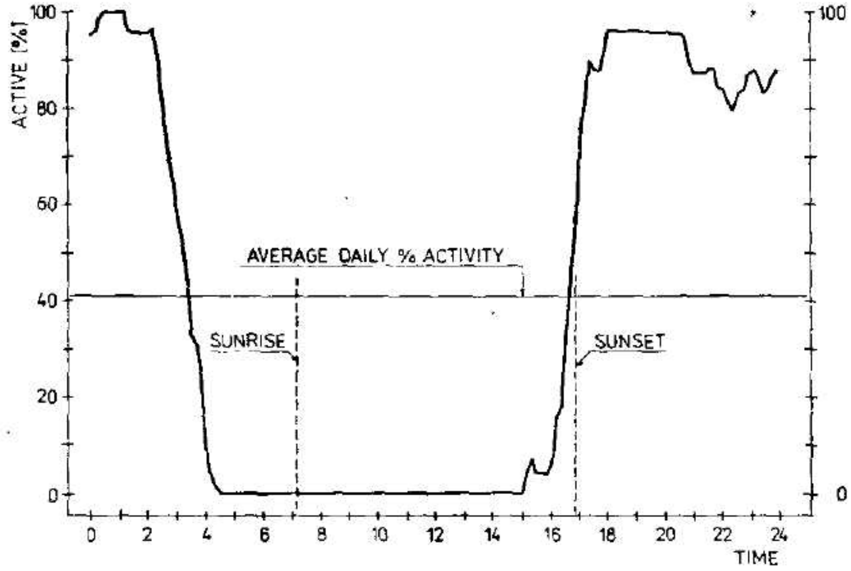

Fig. 2. Activity pattern for an adult male snowshoe hare for November 1967 showing percent of days the hare was active for each 5 minute interval during the 24 hours.

Actual onset and end of activity are probably somewhat different from these values. However, because the definitions are consistent for all months studied, the relative values should be valid in revealing general trends of the circadian pattern.

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

RESULTS

A. Phase angle

Phase angle, Ψ, is defined as the time difference between 2 corresponding phase of synchronized oscillations (Aschoff 1965). Usually 3 values of Ψ are determined. In night-active animals the phase-angle difference of onset, Ψ_{onset}, is the time between the beginning of activity and sunset. The phase-angle difference of end, Ψ_{end}, is the time between cessation of activity and sunrise. The phase-angle difference of midpoint, $\Psi_{midpoint}$, is the time between the midpoint of activity and the midpoint of the night.

Monthly average of times of activity onset, end and midpoint for March 1966 through March 1968 are given in Figure 3. Darkness midpoint is the calculated midpoint between sunset and sunrise. In comparing the 3 sets of data, it is apparent that onset followed sunset much more closely than end followed sunrise or midpoint followed darkness midpoint. Similar patterns were observed for each year.

Figure 4 illustrates Ψ_{onset} as a function of time of year. From October—March, onset of activity occurred near sunset ($\Psi_{onset} = 0$). The largest values (+2.3) occurred in the summer. This annual pattern, which is consistent for the entire period of study, has been shown to exist for caged night-active animals (Daan

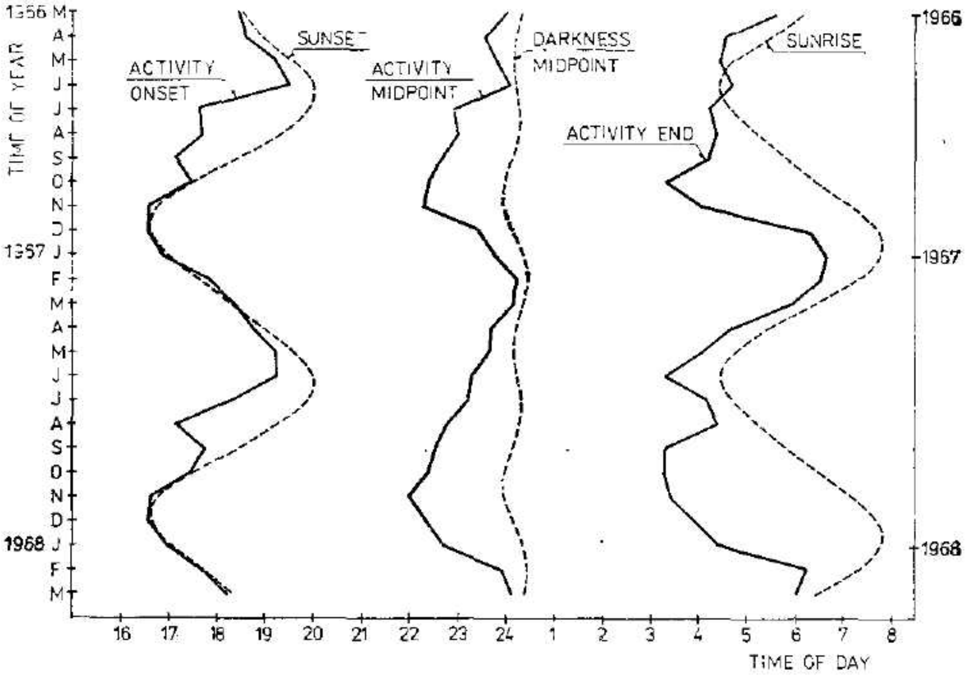

Fig. 3. Comparison of the monthly average of activity onset with sunset, midpoint with darkness midpoint, and end with sunrise for an adult male snowshoe hare from March 1966 through March 1968.

and Aschoff, 1975). Ψ_{onset} for golden hamsters (*Mesocricetus auratus*) ranged from approximately —1.5 to +1.0 in southern Germany (48° N. latidue), and from approximately —3.0 to +3.0 at the Arctic Circle (66° N. latitude).

As noted previously, onset of activity occurred near sunset for the months of October through March. The positive values of Ψ_{onset} occurred from May through September which is the time in which there are leaves on the trees and sunset occurs later in the evening. If onset is related to light intensity, leaves on the the trees will make the forest darker earlier compared to the actual sunset. Thus the onset of activity would be earlier than sunset, giving positive values of Ψ_{onset}.

Ψ_{end} as a function of the time of year is shown in Figure 5. Lowest values occurred in the summer (activity end close to sunrise) and the largest values in winter. This pattern has also been described for night-active caged mammals by Daan and Aschoff (1975). Ψ_{end} for golden hamsters ranged from approximately 0.0 to +2.5 in southern Germany and from —0.5 to +6.0 at the Arctic Circle. Ψ_{end} for flying squirrels (*Glaucomys volans*) ranged from approximately +0.5 to +1.3 in southern Germany and from —2.0 to +6.0 at the Arctic Circle. Since the length of darkness is greatest during the winter, the snowshoe hare does not have to be active during the entire night, thus creating large positive values for Ψ_{end}.

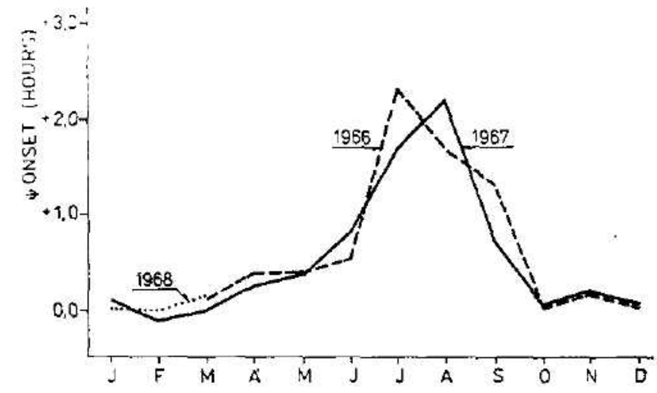

Fig. 4. Phase angle differences of activity onset of a snowshoe hare and sunset as a function of time of year.

Upon further examination of Figure 5, large differences between years can be seen in the values for January, June, and December. Low values of Ψ_{end} occurred for December 1966 and January 1967. There were some problems in defining the end of activity for these two months because of oscillations of as to the end of activity. For June 1967, the percent active line dropped below the percent active line about the average line in the morning giving uncertaintly the average line and stayed near, but below, the average line for about an

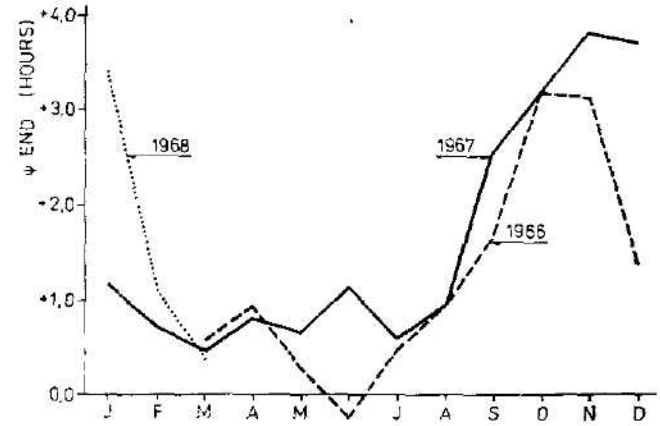

Fig. 5. Phase angle differences of activity end of a snowshoe hare and sunrise as a function of time of year.

hour before dropping to the 0% active value. June 1967 contained a large amount of unknown time (52%) which may have affected these percent active and average active lines.

Aschoff et al. (1970) reported that, for golden hamsters at the Arctic Circle, the end of activity changes its position relative to sunrise more than did onset of activity to sunset (Rule No. 5a; Aschoff and Wever 1962). For the snowshoe hare, maximum Ψ_{onset} equals approximately 2.3 and maximum Ψ_{end} equals approximately 4.0, thus supporting this rule.

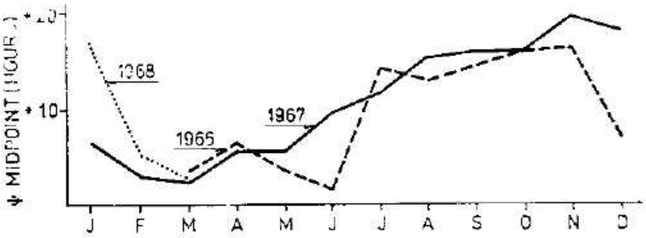

Fig. 6. Phase angle differences of activity midpoint of a snowshoe hare and darkness midpoint as a function of time of year.

Figure 6 illustrates $\Psi_{midpoint}$ as a function of time of year. The range of values for $\Psi_{midpoint}$ (approximately from 0.0 to +2.0) is less than the range for Ψ_{onset} or Ψ_{end} which makes it somewhat more difficult to detect seasonal trends. $\Psi_{midpoint}$ was always positive and had its lowest values from February — June and its highest values from July — January. Aschoff et al. (1970) reported $\Psi_{midpoints}$ always being positive for golden hamsters at the Arctic Circle. $\Psi_{midpoint}$ reached its largest positive values in the midwinter and minimal positive values at the equinoxes (not found for the snowshoe hare). $\Psi_{midpoint}$ for golden hamsters ranged from approximately 0 to 3.0. $\Psi_{midpoints}$ for golden hamsters reported by Daan and Aschoff (1975) ranged from approximately —0.3 to +1.0 in southern Germany and from approximately +0.5 to +2.5 at the Arctic Circle. $\Psi_{midpoint}$ for flying squirrels ranged from approximately +0.1 to +0.5 in southern Germany and from approximately —1.0 to +1.5 at the Arctic Circle. As far as discovering general trends for $\Psi_{midpoint}$, Daan and Aschoff (1975) described their findings by stating, "The seasonal changes in activity time result from roughly mirror-like changes in the times of onset and end of activity relative to sunset and sunrise, cancelling each other out. Therefore the midpoint of activity stays relatively stable; remaining minor changes in the midpoint do not produce a general seasonal pattern".

B. Activity and rest

Activity time, α, is defined as the time interval in minutes between onset and end of activity. Rest time is 24 hours minus α. A strong correlation normally exists between α and the length of the night, with the exact nature of the relationship being determined by the length and light intensity of the twilight periods.

Activity time as a function of the time of year is shown in Figure 7. Highest values of α occurred in the winter with the lowest values in the summer. Activity time generally followed the dark-light cycle for the year but was a sharp increase of α from June — August and then a decrease from August — October which deviates from the general trend. This phenomenon occurred for both 1966 and 1967 which indicates that some strongly influencing, but unknown, factors are affecting the activity of the snowshoe hare during the time of the year.

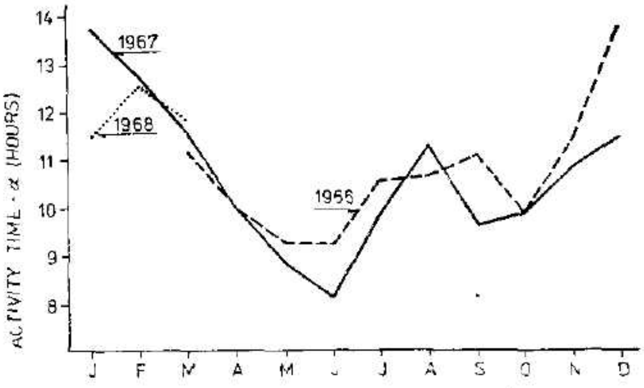

Fig 7 Activity time (α) of a snowshoe hare as a function of time of year.

Figure 8 shows how α, as a function of darkness, progressed for each month throughout the year. From February — June of each, the points follow quite closely along the theoretical value of α/darkness = 1. From July — December the values deviate from this theoretical value producing a more horizontal

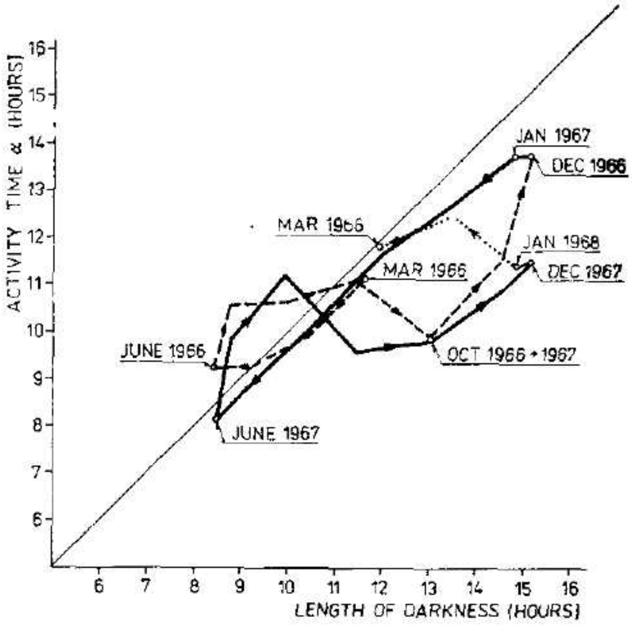

Fig. 8. Activity time (α) of a snowshoe hare as a function of **length of darkness**. Data points are monthly averages.

line. This trend was fairly consistent for the 25 month period studied. In fall, α was shorter than in spring for a given length of darkness. This phenomenon has also been shown for caged day-active male starlings (*Sturnus vulgaris*) primarily due to changes in the physiological state relating to the reproductive cycle (Gwinner and Turek 1971).

For golden hamsters at the Actic Circle, Figure 4 of Aschoff et al. (1970) resembles Figure 8 quite closely but does not indicate the data points as separate months which are needed to compare changes in α between spring and fall for golden hamsters.

Activity data for a woodmouse (*Apodemus flavicollis*) (Erkinaro 1970) resemble Figure 8 quite closely. Spring activity time was also larger than fall activity time, but activity time, as a whole, was less than shown for the snowshoe hare. α was never greater than length of darkness for the woodmouse.

Using a slightly different approach Daan and Aschoff (1975) compared α and duration of sunlight. Their curves are also generally similar to Figure 8. However, only for golden hamsters in southern Germany was α in spring greater than α in fall. This did not appear to be true for flying squirrels in southern Germany or at the Arctic Circle or for golden hamsters at the Arctic Circle.

DISCUSSION

Threshold and niveau are the 2 important determinents of onset and end of activity (Aschoff and Wever 1962). When the periodic function crosses the threshold, activity begins or ends. Calculating the threshold as the average daily percent activity, as we have done for the night active snowshoe hare, has the advantage of reducing the effect of activity during daylight, which occurs mainly in summer. This method appears to be especially appropriate for animals which are not clearly day-active or night active, such as waterfowl (Ball et al. 1975), *Microtus* in spring and fall during the phase change (Erkinaro 1961) and *Odocoileus virginiana* (Kammermeyer, K. E. and R. L. Marchinton 1977). Use of the average daily percent activity as the threshold for such species would permit determination of the phase of activity throughout the year.

All of the calculated circadian characteristics of the snowshoe hare, phase-angle differences of onset, end and midpoint of activity and activity time, show a strong similarity in successive years. This suggests that the telemetry data and our analyses are consistent and suitable for studies of circadian rhythms in free-ranging animals. In addition, the yearly similarities in circadian characteristics suggest that exogenous conditions which might affect rhythms must have been generally the same in each year of the investigation. Pohl and West (1976), on the other hand, found that circadian rhythms of redpolls (*Acanthis flammea*) were different during 2 consecutive winters with similar ambient temperatures. They reported that the differences might be due to cage effects or to the transfer of birds from one locality to another prior to the study.

Use of telemetry on free-ranging animals has the advantage of eliminating effects of cages and disturbances caused by human activities such as feeding and maintenance. Furthermore, telemetry allows measurement of all locomotor movements, not just activity measured by running wheels, at food or nest boxes or on perches.

It is important to realize, however, that animals living in the wild are subject to the entire range of biotic and abiotic environmental forces. Many of these might influence the activity rhythm by coupling with photoperiod, the strongest Zeitgeber (Hoffmann 1969). For example, food supply, breeding behavior and weather factors such as temperature and precipitation would likely have strong effects on the physiology and behavior of an organism.

Most aspects of the circadian rhythm of the snowshoe hare appear to be related to its biological needs, i. e., seasonal changes in rhythms can be interpreted in terms of physiological, ecological and behavioral requirements. However, we are not able to explain the reason for the marked decrease in activity time in September 1966 and October 1967 (Fig. 7). Leaves begin dropping from deciduous trees at this time causing an increase in light intensity and length of photoperiod which may affect activity time. This may be especially important in the dense shrub cover typically used by snowshoe hares. The reproductive season ends in late summer or early fall and may affect activity through changes in hormone levels. Gwinner and Turek (1971) observed differences in activity of birds in spring and fall under the same photoperiod and attributed the lower fall level to a reduction in testes size.

The actual difference in the dates when the decrease occurred each year may be somewhat obscured by using monthly averages. However, weather conditions were different with 1967 being cooler during night, warmer during day and much drier than 1966. Frost occurred earlier in 1967. These weather conditions might affect rhythms directly, but more likely they affected such aspects as leaf fall, reproduction and food supply and these, in turn, may have affected activity time.

Examination of phase-angle differences reveals a similarity in Ψ_{onset}, Ψ_{end} and $\Psi_{midpoint}$ between the snowshoe hare living at 45° latitude and several species of night-active mammals in southern Germany at 48° latitude (Aschoff 1969, Daan and Aschoff 1975). This shows that determining onset and end of activity using the 50% level produces results comparable to those obtained by other methods.

It is important to note, however, that the actual values of Ψ_{onset} and Ψ_{end} are several hours longer in Minnesota than in southern Germany. With reference to $\Psi_{midpoint}$, Aschoff (1969) stated that the summer increase in photoperiod should result in a lower value for $\Psi_{midpoint}$ in night-active animals. In the first half of the year the snowshoe hare follows this rule, but the expected fall minimum value does not occur.

In terms of biological requirements, the large value of Ψ_{onset} in summer, with a short dark period, may indicate that the hare had to begin activity several hours before sunset to have sufficient time for feeding, grooming and other activities. Winter nights are longer, and Ψ_{onset} was near 0 and Ψ_{end} was 3—4 hours suggesting that the hare had ample time to complete required activities.

In general, activity of the snowshoe hare appears to follow circadian rules. This indicates that radio-telemetry methods could be very helpful in determining activity patterns of other free-ranging animals. An advantage of using this method is elimination of cage effects as described by Lehmann (1976) for *Microtus agrestis*. In addition, telemetry provides an opportunity to determine how factors such as temperature, precipitation, food, cover and reproduction interact with photoperiod in determining the circadian pattern.

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NOTES ON THE GROWTH OF THE COMMON CARP (CYPRINUS CARPIO) IN NORTHERN INDIA AND IN CENTRAL EUROPE

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Abstract The growth of 87 specimens of the common carp, *Cyprinus carpio* Linnaeus, 1758 from four localities of northern India viz, Gobindsagar Himachal Pradesh Nangal Lake Punjab Sukhna Lake, Chandigarh and Ghagger river Rang Mahal Rajasthan based on the scale structure has been compared with that of the selected European and Asian localities The growth of carp in the northern Indian waters with temperature ranging from 7 °C to 33 °C was found to be very fast, *especially in the first two years of life*

INTRODUCTION

According to Alikunhi (1957), the carp was first introduced into India from Sri Lanka in 1939 and was originally stocked in the Nilgiri Hills in the Madras State According to Steffens (1957), Sri Lanka imported this carp from Germany in 1914 India received its second consignment from Bangkok (Thailand) in 1957 (Steffens, 1975), which in turn had received the same in 1914 and 1962 from Japan The carp has adapted itself to warm-water conditions of India In India it is bred in Kumaon, Himachal Pradesh, Kashmir, Sikkim Punjab, Madhya Pradesh and Rajasthan since 1947, 1955, 1956, 1957, 1958, 1960 and 1960, respectively

In India it is commonly known as „common carp" and is distributed in almost all the States definitely due to its fast rate of growth as compared to Indian major carps (*Catla catla, Labeo rohita, Labeo calbasu* and *Cirrhina mrigala)* and wide range of adaptability Considering this fact growth studies have been undertaken using scale method from different water bodies, e g, natural and artificial lakes and rivers, and compared with the carp populations of central Europe and that part of Eurasia where it occurs as a component of natural fauna (Balon 1970)

So far reports on the growth studies from the natural waters are not numerous, however, vast information is available on the growth from the ponds from India Therefore it was considered appropriate to study the growth of common carp using scale method from some natural waters of northern India, hitherto unknown, and to compare it with other populations from central Europe and Eurasia

MATERIAL AND METHODS

Scales of the acclimatized Indian common carp were collected from the samples obtained from Gobindsagar, Himachal Pradesh (Longitude 76° 20′ E, latitude 30° 40 N), Nagal Lake Punjab (Longitude 76 30 E, latitude 29° 48′ N), Sukhna Lake

Chandigarh (Longitude 76° 46′ 30″ E, latitude 30° 45 N) and Rang Mahal, Rajasthan (Longitude 75° 20′ E latitude 29° 48 N) A brief account of the hydrobiological features of these spots is given below

Gobindsagar is a riverine lake with maximum water level the area is 16 838 ha, maximum depth 165 m (in post monsoon period August-September), minimum depth 2—3 m average depth varies from 40—70 m This reservoir becomes thermally stratified in summer The epilimnion is limited to 3 meters from the surface while metalimnion (thermocline) during August 1978 extended from 3 to 8 meters The water level shows seasonal fluctuations maximum during the rainy season then it decreases gradually Strong chemical stratification with respect to carbon-dioxide bi-carbonates was observed in 1976 Other parameters are as under Water temperature (in centigrades) 13 5—25 3, ave 19 3, transparency (in cm by Secchi disc) 44 2—180 0 ave 112 0 pH 7 7—8 4 ave 8 0 In some of the parameters appreciable changes were recorded during pre – and postmonsoon periods Fish fauna Only commercial fishes are quoted here *Catla catla, Tor putitora, Labeo calbasu, Labeo dyocheilus, Cirrhina reba, Hypophthalmichthys molitrix, Mystus seenghala* Maximum catches consist of *Cyprinus carpio, Hypophthalmichthys molitrix, Labeo rohita, Catla* The catches of *Cyprinus carpio* and *Hypophthalmichthys molitrix* are increasing (Anon 1980) whereas the catches of *Tor putitora, Catla catla, Labeo dero, Labeo rohita* and *Cirrhina mrigala are showing a decreasing trend (Johal and Tandon,* 1981)

Nangal Lake It is situated 100 km from Chandigarh (Longitude 76° 30′ E, latitude 31° 20′ N) Length of this lake is 4 24 km, width 2 83 km, maximum depth 15 3 meters minimum depth 15 8 meters, minimum depth 2 5 meters Total area (surface) could not be calculated because of the daily water level fluctuations In this lake *minimum* water *temperature was measured in February* (17 °C) and maximum in May (22 °C) pH 7 4—7 6, dissolved oxygen 14 2 mg l^{-1} in May, turbidity was very high in May and June alkalinity 1 6—1 8 molequiv l^{-1} phosphate was absent in October minimum in September 3—5 mg l^{-1} (After Tandon and Singh 1972) Fish fauna *Cyprinus carpio, Tor putitora, Puntius sarana, Labeo dero, Labeo rohita, Catla catla, Schizothorax* sp, *Mystus seenghala (Johal and Tandon, 1979 1980)*

Sukhna Lake It is situated 6 km from the Punjab University Campus (Longitude 76° 46 30″ E latitude 30° 45′ O N) The total area is 3546 ha According to Vasishit (1968) it is a oligothrophic lake with the following hydrobiological features Maximum temperature 32 °C in June and July, minimum 13 °C in December and January maximum turbidity in August to mid November and minimum in February depth varies from 4 5 m in dry season and 7 5 m in rainy season and 7 5 m in rainy season dissolved oxygen 9—10 mg l^{-1} pH 7 8—9 total alkalinity 1 6—20 molequiv l^{-1} chloride 12—18 mg l^{-1} Fish fauna *Notopterus notopterus Labeo rohita, Labeo gonius Labeo calbasu, Labeo bata, Catla catla, Cirrhina mrigala, Puntius sarana, Puntius* sp, *Cyprinus carpio, Heteropneustes fossilis, Mystus vittatus, Ophicephalus striatus, Callichrous pabda, Gobius giuris, Mastacembelus armatus* All the species have been collected by Dr K K Tandon and senior author during angling competition in 1979 and during the visits undertaken for the collection of fish scales

The Ghagger river Specimens were collected from the river Ghagger folowing through the district of Sriganganagar of Rajasthan State (Longitude 75° 20 0′ E, latitude 29° 48′ 10 ′ N) The river Ghangger is a seasonal river with its end point at Rang Nahal After this point water cannot flow onwards due to sand dunes Here the water is stored in 18 depressions locally called cuts of varying size, depth and shape In the rainy season the depressions are connected with each other, otherwise they remain isolated Their collective area comes to about 20 000 ha The depth of the depressions varies from 3—25 m The temperature of the water varies from 7 °C—33 °C, minimum in January and maximum in May and June Fish fauna *Notopterus notopterus, Notopterus chitala, Puntius sarava, Catla catla, Labeo rohita, Labeo calbasu, Labeo bata, Cirrhina mrigala, Cyprinus carpio, Wallago attu, Mystus seenghala* In certain areae where there is deficiency of oxygen snake heads are found along with other percids Johal and Dhillon (in press) described 58 species of fishes from this district out of which about 15 species constitute commercial fisheries

While collecting the scales of the common carp measurements such as body or standard length (from the tip of the snout to the posterior margin of the caudal base = SL) and the total length (from the tip of the snout to the greatest length of the caudal fin = TL) were also recorded

All the scales were studied in dry condition mounted between two glass slides

Before mounting they were washed in water, rubbed between fingers to remove the dried slime. Magnification 9X or 13X of the projection apparatus "Lesegerät Zeiss", VEB, Jena, GDR. The annuli were counted on the lower diagonal radius of the scale. The lepidological terminology was used after Van Oosten (1923), Creaser (1926), Matsui (1949), Beckman (1943), Živkov (1947, 1969), Matsui (1949), Oliva (1955) and Holčík and Hensel (1972).

For back calculations the method of E. Lea (1910) in the classic concept was used.

RESULTS AND DISCUSSION

A. The scale structure

The scale structure of the acclimatized Indian common carp differs remarkably from that of the domesticated Czechoslovak carp (see Oliva, 1955), although both in India and in most part of Czechoslovakia the common carp is an acclimatized species. The shape of the "representative" scales of the Indian specimens is rounded, sometime almost circular (Plate 1B), mostly without prominent diagonal lobes in the oral field. On the surface there are many small or larger areas bordered by broken lines (Plate 1A), there are also many irregularities in the course of circuli, especially on both lateral margins in the oral field (Plates 2A, B, C, 3A).

The formation of new annuli, especially the first one, is characterized by widely spaced circuli following the compactly spaced ones (Plate 4A, B). This is evident in both the Central European carp (Oliva, 1955, Živkov, 1967, 1969) and the Indian common carp. Some confusion can arise with the so called spawning mark (Živkov, 1967, 1969) which merges with the true annulus (Živkov, 1967, 1969). The first spawning takes place in the third or fourth year of life in the Czechoslovak waters, but in the Indian waters it occurs in the first year of life and is prolonged. On the other hand the spawning period strictly coincides with spring in central Europe and is of short duration. As pointed out by Živkov (1967, 1969) such a spawning mark in the European common carp is a true annulus formed over the circuli which show resorption. However, no such resorption takes place in the Indian specimens (Plate 5A, B). Thus the study of the scale of the Indian specimen is rather difficult and the recognition of a true annulus depends upon a careful study of many scales.

Živkov (1967, 1969) proclaimed the spawning mark on the course of the true annulus; thus the annulus is confluent with the circuli resorption of the scale. Such type of the annulus is more pronounced than in the Indian common carp, in which the resorption does not occur — compare, e. g., scales figured in Plate 5A, B, where true annuli are less pronounced than the spawning marks. False annuli and their correct localization are recognizable only after a careful study not only of a single one but of several scales of the same specimen, using a different focusing of the projected scale. Consequently, an exact photo of all structures seen on the whole area of the projected scale is impossible.

In many scales of various specimens the radii of the oral area normally running parallel to each other assume a fan-shaped appereance towards the caudal field (Plate 1A). The number of circuli during the first growth season reaches up to 203 or more, the minimum being about 120. The scale of a young of the year specimen is shown in Plate 3B.

In a three — year old common carp of the European waters, Hoffbauer (1898) counted as many as 200 circuli; Oliva (1955) counted, on the average, 20 circuli up to the Ist annulus, 30 to 45 between the Ist and IInd annulus and the same number between the IInd and IIIrd annuli in a stunted common carp specimen from the central Bohemian backwater of the river Labe called "Mansfeldova tůň"; in the fast growing specimens, however, the number was found to be 40—60, 80—90, 50—60, respectively.

The most common and most easily recognizable arrangement of the circuli in the normal growth pattern consists of the gradual narrowing of the spacing outward from the focus to the annulus followed by an abrupt change to wider spacing (Plates 4A, B; 5A, B; 6A, B).

The Indian common carp does not show the seasonal retardation in the growth, therefore the annulus can be recognised only on the boundary marked by the increasing and decreasing growth of the scale. We assume that in the rainy season under higher temperatures, the scale and fish grow nore quickly than during the dry period.

The annulus formation in the Indian common carp lasts from March to May. The specimens of the age classes II, III, IV caught from February 6th to March 7th, 1980, from Sukhna Lake had no annulus from the same year. The same was observed in the specimens of the II, V, VII and VIII age classes from January 11 to February 22, 1979, from the river Ghagger at Rang Mahal (Rajasthan). Specimens of the III and VII age groups caught on May 30, 1980, from Gobindsagar (Himachal Pradesh) had an annulus from the year 1980; they were 3+ and 7+ in age. Similarly a new annulus was formed in the specimens in the age classes I(1+) and II(2+) from Nangal Lake caught on May 29—30, 1980.

The annulus formation in the common carp originating from the riverine lakes in the mountain area of Bohemia (Czechoslovakia) shifts to May. In one such riverine lakes, 2—9 years old carp were harvested measuring 231—460 mm in S. L. (Vostradovský, 1963).

The production of radii is dependent upon the structure and thickness of the scale, on the degree of activity of the portion of the body where the scale is located and on the degree of the overlap of the scale (Creaser, 1926). Hoffbauer (1899) showed that in the common carp several of the radii from the old areas of the scale often end or new radii in the new area may at the contact of these areas. The apparent increased number of radii, both primary and secondary ones on the scale of the Indian common carp (Plate 4A, 6B) can be attributed to the fast growth of the scale in its first year of life. This confirms also the apparently numerous number of circuli formed in this period. Because with the simultaneous fast growth of the scale the distance between any two circuli remains constant, the larger of the scales are equipped with a great number of circuli and these again with a large number of radii. This confirms the statement of Creaser (1926) that radii having uncalcified nature are hinges or organs of flexibility, noted previously by Taylor (1916). Radii give some idea about the activity of an individual, which is apparently greater in the common carp of tropical and subtropical areas, as compared with the slow activity in central Europe, where the total activity of the fish is lessened by a half due to climatic conditions.

The growth of radii is not uniform in all fields. Matsui (1949) counted 13—15 radii in the specimen of 15 to 76 cm of SL; almost in all specimens he found a tendency for an increased number with growth. Matsui (1950) also stated that the number of radii increased with growth.

The higher number of radial canals (radii) in the first year of life perhaps accounts for a better nutrition and support of the scale during the high growth tempo of the fish. The great density of radii in the scales of the Indian common carp can make the lepidologist suppose that the scales do not belong to common carp, but to some other Indian cyprinid species.

B. The growth

The data from India were compared with selected localities from Czechoslovakia (central Europe) and the U. S. S. R. A backwater in Czechoslovakia, situated about 30 km east of Prague in the inundation area of the river Labe was chosen as an example of the place with slow growth tempo of the common carp ("Mansfeldova tůň", for further details see Oliva, 1955). An artificial pond from Southern Bohemia, Nový rybník (for details see Živkov, 1967), and two riverine lakes situated on the river Vltava in Central Bohemia, Slapy and Orlík were chosen as examples of normal growth (for details see Živkov, 1967). In all these localities, the common carp is domesticated. It has been bred in central Europe from the 12th century (Balon, 1974) and later acclimatized in rivers. But the Czechoslovak part of the Danube river possesses the true autochthonous carp which occurs (Berg 1949) in the Black, Caspian

Table 1. The growth of the common carp in the Ghagger River

Age group	Body length in mm	n	Back calculated body lengths in mm						
			l_1	l_2	l_3	l_4	l_5	l_6	l_7
I	420	1	242						
IV	550	1	242	413	496	525			
VI	635	2	277	363	481	534	576	613	
	(620; 650)		(269; 285)	(337; 388)	(468; 494)	(512; 555)	(573; 578)	(609; 616)	
VII	720	2	221	344	433	514	623	669	692
	(690; 750)		(152; 290)	(275, 413)	(389; 477)	(453; 575)	(580; 665)	(635; 703)	(660; 724)
total;		6	246	373	470	524	600	641	692
averages, ranges			(152, 290)	(275; 413)	(389; 496)	(453; 575)	(573; 665)	(609; 703)	(660; 724)

Table 2. The growth of the common carp in the Gobindsagar 1979

Age group	Body lemgth in mm	n	Back calculated body lengths in mm					
			l_1	l_2	l_3	l_4	l_5	l_6
0	300	1						
I	363	3	234					
	340-390)		(203–253)					
II	474	5	337	444				
	(440–510)		(276–388)	(409–483)				
III	518	4	267	372	457			
	(470–650)		(208–312)	(320–452)	(416–546)			
IV	455	2	215	315	386	429		
	(440; 470)		(180, 249)	(249; 380)	(356; 416)	(413; 445)		
VI	640	1	293	476	507	533	587	622
total;		16	269	400	450	481	587	622
average, ranges			(180–388)	(249–483)	(356–546)	(413–533)		

Table 3. The growth of the common carp in the Gobindsagar 1980

Age group	Body length in mm	n	Back calculated body lengths in mm l_1	l_2	l_3	l_4	l_5	l_6	l_7
I	345 (295–380)	3	213 (175–251)						
II	438 (418–470)	5	275 (210–325)	393 (374–412)					
III	500	1	328	438	483				
IV	630 (600; 660)	2	275 (248; 302)	498 (422; 573)	574 (542; 606)	609 (578; 639)			
VII	570	1	304	424	469	502	521	540	562
total; averages, ranges		12	279 (175–328)	438 (374–573)	509 (469–606)	556 (502–639)	521	540	562

and Aral sea drainages. The second autochthonous centre of the common carp is China and the river Amur drainage in the U. S. S. R. (Berg, 1949) where separate subspecies of *Cyprinus carpio haematopterus* Temminck & Schlegel occurs (see also Balon, 1974; Wolny, 1974; Steffens, 1975). All data about the common carp growth from outside India were compiled from papers of Berg (1949), Oliva (1955), Nikolskij (1956) and Živkov (1967).

From the growth Tables 1—7 it is evident that:

The best growth is shown by the common carp from Sukhna Lake and the river Ghagger (1979, 1980 collection) followed by the common carp from Nangal Lake and Gobindsagar. The differences are not very conspicuous.

From Table 7 it is also evident that all localities outside India show a substantially slower growth tempo of the common carp, which concerns especially the first two years of its life.

Table 4. The growth of the common carp in the Nangal Lage 1979

Age group	Body length	Back calculated body lengths in mm n	l_1	l_2
I	207 (260—340)	23	235 (162—279)	
II	510	1	240	423
total, averages, ranges	24	238 (162—279)	423	

In the Indian common carp the absolute and relative growth are maximum in the first year of life. This is contrary to the Czechoslovak common carp, in which the absolute length increment in the second year of life is greater than in the first year.

In the carp pond Nový rybník in Southern Bohemia (Czechoslovakia near the town of Blatná) the absolute growth increment in the second year of life is larger as compared with the Indian common carp. In the 3rd—5th year of life the increment in the Indian common carp is the smallest of all localities compared with the exception of the river Amu-Darja (3rd year), and the river Danube (5th year). The values of the growth for the subsequent years

Table 5. The growth of the common carp in the Nangal Lake 1980

Age group	Body lenght in mm	n	Back calculated body lengths in mm						
			l_1	l_2	l_3	l_4	l_5	l_6	l_7
0	220	1							
I	310 (260–380)	6	298 (250–329)						
II	326 (290–450)	7	230 (180–293)						
V	540	1	231	359	474	498	532		
VII	740	1	294	541	623	658	684	710	727
total; averages, ranges		16	263 (180–329)	450 (359; 541)	549 (474; 623)	578 (498; 658)	608 (532; 684)	710	727

concerning the Indian common carp were not taken into consideration due to unsufficient material. In general, in the temperate European climate the highest *absolute length increment* is in the 2nd or 3rd year of life, whereas in other localities, e. g., the river Kura, the Aral sea, the river Amu Darja, the Amur, northern India, the greatest absolute increment is in the first year of life and decreases in subsequent years. The oldest northern Indian common carp had the age 7+ measuring 800 mm/TL, 740 mm/SL and weighing 10 500 g, coming from Nangal lake.

The maximum length of the common carp in the lower part of the Amur in commercial catches was 810 mm (SL) and maximum weight 11 550 g (Nikolskij, 1956). These values are similar to those from northern India. From

Table 6. The growth of the common carp in the Sukhna Lake 1980

Age group	Body length in mm	n	l_1	l_2	l_3	l_4	l_5 2
II	431 (380—470)	11	300 (254—325)				
III	470	1	244	370			
VI	590	1	251	384	432	509	554
total; averages, ranges		13	265 (244—325)	377 (370—384)	432	509	554

but becomes mature in the 4th or 5th year of life. Sexually mature specimens measure from 315—1020 mm (TL) and weight 360—12 250 g (Berg, 1949). The maximum length and weight values in *Cyprinus carpio* recorded by Berg (1949) are 32 kg, Italy, Lake Garda at Lugano, 1886; 18 kg, the U. S. S. R. near Leningrad, 1932; 17 kg, 960 mm (TL), riverine lake Jordán at the town of Tábor, Czechoslovakia, 1961, after Hnízdo 1968; the river Vltava, 1060 mm the Caspian region the common carp the Kura river shows the fastest growth, 24.6 kg, 1951 (unpublished data communicated to O. Oliva by the late Mr. Jan Tašner together with a documentary photo).

Basing on the body lengths in Tables 1—6 the average weights were calculated using graphical length/weight relationship. Figure 1 shows the average

Table 7. The growth of the common carp from various localities. The second row annual increments

Locality, yuthor	Back calculated body lengths in mm											
	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	l_{12}
backwater Mansfeldova tůň 1953, inundation region of the river Labe, central Bohemia, n = 8	39	104	198	272								
	39	65	94	74								
river reservoirs Slapy 1960, 1962 and Orlík 1964, Bohemia, average (Živkov, 1967), n = 30	102	245	361	418	473	546						
	102	143	116	57	55	73						
fishpond Nový rybník, southern Bohemia 1956 (Živkov, 1967), n = 56	108	315	430	496	580	588	609	590	630			
	108	207	115	66	84	8	21	−19	40			
river Dunaj, Czechoslovakia 1953—1959 (Živkov, 1967), n = 85	107	247	330	393	405	470						
	107	140	83	63	12	65						
river Kura, Caspian Sea drainage (Berg, 1949)	145	280	385	455	500							
	145	135	105	70	45							
Aral Sea, average from two localities (Berg, 1949)	127	215	290	352	400	465						
	127	88	75	62	48	65						
river Amu-Darja at Čardžou, Aral Sea drainage (Berg, 1949)	79	128	172	233	302	362	400					
	79	49	44	61	69	60	38					
river Amur, average from four localities (Nikolskij, 1956)	120	209	274	330	378	421	463	514	557	581	600	610
	120	89	65	56	48	43	42	51	43	24	19	10
India, average) (authors), n = 87	254	408	470	521	543	648	660					
	254	154	62	51	22	105	12					

absolute and relative weight increments for all Indian common carp in samples studied, computed after Ricker (1969).

The absolute weight increment is maximum in the third year of life, then it decreases.

The growth tempo of the common carp in Czechoslovak artificial fish ponds is influenced by the food supply, which in turn is influenced by manuring, natural or artificial, and by the density of planted population of the carp.

The change in the growth tempo in the fish pond can be influenced by the penetration of coarse fish into the carp pond and subsequent overfishing leading to a slow growth. In natural conditions the slow growth tempo of the common carp may be attributed to the non-availability of proper food supply (for details see Oliva 1955b; Rudziński and Miaczyński 1961; El-Boloch 1963). The average growth of the common carp in Djawa is much slower, often slower than in European specimens (Steffens, 1975), because the ponds are overstocked, thus they are overfished and the final growth, in spite of the warm climate, is slower than it could be expected. On the contrary, under favourable food conditions due to the warm climate the growth of the carp can be extremely fast here. for details see Steffens (1975).

As regards the growth of the common carp in the Lipno Valley water reservoir (Czechoslovakia). during 1958—64 it was rapid. Vostradovský (1966) came to conclusion that the artificial stocking was uneconomic owing to the small proportion of the common carp harvested. The same view has been advocated by Schäperclaus (1949) concerning the common carp industry in the natural lakes of the German Democratic Republic.

The wild common carp of the river Danube stocked in artificial ponds in the first summer showed higher increments than the pond common carp but in the later life its increments were smaller (Bastl, 1962). A slower growth of the wild common carp was also observed by Unterüberbacher (1962—3) in Hungary.

In Czechoslovak rivers and riverine lakes the water temperature together with food supply and competition with other Cyprinid species play a considerable role in influencing the growth tempo of the common carp. The higher temperature will generally cause a better growth in the first year of life in subtropical or tropical areas of the recent common carp occurrence due to its acclimatization. The slowing of the growth rate in the later years in India may be due to the lack of suitable food for fish of the larger size.

C. Effect of temperature on the growth of the common carp

When in central Europe the temperature falls to —15 °C for several days, the ice cover is 30—40 cm thick; in exceptionally winters, the air temperature falls to —40 °C, when the ice cover measures up to 100 cm. Thanks to the availability of large space, depth of water, hig oxygenation and health of the stocked carp, fish can overcome such winter (Wunder, 1963b).

The strong frost in central Europe in the winter of 1962—63, when the ice cover in some places in the German Federal Republic was 40—60 cm, the loss of young carp was considerable (Wunder, 1963). At about 14 °C the common carp of the third year and older does not feed on artificial food, up to 8 °C, it feeds a little on natural food, but does not digest well (Wunder, 1963b) The common carp yearling feeds sometimes up to 5 °C Very low temperature (3 °C) causes the immobility of the common carp leading to imbalance during swimming (Kulmatycki, 1930).

In the climatic conditions of central Europe the common carp 2—3 years old stops its growth by the end of September, when the water temperature falls to 8—10 °C. During seining of such carp in October and November (Wunder, 1966a, b) the intestinal tracts were always found empty.

The fry of the common carp feeds longer in cool water than the adult carp, sometimes up to the 2nd half of December, the search for food weakens the fry and subsquently leads to a higher mortality.

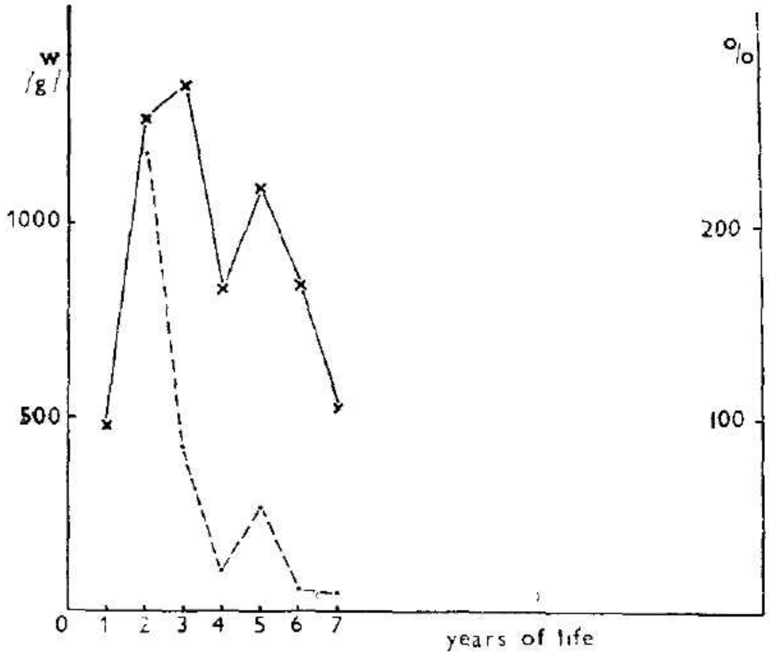

Fig. 1 Average, absolute (solid line) and relative (broken line) weight increments at the Indian common carp

The wintering of the common carp fry in central Europe has its effect in very low water temperatures, causing the starvation of the carp and loss of fat, sometimes resulting in a high mortality. The individual weight of young carp reared on natural food should not be below 25 g, less weighing carp show a considerable mortality due to artificial lowering of protein during winter (Wojno, Trzebiatowski and Wolny, 1965).

The 3—4 cm common carp grows at the fastest when the temperature is 21.3 °C, although under artificial conditions it can be raised to 23—27 °C (Steffens, 1964). In southern Europe, in subtropical and tropical zones the growth of the common carp is better when good supply is available. But under very low temperatures the carp does not feed being in a dormant state (Steffens, 1964).

D. Age in relation to spawning and sexual maturity

Indian common matures at the age of 6—8 months (Parameswaram et al., 1972), males maturing earlier (at the age of 4—6 months) than females. It was observed that the Assam (India) fry of the common carp, age two weeks in March, *spawned in July of the same year. The males measuring 92 mm and* females measuring 136 mm had fully ripened gonads. Following Alikunhi (1957), in the tropical climate of India females reached sexual maturity at the age six months, weighing 500 g. The common carp in India living in tropical conditions spawns 5—6 times within a year (Alikunhi, 1957), therefore several spawning marks together with false annuli can be observed within one year (Plate 5A, B).

Parameswaram et al., (1972) observed the spawning in ponds throughout the year in Cuttack (Orissa) between 1960—68; maximum frequency of breeding falls into the months of January to June and July to August. In free living common carps the spawning began earlier before monsoon. Tandon (1965) observed the breeding in the Botanical Gardens of the Punjab University, Chandigarh, in May-June. Anon. (1962) in Himalayan waters from March-September (400—1300 m above the sea level), with the peak period from March to April.

The senior author (Johal) observed the mature males and females in Sukhna Lake, Chandigarh in the months of April and May. The acclimatized common carp spawns earlier than the Indian "major carps" of native Indian origin.

In Gobindsagar, the common carp breeds in April up to June and similarly also in Nangal Lake. It is supposed that the common carp in the river Ghagger spawns slightly later, i. e., May onwards.

From all the above observations, it is clear that the common carp in natural waters of northern India spawns twice a year, once in February-March and April and then in September—October.

Hickling (1962) observed that in Malayasia the common carp attained maturity and spawned at the age of six months and, similarly, Buschkiel (1953) reported that in Indonesia the common carp started breeding at the age of three months only. In the Djawa river the common carp matures after 5 months ,males having the body length of 16 cm (Steffens, 1975).

In the subtropical climate of Israel females are ripe after 18 months (Sarig, 1966), weighing about 1500 g. In the warm water, previously used for cooling purposes of electric power station in Goslawice (Poland), having the average annual temperature of 18 °C, males were ripe at the age of 10 months, weighing about 300 g, females at the age of 2 years, weighing 2.2 kg (Wolny, 1974). *In the Jordan Valley (Israel) the common carp spawns twice in early spring an* in autumn (Wolny, 1974).

Anon. (1962) reported that the Himalayan common carp must achieve 2 years of age before maturity in cold water at the altitude of 400—1300 m above th esea level. Matsui (1957) observed that in Japan common carp matures in the first year (male) and in the second year (female); rerely, males also mature in the second year of life. The European common carp matures in the third (male) or fourth (female) years of life (Schäperclaus, 1933; Dyk, 1956).

In artificial spawning ponds in Czechoslovakia the common carp spawns by the end of May or in June, where water temperature is about 20 °C (Schäferna, 1930).

According to Wunder (1966) the spawning temperature in central Europe is 19—20 °C; in the late spring the temperature must be constantly above 15 °C, lower temperature below 10 °C destroying eggs and common carp fry. The common carp spawns mostly in June, rarely in May, when temperature falls and the spawning is unsuccessful.

In central Europe the spawning act begins in the late spring when the water temperature increases minimally up to 13 °C (Šusta, 1884).

Papadopol (1965) stated that the sexually mature common carp males in the delta of the Danube arrive in the third year (SL = 28 cm, weight 550 g), females a year later (SL = 30 cm, weight 750 g). The common carp inhabiting the lower Danube reveals some dilfferences; the maturation is much earlier as compared with that of the common carp of Central and Northern Europe, but later as compared with the "cultured" common carp reared in Romania. The lower Danube common carp does not spawn before April.

Physiological and ecological factors cause induction for spawning in the common carp. Under Hungarian climate condition, the majority of the carp spawns when subtropical air mass forms a warm front or when the subtropical air retreats owing to a cold front. These facts are useful for intensive rearing of the common carp (Jászfalusi-Páskándy 1962—63).

Scháferna (1930) stated that on 1 kg of female's weight 200 000 to 300 000 eggs can be calculated. One female weighing 3—4 kg has about 600 000 to one million eggs. Matsui (1957) recorded 19 000—700 000 eggs in the ovaries, out of which 50 000 to 620 000 eggs were spawned.

Křiženecký (1937) based his studies on several Czech and Moravian pond fisheries and arrived at the conclusion that males mature earlier than females, the ovaries always weighing more than testes.

Hence it can be concluded that the common carp shows much variation in its scale structure, annulus formation and spawning behaviour under different *ecological conditions.*

SUMMARY

The growth of 87 specimens of the common carp, *Cyprinus carpio*, was studied using scales of the acclimatized carp from four different localities in northern India. The growth was compared with the growth data of the carp from the original centre of its distribution (the drainage of the Caspian, Aral and Black seas and the Amur drainage in the Far East) and with the growth data of the common carp in central Europe. Here the common carp was also acclimatized from the 12th century, spread out from fish ponds into rivers, bick waters and finally into artificial riverine lakes.

The growth of the common carp in northwestern India is very rapid in the first year of its life. The absolute growth increments in the Indian common carp in further years of life (from the third one) are smaller then in the specimens from the above cited localities.

The common carp from the temperate regions of Europe shows the highest absolute increments in the second and third years of life; on the contrary, the common carp from India and the Caspian and Aral Sea drainages and the river Amur shows the greatest absolute increments in the first year of life. The scale structure of the Indian common carp is somewhat different in comparison with that of the European one. In the Indian common carp numerous spawning marks, errosions and false annuli are evident. There is also a continuous growth of scales, which is in contrast to central European common carp, wintering under the ice cover and stopping its growth during the cold months. The true annulus is not characterized in the adult Indian common carp

because of the resorption on the scale surface. It is not identical with the spawning mark, as it is usual in the European common carp.

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

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FECUNDITY AND YEAR CLASS STRENGTH OF ROACH FROM THE KLÍČAVA RESERVOIR (PISCES)

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Abstract. The mean population fecundity is negatively, the total population fecundity positively influenced by the abundance of the parental stock. The relationship between the abundance of the parental stock, the total population fecundity and the year class strength retains a form of Ricker's recruitment curve. From the factors influencing the year class strength besides the course of temperature during and after spawning, it is necessary to emphasize the role of the mean age of the parental stock and the positive correlation between the age of females and the weight of their eggs.

The shift of interest in the first year of life of fish has been recently well perceptible, and the reasons for it are quite evident (comp. Larkin, 1978). It can be assumed that the total population fecundity influences the abundance of the arisen year class. The whole matter disintegrates into two ranges of questions — what the total population fecundity itself is influenced by, and how this influence becomes evident in abundance of a new year class. At the same time it is necessary to keep in mind the whole complex of abiotic and biotic factors and their relationships that start to function after spawning. The direction of their operation is considerably independent on the total population fecundity, so that the prediction of abundance of a new year class is not simple on the basis of the total population fecundity values.

MATERIAL AND METHODS

In the period between 1964 and 1979, the fecundity of 376 roach specimens (*Rutilus rutilus* (L.)) was estimated (Stehlík, 1968; Pivnička, Kůs, Rejnek, 1979; Kůs, 1980) using common methods (Bastl, 1962; Bagenal, 1967; Anochina, 1969). Further we operated with the abbreviation of TPF for total population fecundity, i. e., the fecundity of all females in the reservoir and the respective year, MPF for mean population fecundity, i. e., the mean fecundity of the sample taking into account the age composition of the population and, finally, with the AG for an age group. The abundance of the roach in the Klíčava reservoir (Middle Bohemia) was estimated by the Schnabel's method (Pivnička, 1975, 1982).

RESULTS AND DISCUSSION

The relationship between MPF of the 3rd—9th AG and abundance was characterized by the equation $y = 69.1 - 0.0006x$, $r = -0.764$ (Kůs, 1980). For extreme cases (20,000 and 60,000 individuals) a decrease of MPF from 57,000 to 33,000 eggs was recorded. However, it simultaneously means that the TPF is on the level of about 2.10^9 eggs at high population abundance, and on the level of about 10^9 eggs at low population abundance (Tab. 1.). To put it in another way, abundance in fact, undoubtedly, negatively influences MPF, but TPF simultaneously increases. The negative correlation between abundance and MPF is also connected with a negative influence of abundance on the length and also weight growth (Pivnička, 1975) — if the abundance decreases, the growth tempo increases and the same holds for MPF. Thus, the positive correlation between the growth (characterised by the sum of instantaneous growth coefficients of length or weight) and MPF can be characterized by the equations $y=57.6x+8.9$; $r=0.667$ for length and $y=20.5x+2.7$; $r=0.666$ for weight (Kůs, 1980).

Table 1. Total population fecundity (TPF), mean age of the spawning population (AG) and abundance of the arising year class after three years (N^{t+3})

YEAR	TPF	AG	N^{t-3}
1964	2,145,815,700	3.84	11,400
1968	1,982,742,000	4.79	21,641
1969	1,277,719,200	5.61	34,305
1970	1,984,621,400	4.51	14,095
1971	1,594,801,600	4.86	33,682
1972	1,295,766,400	5.42	31,112
1973	1.786.330.500	4.32	10,828
1974	2,388,240,000	3.97	30,154
1975	1,897,619,800	4.26	14,143
1976	1,867,194,800	4.80	10,828
1977	1,774,080,000	4.75	10,875
1978	1,559,424,000	5.51	—

The relationship between the TPF and the abundance of new year classes estimated afer three years seems to retain Ricker's recruitment curve (Ricker, 1975). Also the relationship between the abundance of the parental stock and the year class strength has a similar character (Fig. 1. and 2.). The correlation coefficient of the first relationship in much higher than the second one, the reason is probably in the presence or absence of the points from 1963 and 1966. The common characteristics of both relationships is the fact that the majority of points is behind maximum abundance values of TPF or parental stock which should theoretically lead to a maximum abundance of a newly born year class.

It is still possible to notice individual points of these graphs in correlation with the course of temperature (average daily temperature) in the spawning period till the period of hatching and the transition of larvae to the exogenous feeding (Fig. 3.) We consider the type of the course of temperatures in 1963 and 1971 as optimum, in 1967 and 1969 as average and in 1965 and 1970 as disadvantageous. If we return to Figs. 1 and 2, it can be concluded that strong year classes arose in the years of the successive increase of temperature like in 1963 and 1971 or also in 1967 and 1969, whereas years with the course of the temperature as in 1965 or 1970 give weak year classes. However, in the conditions of the Klíčava reservoir it was impossible to evaluate quantitatively the relationship between the temperature and the year class strength with roach (see in Švátora and Pivnička, 1981) as it is evident in the waters

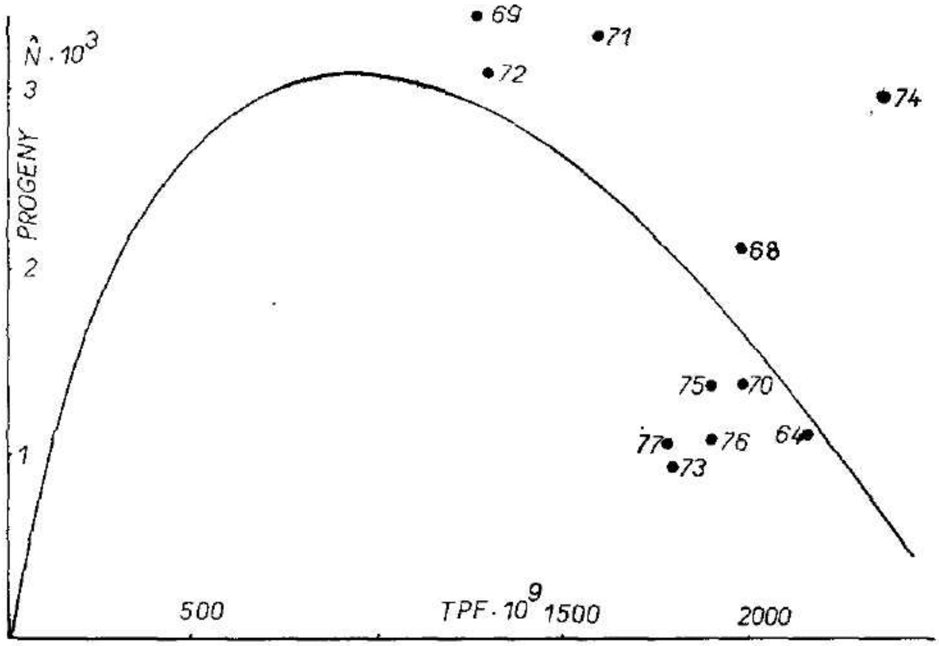

Fig. 1 Relationship between the total population fecundity (TPF) and year class strength estimated after three years ($\hat{N}$ 10^3) $y=x\,(253.5-32.2 \ln x)$, $r=-0.769$.

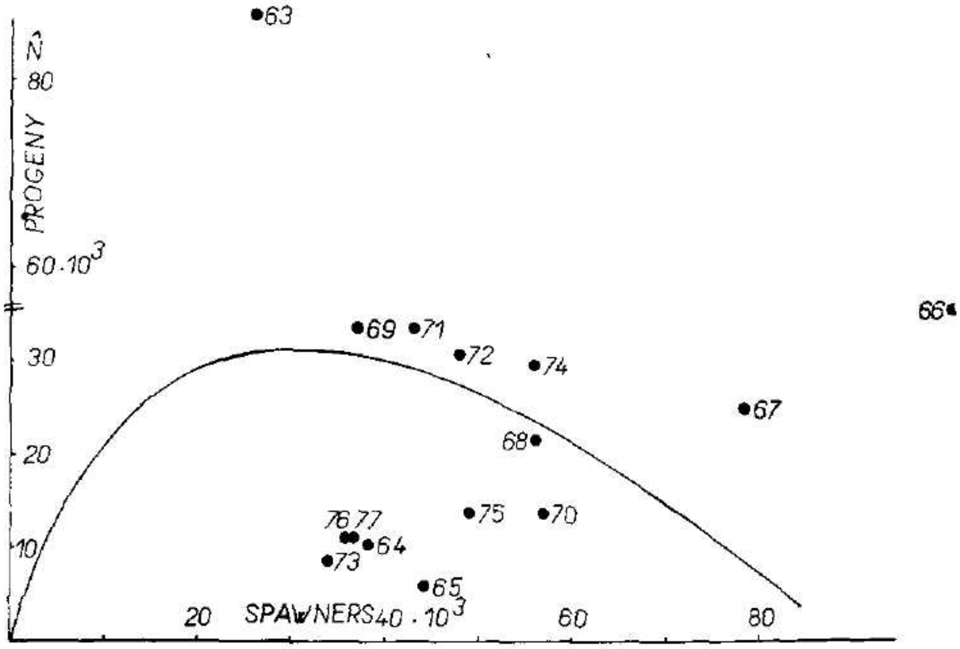

Fig. 2. Relationship between the abundance of spawners and year class strength estimated after three years $y=x\,(11.6-1.02 \ln x)$, $r=-0.456$

located further to the north (see Dementeva, 1976 for review). It is very likely that, as far as the temperature is concerned, only a few days are important in which a sudden fall of temperature means a lower activity and predatory capability of fry (cf. Braum, 1967). Thus the evaluation of these relationships on the basis of daily temperatures is very difficult, because any other day that is represented in the evaluation can indicate another drift of the relationship in question. On the whole it is possible to conclude that the *optimum temperature can shift the examined relationships onto a substantially* higher level (see also Menšutkin, 1968).

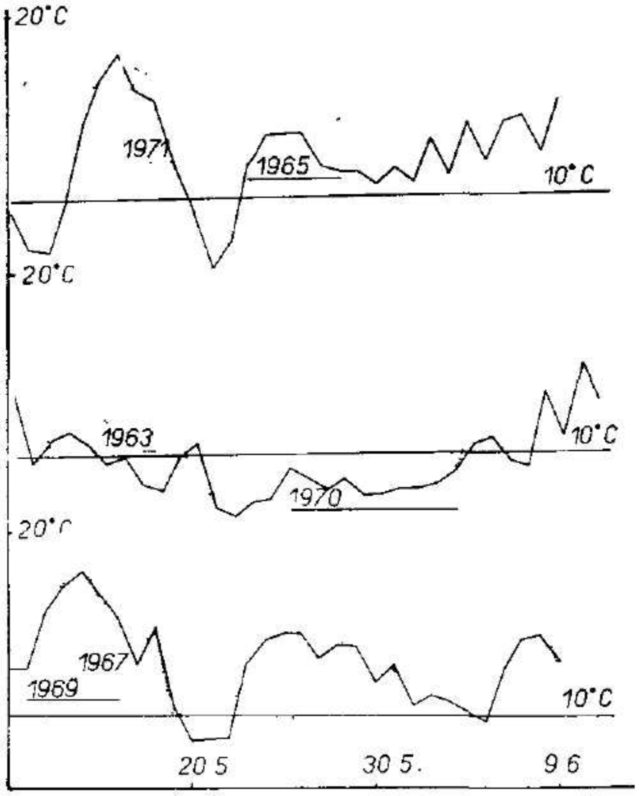

Fig 3 Course of the average daily temperatures of the air during and after spawning *Short horizontal lines indicate duration of spawning in respective year.*

Also the area of spawning grounds influences the success of spawning. It is constant in the case of the Klíčava reservoir (and also in many other waters), so that a more numerous parental stock produces more eggs that are found in more layers, moreover they could be mechanically damaged by continuing spawning. The predatory activity of perch and other fish species which gather on the spawning grounds of roach in great numbers can undoubtedly be positively influenced by an increased food supply of eggs of a more numerous parental stock (the same positive correlation was experimentally proved by Ivlev (1955).

The last relationship discussed, which is very interesting in connection with forming new year classes, is the relationship between the weight of eggs and the age of females ($y=0.09x+0.7$ $r=0.826$, Kůs, 1980) whereof it is evident that older fish have heavier eggs. This fact is generally well-known and often confirmed. Essential contradictions arise when considering the question whether bigger (heavier eggs) contains also a greater yolk reserve. Considering that younger age groups are in most cases more numerous, the food competition among them should be rather sharp and, additionally, their somatic growth is relatively quick, we can assume that from the total energy received by food less is left for their eggs. We can thus presume that heavier eggs of *older age groups have greater contents of yolk, which influences positively* the year class strength. Consequently, with an increasing abundance of parental stock the average population fecundity falls (total population fecundity increases) and the average weight of eggs falls too, because the share of the youngest age groups increases — the relationship between mean age of the parental stock and TPF has a decreasing trend with a high negative correlation coefficient ($r= -0.893$).

SUMMARY

Mean population fecundity is negatively influenced by the abundance of the parental stock. For extreme cases (20,000 and 60,000 mature fish) the mean population fecundity decreases from 57,000 to 33,000 eggs. At the same time the total population fecundity increases from 10^9 to 2.10^9 eggs.

The relationships between the total population fecundity and the year class strength, and between the abundance of the parental stock and year class strength retain the form of Ricker's recruitment curve. Most points of these relationships are in good coincidence with the course the temperature during and after spawning. The positive correlation between the age of a female and the mean weight of her eggs and the presumption of a bigger yolk reserve *in heavier eggs influence positively the year class strength, especially in the* years when the mean age of the spawners is higher.

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MITES ON FLIES OF THE FAMILY SPHAEROCERIDAE

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Abstract: Eighteen species of mites from five families were found. Seven species are described as new *Pediculaster pfefferianus* sp. n., *P. hispanicus* sp. n., *P. limosinae* sp. n., *P. moravicus* sp. n., *P. incompletus* sp. n. (Prostigmata, Pygmephoridae), *Myianoetus rohaceki* sp. n., *M. zdena* sp. n. (Astigmata, Anoetidae).

The material described in the present paper was obtained from Dr. Jindřich Roháček of the Entomological Department of Silesian Museum in Opava, who is engaged in the study of Sphaeroceridae (Dipt.). During the determination of flies he set aside specimens on which mites were attached. All Diptera used in the present work were determined by Dr. Roháček and, unless otherwise stated, they were also collected by him. I carefully removed the mites from the flies and processed them. The material obtained is very interesting and provides many new data. This is also a supplement and revision of the list published by Richards (1930) after Vitzthum's determination which includes five species of mites. Some of them were kept in Vitzthum's collection in Munich and were kindly loaned to me for a revision.

The type material is deposited in collection Samšiňák.

The material under study included the following species:

MESOSTIGMATA

Family Parasitidae

Cornigamasus lunaris (Berlese, 1882)

Deutonymph. This well characterized species has been reported many times from Europe., Asia and North America. Already Richards (1930) recorded it on flies of the family Sphaeroceridae, *Limosina crassimana* (= *L. clunipes*). Our material contained a single specimen: *Limosina talparum* Richards, 1927. Mor. sept. H. Jeseník Mts., peat-bog Skřítek, sifting decayed grass by runs of *M. agrestis,* 23 June 1978.

Gamasodes spiniger (Trägårdh, 1910)

Deutonymph. The phoresy on flies has been recorded several times (Samšiňák, 1979). Our material contained a single specimen: *Limosina clunipes* (Meigen, 1830), Slov. centr. Kremnické pohorie Mts., Turček env. 850 m, on excrement of red deer, 26 June 1979. The mite was attached on the surface of abdomen. Other flies of this species beared numerous hypopi *Myianoetus virgatus* Scheucher, 1957, which were completely absent on the studied specimen. This indicates that *Gamasodes* are very ravenous.

Family Macrochelidae

Macrocheles (Glyptholaspis) americana (Berlese, 1888)

Richards (1930) reported this species under the name *Holastopella* (!) *vagabunda* (Oudem. nec Berlese) from *Spherocera (Ischiolepta) pusilla* (Fall.). He alleged to have found a deutonymph, which must be a mistake as only females are phoretic in the genus *Macrocheles*. Also the Vitzthum's collection comprises only females of this genus. Moreover, the finding of this large species on a minute fly is very doubtful. There were no specimens in our material.

Family Eviphididae

Eviphis? sp.

Deutonymph. Length 425 μm, width 340 μm (lateral margins of body are bent under the body so that the width seems to be much greater). The deutonymph possesses all principal characters of the genus mentioned in the key by Evans and Till (1979): palpgenu with 6 setae, tibiae I with three ventral setae, trochanter I with 5 setae, genu III with one ventral seta. Apotele two-tined, idiosoma strongly arched. Chelicerae, however, massive, not uropodine-like, with long slender shafts. Tectum with a long median lance-like process possessing two thinner lateral branches in the middle. Peritrematic shield not extending posterior to coxae IV. Legs rather thin and long.

Material. *Limosina mirabilis* Collin, 1902 Mor sept H. Jesenik Mts, peat-bog Skřítek, on horse excrement, 21 may 1977; between head and thorax. *Limosina parapusio* Dahl, 1909 Boh mer Palupin u Strmilova, 11 Sept. 1974, on fungi. Under head

Crassicheles holsaticus (Willmann, 1937)

Deutonymph. Species described originally from caves, occurring rarely in soil (Karg, 1971). Prosopi unknown. Hirschmann (1966) assigned the genus *Crassicheles* Karg, 1963 to the genus *Thinoseius* Halbert, 1920, the members of which live on the sea coat under the remnants of grasses and algae in the surf zone. However, the different bionomy and morphological detail (Karg, 1963, Evans et Till, 1979) suggest that two genera are involved.

Our specimens fully conform in their morphology to the description by Willmann (the types are not preserved — Hirschmann in litt.). On the dorsal side are conspicuous, strongly thickened vertical setae. Marked marginal structure of dorsal shield consists of longitudinal parallel lines. The reticular structure of dorsal shield in the middle occupies various areas in individual specimens. Our material involved specimens in which the whole middle of the shield was netted, whereas in others the netting was lacking in the dorsal half (see Willmann 1937) or only slightly designed by some striae near the setae i_3. Very characteristic is the striation of the sternal shield where transverse striae not reaching the middle of the shield prevail. The appurtenance to the family Eviphididae is evidenced by slightly bulbous, thickened setae on the ventral side of gnathosoma and on coxae I (the same also in the material loaned from Biologisches Zentralanstalt Berlin-Kleinmachnow). The deutonymph somewhat resembles the species *Alliphis halleri* (G. et R. Canestrini, 1881), which led Vitzthum (in Richards, 1930) to a wrong determination, as it was revealed by a revision of the material.

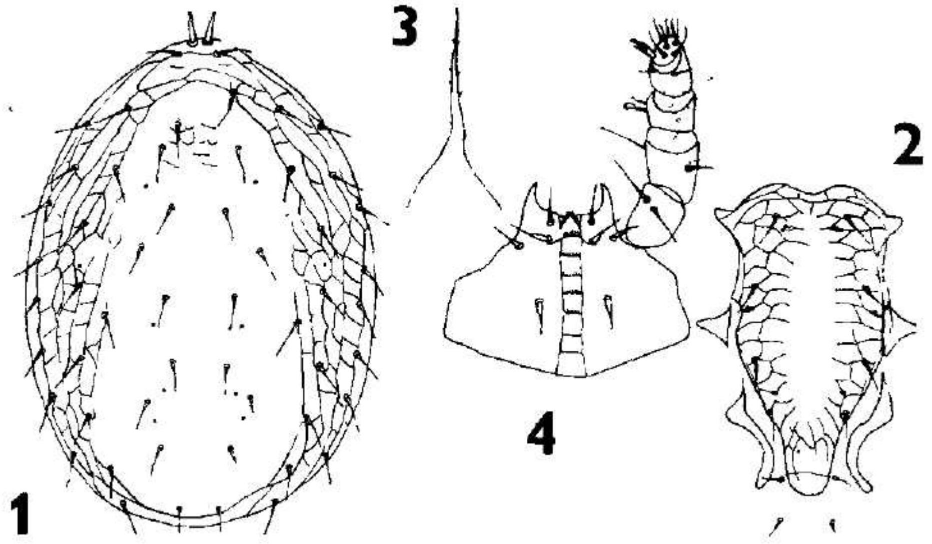

Fig. 1 *Crassicheles holsaticus* (Willmann, 1937), **deutonymph**: 1 dorsal shield, 2 sternal shield, 3 tectum, 4 gnathosoma from below

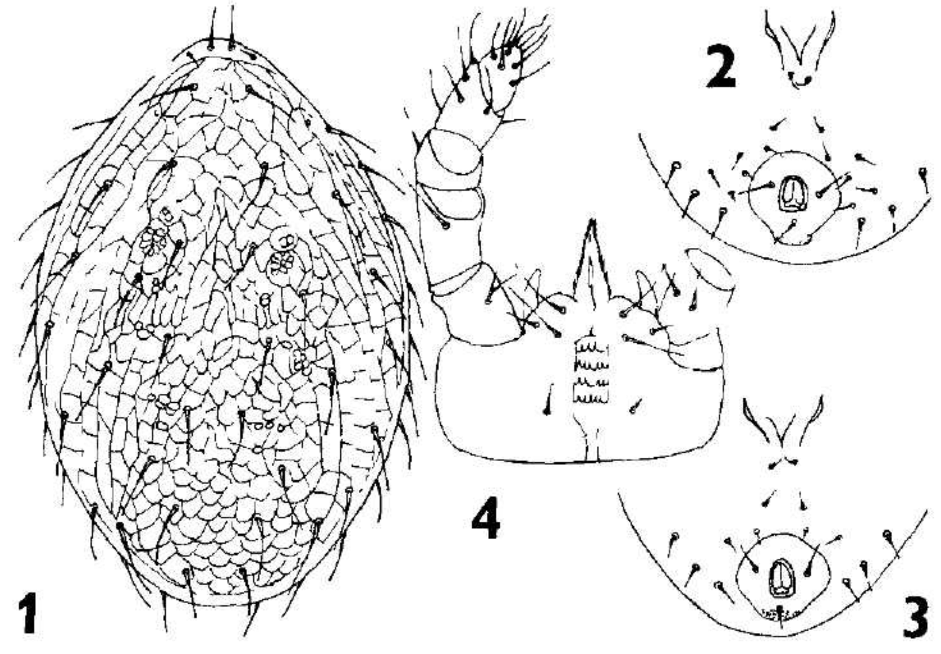

Fig. 2. *Crassicheles concentricus* **(Oudemans, 1904)**, **deutonymph**: 1 dorsal shield, **2** and **3 two** variants of **opisthosoma setation**; **male**: **gnathosoma** from below.

Material: *Limosina silvatica* (Meigen, 1830), Mor. sept. Hněvošice. 6 Sept. 1979, on decayed leaves by stream; *Limosina luteilabris* Rondani, 1880, Boh. or. Pardubice--Svítkov lgt Mocek; *Copromyza (Crumomyia) glabrifrons* (Meigen, 1830) Hisp. mer. Sierra Nevada Mts., Llano Prado 2200 m, 14 May 1979 — a series of 15 flies. Most frequently one mite specimen between head and thorax or under coxa I. In contrast to hosts of the next species, the carriers of *C. holsaticus* are terricolous, living mostly on decaying leaves. Evans (1980) reported this mite from *Limosina clunipes* (Meigen, 1830) at Minworth, Birmingham, England.

Crassicheles concentricus (Oudemans, 1904)

Deutonymph and male. The dorsal structure is usually more conspicuous in this species than in *C. holsaticus*. Particularly the middle of the dorsal shield is more markedly striated. The sternal shield is reticular over its whole area. Evans (1980) recorded a variability in the number of setae on the opisthosoma of *C. holsaticus*. The same variability appears also in *C. concentricus*, where some deutonymphs possess 9, others only 6 pairs of opisthosomal setae.

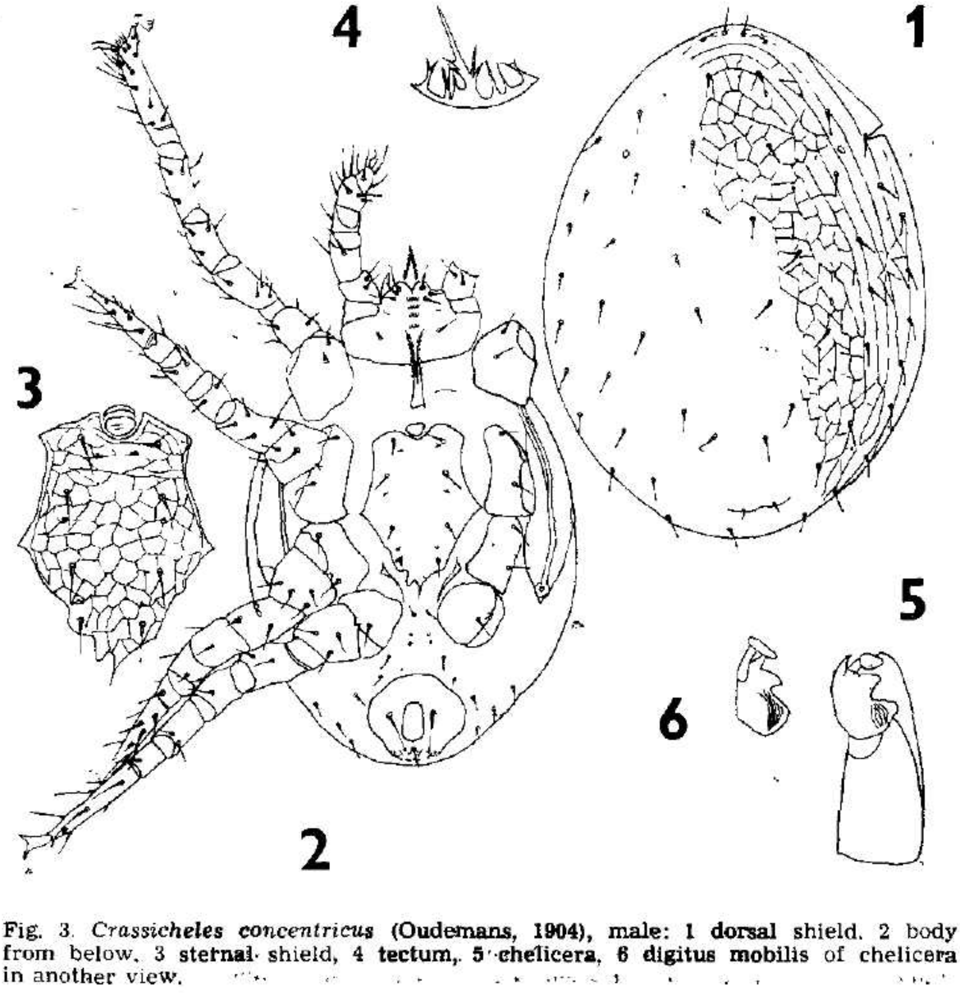

Fig. 3. *Crassicheles concentricus* (Oudemans, 1904), male: 1 dorsal shield. 2 body from below. 3 sternal shield, 4 tectum, 5 chelicera, 6 digitus mobilis of chelicera in another view.

Male: Dorsal shield 330 µm long and 300 µm wide, covering the whole surface of idiosoma. The structure is typical of the genus *Crassicheles:* longitudinally striated on sides and reticular in the middle. The reticular structure is sometimes reduced, particularly in posterior half of the shield, or badly visible. All setae of the dorsal shield are needle-shaped and 17 µm long. The vertical setae (30 µm) are somewhat thicker than the others. J_4 in form of very short, pointed pegs.

Ventral side: Praesternal shields absent. Sternal shield 125 µm long, lying between coxae II and IV, with pointed end, at the border between coxae II and III extended in narrow protrusions. It bears four pairs of setae: one pair of short setae between coxae IV, three pairs of similar setae near anterior margin of anal shield, which is 63 µm long and 76 µm wide, with three usual setae and cribrum. Endopodalia developed only as a narrow strip in the space of coxae III and IV.

Gnathosoma: Tectum with thick, branched point in the middle and three thin processes on each side of it. Chelicerae thick, digitus mobilis with one tooth, spermatodactylus short, arc-shaped, with a transverse branch at the end. Palpgenu with six setae.

Legs: Setation of tibia and genu I: $2\,\frac{2\ 3}{1\ 2}\,2$, tibia II: $1\,\frac{2\ 2}{1\ 1}\,2$.

Locality: *Ischiolepta pusilla* (Fallén, 1820), Hispania mer. 14 May 1979, Sierra *Nevada Mts.. Llano Prado 2200 m. Two specimens on one fly.*

Locality of deutonymph: *Sphaerocera curvipes* Latreille, 1805, Hisp. mer., 14 May 1979, Sierra Nevada Mts., Llano Prado, 2200 m — two flies from the same *locality. Slov. centr. Kremnické pohorie Mts., Turček env. 850 m, 22 June 1979*, on window. Other specimen of the same species, the same locality on decayed fungi. 23 June 1979. *Ischiolepta pusilla* (Fallén, 1820), Hisp. mer., 14 May 1979, Sierra *Nevada Mts., Llano Prado 2200 m, in runs of Arvicola. Deutonymphs, always one* specimen on fly, most frequently on the end of abdomen, sometimes with gnathosoma burried between tergites of the fly. Both fly species coprophagous and synbovil.

The finding of males on a fly is very interesting in that it makes doubtful the presumption of phoresy of this mite. According to previous experiences, only one stage of mite, deutonymph or prosopi, occurs on insects in case of pure phoresy. This fact does not follow from the definition by Farish and Axtell (1971), but it bears upon its demand of "limited time". Cases of pure phoresy known in detail suggest that the transformation to the following stage occurs in phoretic deutonymphs only in a suitable environment and after leaving the carrier. Nevertheless, there are some mite species of the family Eviphididae which are known to live on insects in several developmental stages, sometimes mixed together on a single carrier. However, they are situated under the erythrae of large beetles (*Geotrupes*), in a space suitable for a longer stay and for transformation. This phenomenon, known e. g. in *Alliphis halleri* (G. et R. Canestrini, 1881) (Karg, 1971) was confirmed by Evans (1980), who found a male of *Crassicheles greeni* Evans, 1980 together with deutonymphs on a staphylinid.

Family Rhodacaridae

Dendrolaelaps sp.

Deutonymph. Length 387(—400) µm, width 254 µm. Distributed over the whole Europe. Its characteristic feature is a narrow sternal shield the sides of which are parallel between coxae IV and at the end of coxae IV the end of the shield is slightly extended in points on sides (at this place is the last pair of sternal setae). Posterior margin of the shield is strongly convex. The tectum is roof-like, extended into a long point in the middle. According to the key by Hirschmann (1971), the species is related to *D. quadrisetosus* (Berlese, 1920), but the long setae at the end of body are lacking. As to the specific determination, in accordance with the recommendation of Rack (1976) I leave the mite without description.

Material: *Limosina parvula* Stenhammar, 1854. Slov. centr. Kremnické pohorie Mts., Turček env. 850 m, 23 June 1979, on window, on the surface of abdomen: *Limosina spinipennis* Haliday, 1836, Slov. mer. Kremnické pohorie Mts., Turček env. 850 m, 23 June 1979, four specimens on the surface of abdomen; *Limosina cambrica* (Richards, 1929), Finland: Finnström lgt. R. Frey, on the abdomen; *Limosina pseudosetaria* Duda, 1918, Hisp. mer.-or. Tortosa env., 8 May 1979, on decayed vegetation, on thorax under wing; *Coproica vagans* Haliday, 1833, Hisp. mer.-or. Cravillente nr. Elche, 11 May 1979, on human excrement; Cullar de Baza env., 12 May 1979, on rabbit excrement (2 flies), always on the surface of abdomen; *Coproica hirticula* Collin, 1956, Hisp. mer.-or. Cullar de Baza env., 12 May 1979, on rabbit excrement, on the surface of abdomen; *Limosina heteroneura* Haliday, 1836, Hisp. mer Grazalema nr. Ronda 1000 m, 16—17 May 1979, sweeping by stream, on the surface of abdomen.

PROSTIGMATA

Family Pygmephoridae

Genus *Pediculaster* Vitzthum, 1932

Until recently, all Pygmephoridae found on Diptera, in which apodemes V were not developed, were regarded as *Pediculaster mesembrinae* (Canestrini, 1881). Krczal (1959) pointed out the polymorphism of this species and recorded some deviations, particularly in the length of dorsal setae. Many of other characters, particularly the shape and length of solenidia on tarsus I, indicate that a whole well defined group is involved, including *P. mesembrinae*, which is the type species of the genus *Pediculaster*. After the detection of phoretomorphs the older systematical units were no more recognized. Martin (1978) and after him also Rack (1980) assigned the whole group to the subgenus *Siteroptoides* Cross, 1965, but already with regard to the presence of the type species *P. mesembrinae* in this group, the old name should be preserved and cannot be rejected on the basis of a new — though very important — phenomenon in the polymorphism of these mites. For this reason, in this paper I keep the name Pediculaster for the genus and assigne to it all phoretomorphs in which the seta c on femur I is markedly thickened and elongated. (Figure of *P. mesembrinae* vide Samšiňák, 1979.) I use Martin's (1978) designation for body setae, but for the solenidia on legs I apply an older designation which is common also in the group Acaroidea. This designation was also used, e. g., by Mahunka (1970).

Pediculaster manicatus (Berlese, 1904)

Female, phoretomorph. The species is very closely related to *Pediculaster mesembrinae* (Canestrini, 1881). Our specimen fully conforms to the redescription given by Rack (1974). Records of this species are only occasional. It was described by Berlese (1904) from Florence at the beginning of this century. Rack (1974) found this species in the vicinity of Halle.

Material: *Leptocera curvinervis* (Stenhammar, 1854) Boh. or., 28 July 1978, Černá u Bohdanče, flowers of Daucaceae, lgt. B. Mocek, between head and thorax of fly, several specimens.

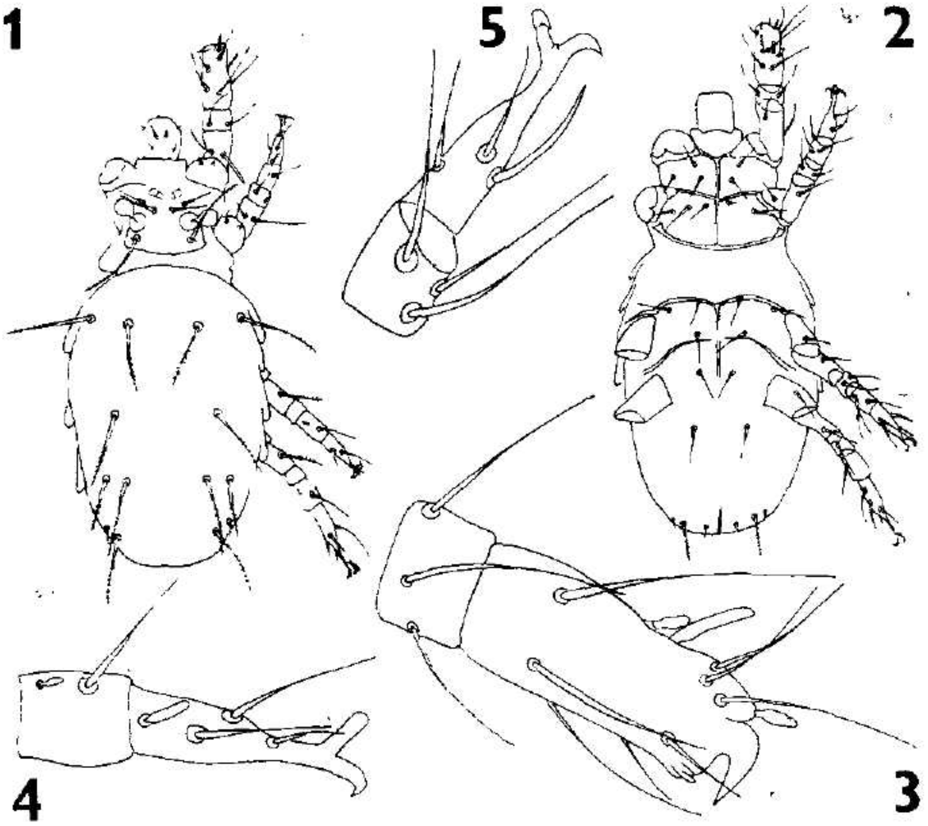

Fig. 4. ***Pediculaster manicatus*** (Berlese, 1904), female, phoretomorph: 1 dorsal side 2 ventral side, 3 tibiotarsus I, 4 tarsus II from above, 5 tarsus II from below.

Pediculaster pfefferianus sp. n.

Female, phoretomorph. *Idiosoma 260 μm long and 140 μm wide.*

Dorsum: Propodosoma with almost parallel sides, widened posteriorly. Peritremas drop-shaped, situated transversaly, distinctly bipartite, contiguous. Three pairs of *propodosomal setae* pr_1 12, pr_2 34, pr_3 63 *μm*. *Pseudostigmatal organs* 14 μm long, rounded, on a long stem. Hysterosomatal setae: c_1 56, c_2 63, d 66, e_1 70, e_2 43, f_1 70, f_2 29 μm. Idiosomal setae, except pr_1, e_2 and f_2 pectinate. Pairs of setae e_1-e_2 and f_1-f_2 *are shifted* up to the body margin and contiguous.

Ventral side: Coxal sclerites perfectly developed, bordering all coxal fields at the whole periphery. There is a great distance between coxae II and III. Apodemes V in shape of wide V turned upside down. Coxae I with three, coxae II with two setae. Hysterosoma with full number of setae (9 pairs). Coxal setae measure about 16 μm, poststernal setae 23 μm. The longest of the caudal setae is that of the middle pair (h_2) — 35 μm. This is the only pectinated seta among the ventral setae. h_3 20, h_1 10 μm, very thin, distance between h_4-h_1 is 30 μm.

Legs: I: tibiotarsus slightly thickened, bearing a simple claw at the end and a split thorn on the opposite side. ω_1 in basal part somewhat thickened. φ_2 cone-shaped (13 μm) φ_1 plug-shaped (10 μm); II: ω plug-shaped (12 μm). One pair of contiguous thorn-like setae on ventral side of tarsus, shifted up to the longitudinal axis of body and measure 1b 20, 2a 30 μm. Coxae III with simple, needle-shaped. Empodia II-IV hair-like.

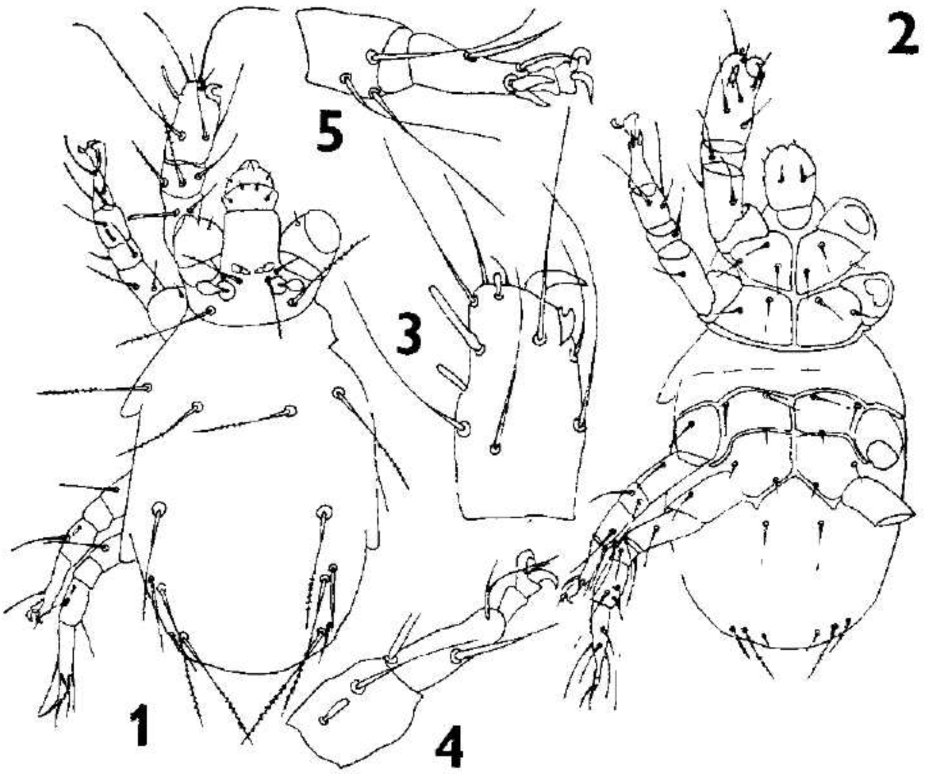

Fig. 5. *Pediculaster pfefferianus* sp. n., female, phoretomorph: 1 dorsal side, 2 ventral side, 3 tibiotarsus I, 4 tarsus II from below.

Material: *Limosina plumosula* Rondani, 1880, Hispania mer., 1000 m Güejar Sierra nr. Granada, 13 May 1979, sweeping by stream, accumulated behind coxae I On one fly a quite pure conoly, another fly mixed with *Pediculaster hispanicus* sp. n. (*P. pfefferianus* — holotype + 11 paratypes, *P. hispanicus* 5 specimens)

Derivatio nominis: Dedicated to the family of Dr. V. Pfeffer, Director of Petr Bezruč Memorial, Department of Silesian Museum in Opava.

Pediculaster hispanicus sp. n.

Female, phoretomorph. Idiosoma 260 μm long and 160 μm wide. Dorsum: Propodosoma of almost the same shape as in previous species. Three pairs of propodosomal setae: pr_1 30, pr_2 34, pr_3 55 μm. Pseudostigmatal organ 18 μm, rounded, on long stalk. Peritremes contiguous, bipartite, final segment at least twice as wide as the previous one. Hysterosomal setae: c_1 40, c_2 50, d 50, e_1 47, e_2 40, f_1 47, f_2 23 μm. e_1 and f_1 considerably shifted to middle of body, distant from e_2 and f_2. All dorsal setae pectinated.

Ventral side: Coxal sclerites developed particularly in propodosoma. In metapodosomal part developed arc-shaped apodemes III. Ventrum between coxae III very thin. Apodemes IV strongly bent anteriorly and feeble. Apodemes V marked only as smooth straight lines in the vicinity of punctation of ventral shield. Coxae I and II with three setae, the bases of these setae forming a triangle

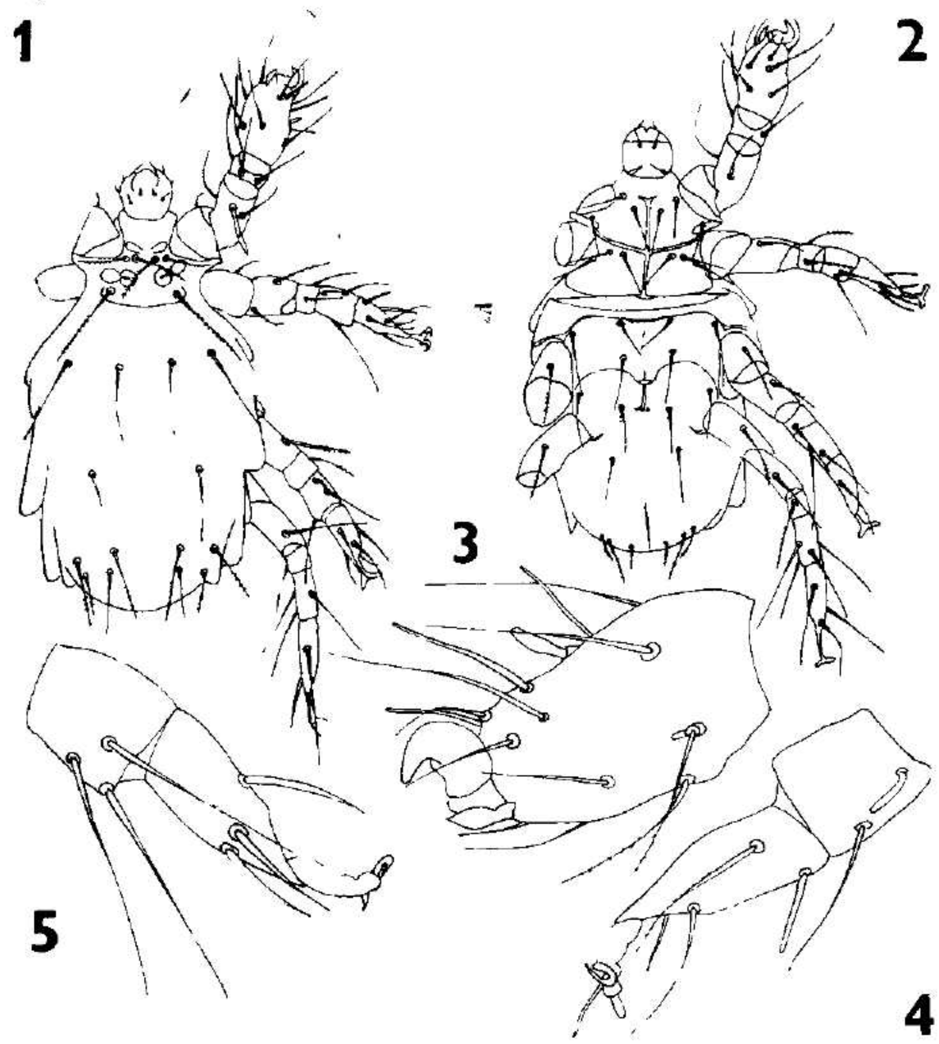

Fig. 6. ***Pediculaster hispanicus* sp. n., female,** phoretomorph: **1 dorsal side, 2** ventral side, 3 tibiotarsus **I, 4 tarsus II from above,** 5 tarsus II from below.

on coxae I and transverse row on coxae II. The longest setae are situated close to the longitudinal axis of body and measure 1b 20, 2a 30 μm. Coxae III with three, IV with two setae measuring from 23 to 30 μm. Poststernal pair 40 μm. Three pairs of caudal setae at body end, accumulated in two groups, distance between them almost the same. The longest are h_2 — 30 μm. Caudal setae finely pectinated.

Legs: I: Tibiotarsus slightly thickened, 53 μm long and 40 μm wide, with a simple claw at the end and bifurcate thorn on the opposite side. Solenidia ω_1 35 μm, ω_2 23 μm and φ_1 23 μm, very thin, bristle-shaped, φ_2 10 μm, thickened,

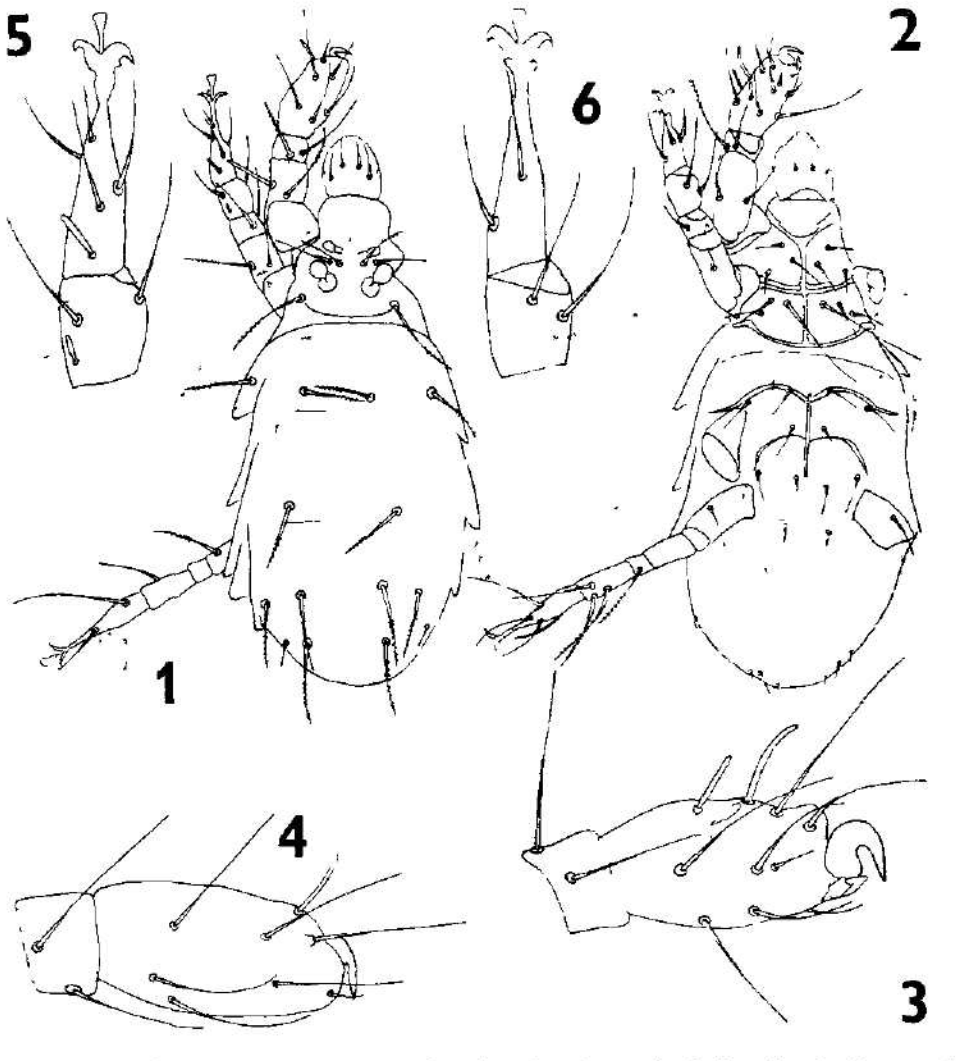

Fig. 7 *Pediculaster limosinae* sp. n., **female, phoretomorph**: 1 dorsal side, 2 ventral side, 3 tibiotarsus I from above, 4 tibiotarsus I from below, 5 tarsus II from above, 6 tarsus II from below.

in form of cone. II: ω of tarsus slightly bent, bristle-shaped, φ little thickened, hooked. A pair of crescent-shaped thicker setae on the tip of tarsi II and III on ventral side, reaching up to the end of ambulacrum.

Material: *Limosina plumosula* Rondani, 1880 Hisp. mer 1000 m, Güejar Sierra nr Granada, 13 May 1979, sweeping by a stream, accumulated behind coxae I together with *P. pfefferianus* sp. n Holotype + 4 paratypes

Pediculaster limosinae sp. n.

Female. phoretomorph. Idiosoma 270 μm long and 150 μm wide.

Dorsum: Propodosoma and propodosomal shield like in the above species. Propodosomal setae: pr_1 30, pr_2 30, pr_3 53 μm. Pseudostigmatal organ 17 μm. Peritremes in middle of body contiguous, terminal segment very large, square-shaped. Hysterosomal setae: c_1 37, c_2 44, d 44, e_1 47, e_2 37, f_1 42, f_2 12 μm (very thin and smooth). Except f_2, all hysterosomal setae are pectinated and bifurcated at the end. Setae e_1 and f_1 shifted to the middle of body, distance between them 65 μm.

Ventral side: Propodosoma with fully developed coxal sclerites. Metapodosoma with developed ventrum and apodemes III and IV. Apodemes V only as very short bands behind roots of trochanters IV. Coxae I and II bearing three setae each, measuring about 17 μm, except the inner seta of coxa II (2a), which measures 43 μm. Coxa III with three, IV with two setae. Poststernal pair of setae 20 μm. Caudal setae: three pairs, the middle one (h_2) being the longest (28 μm). The remaining two pairs very small.

Legs: I: Tibiotarsus 46 μm long and 25 μm wide. Solenidia ω_1, ω_2, φ_1 narrow, bristle-shaped, φ_2 only slightly thickened and 8 μm long. φ_1 and ω_2 almost as long as φ_2. II: ω roll-shaped, slightly thickened in the middle. Terminal setae on ventral side of tarsus not thickened and reaching up to claws.

Pediculaster jaltensis Sevastyanov, 1974, which is closely related to *P. limosinae* in the arrangement of solenidia on tarsus I, differs from our species in closed coxal plates IV and short seta 2a.

Material *Limosina fungicola* Haliday, 1836, Slov. centr. Kremnické pohorie Mts., Turček env, 22 June 1979, on window, attached on lower side of abdomen Holotype + 3 paratypes.

Pediculaster moravicus sp. n.

Female, phoretomorph. Idiosoma 275 μm long and 140 μm wide.

Dorsum: Propodosoma and propodosomal shield like in the above species. Propodosomal setae: pr_1 23, pr_2 30, pr_3 56 μm. Pseudostigmatal organ 17 μm. Peritremes in middle of body, contiguous, last but one segment only little smaller than the last one. Hysterosomal setae: c_1 47, c_2 60, d 53, e_1 47, e_2 37, f_1 43, f_2 10 μm. All hysterosomal setae, except f_2, pectinated. Distance d — d 76, e_1 — e_1 70, f_1 — f_1 83 μm.

Ventral side: Coxal sclerites fully developed on propodosoma. In metapodosomal part well developed ventrum and apodemes III and IV. Apodemes V designated by small splits on end of ventrum and short sclerotized bands near roots of legs IV. Coxae I and II bear three setae each, measuring about 17 μm. Coxae III with three, IV two setae. Poststernal setae 18 μm. Caudal setae: Three pairs at identical distance, the longest being the seta of the middle pair h_2, 27 μm. Setae of outer pairs minute.

Legs: I: Tibiotarsus 50 μm long and 20 μm wide. Solenidia ω_1 thin, peglike, measuring 13 μm, ω_2 also narrow and about by one half shorter, φ_1 of the same shape and length as ω_2, φ_2 of the same length and slightly conical. II ω thin, peglike. Only one ventral seta of tarsus crescentshaped, slightly thickened

Material: *Leptocera (Opacifrona) coxata* Stenhammar, 1854, Mor. sept. Hruby Jeseník Mts., Keprník, peat bog, 15 Aug 1979, sweeping over peat-bog meadow, ventrally between head and thorax Holotype + 4 paratypes. *Limosina ochripes* (Meigen, 1830), Mor. sept., Hrubý Jeseník Mts., peat-bog, Skřítek, 16 Aug. 1977, sifting decayed grass by runs of *M. agrestis*, under coxa I and under head, 4 paratypes.

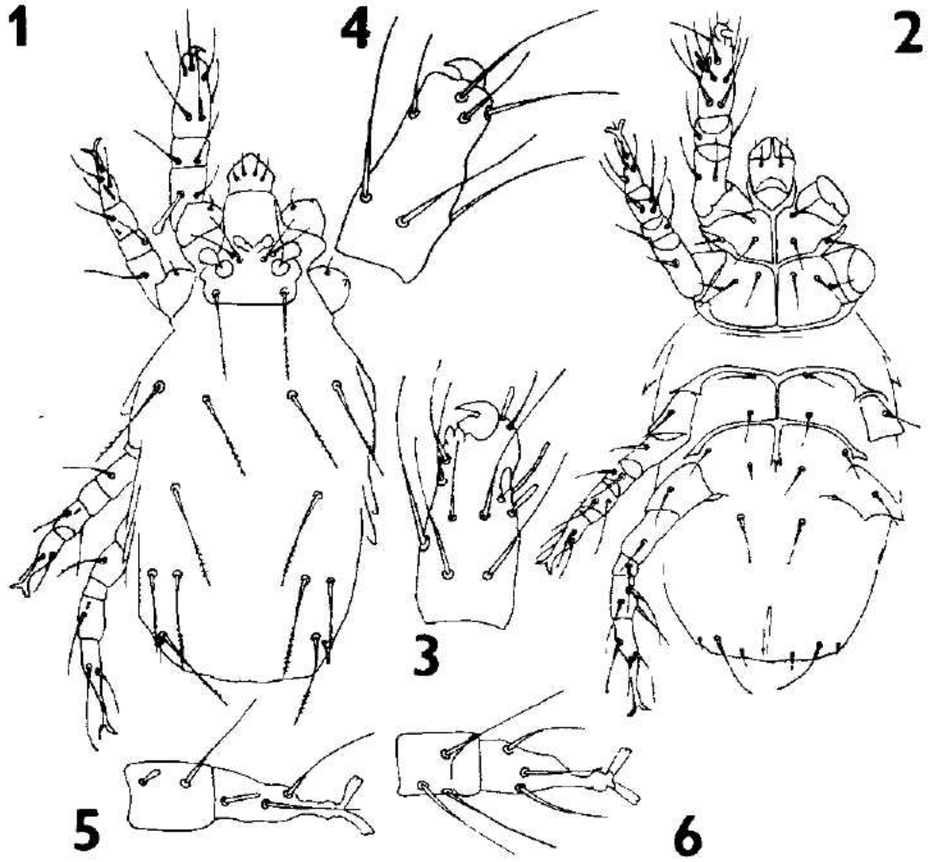

Fig. 8. *Pediculaster moravicus* sp. n., female, phoretomorph: 1 dorsal side, 2 ventral side, 3 tibiotarsus I from above, 4 tibiotarsus I from below, 5 tarsus II from above, 6 tarsus II from below.

The species resembles *P.* ***entzi*** Mahunka, 1976 which possesses longer f_1 and e_2 hardly reaching a half of e_1 length.

Pediculaster incompletus sp. n.

Female, phoretomorph. Idiosoma 310 μm long and 180 μm wide.

Dorsum: Propodosoma as in the previous species. Propodosomal setae: pr_1 29, pr_2 40, pr_2 40, pr_3 84 μm. Seta pr_2 branched into three short processes at the end. Pseudostigmatal organ 18 μm. Peritremes in middle of body contiguous, terminal segment oval, last but one segment narrow, tubular. Hysterosomal setae: c_1 70, c_2 83, d 77, e_1 94, e_2 73, f_1 85, f_2 10 μm.

Ventral side: Apodemes II only feebly visible. Ventrum in form of a cross with a short bar. Apodemes III and IV thicker only at base of legs, their connection with ventrum only feebly visible. Apodemes V very feeble, more conspicuous only at root of legs. Coxae I and II bearing three setae each

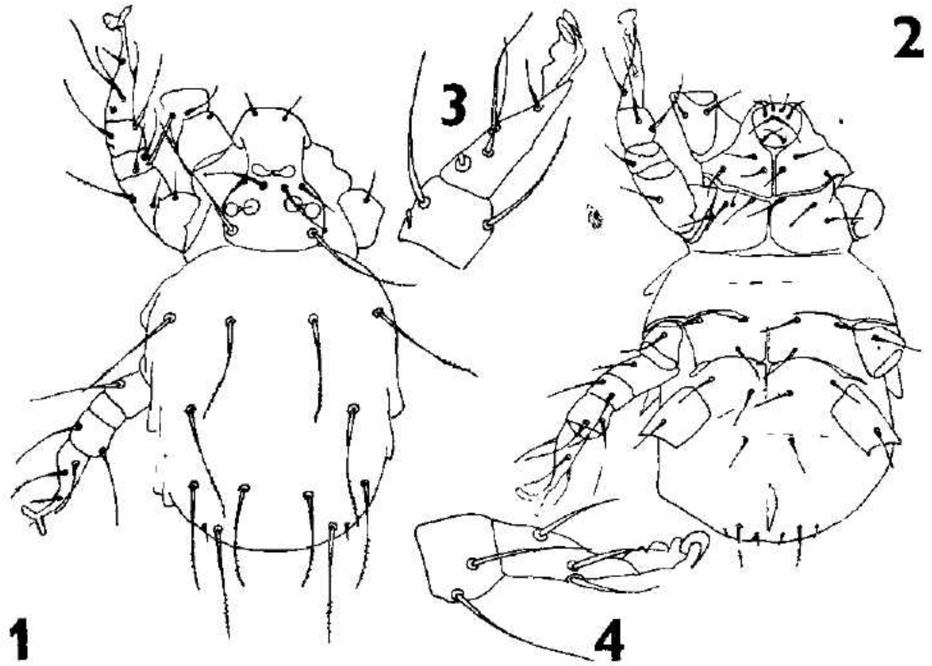

Fig. 9 *Pediculaster incompletus* sp. n., female, phoretomorph: 1 dorsal side, 2 ventral side, 3 tarsus II from above, 4 tarsus II from below.

(middle seta on coxa II double — similar anomalies were noted by Rack (1967) in opisthosomatal setae of *Pseudopygmephorus sellnicki* (Krczal, 1958). Coxal setae measure about 28 μm. Coxae III with three, IV with two pairs of setae. Caudal setae: middle pair (h_2) 27 μm, marginal pairs minute.

Legs: Pairs I and IV completely lacking. ω of tarsus II broken. Only one crescent-shaped seta on the top of tarsus II.

Material: *Limosina schmitzi* Duda, 1918, Mor. sept. Rychlebské hory Mts., Nýznerov, on decayed leaves, 6 July 1977. A single specimen, holotype, found attached on abdomen of fly.

ASTIGMATA

Family Anoetidae

Myianoetus rohaceki sp. n.

Hypopus 210 μm long and 165 μm wide.

Dorsal side: Hysterosomal shield 175 μm long, finely punctated. Propodosoma anteriorly with diadema with setae sc. All dorsal setae simple, neadle-shaped, thin and 17 μm long.

Ventral side: Epimeres III 130 μm from body end, connected with epimeres I and II. Epimeres IV very thick, the ventrale running from them reaches about middle of coxae III, not reaching epimere III. Epimerites I and II very short, III and IV lacking. Suckers on coxae I and III very small, poorly visible. On coxae I situated at end of second third of coxa length. Sucker plate small (30 μm long and 30 μm wide), bordered by band-shaped sclerites anteriorly and laterally. The large paired anterolateral sclerite with two small openings. A pair of large suckers situated in the middle, another pair of small, disc-shaped suckers in front of them, beside anal opening. Four suckers transformed in spines are arranged in transverse row and situated in front of posterior margin of plate. Among all suckers on the lower part of body only these spines are optically active.

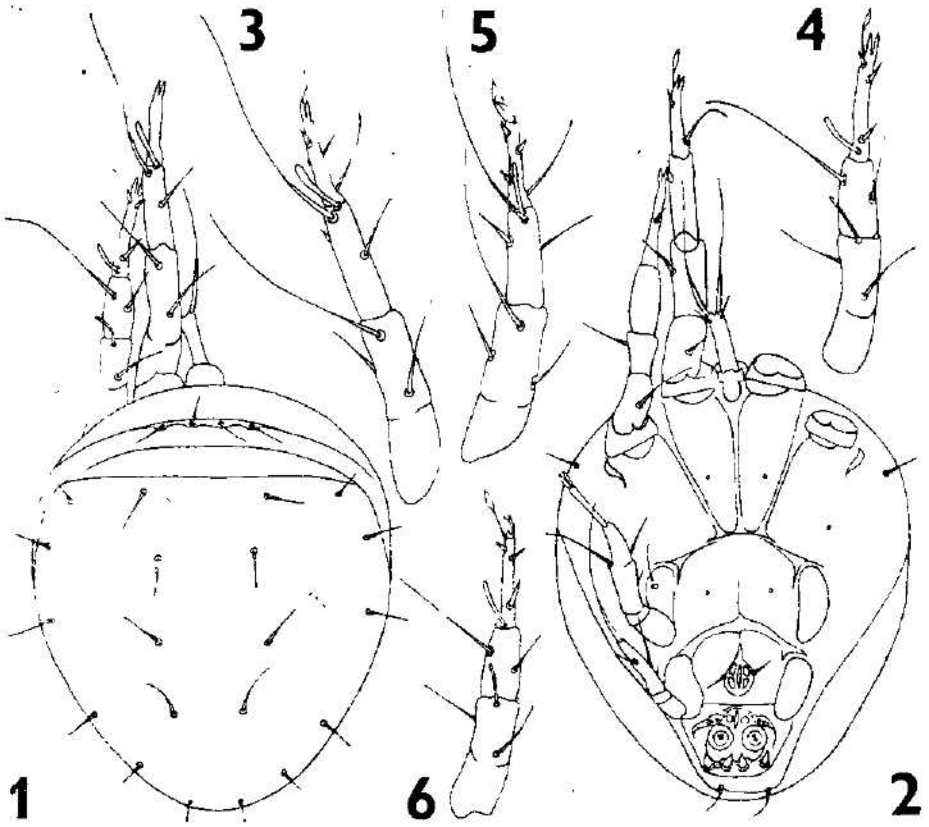

Fig. 10. *Myianoetus rohaceki* sp. n., hypopus: 1 dorsal side, 2 ventral side, 3 leg I from above, 4 leg II from above; *Myianoetus thaleri* Mahunka, 1972, hypopus, paratype: 5 leg I from above, 6 leg II from above.

Legs: Of typical *Anoetus* shape and arranged in a typical way. First two pairs of legs slender and long (femurogenu I 63 μm, II 50 μm, tibia I 40 μm, II 25 μm, tarsus I (without claws) 25 μm, II 35 μm). Claws of legs I—III splitted up to the root. Terminal setae of tarsi I and II leaf-shaped at end. *Inner lateral seta of tarsus I thin, needle-shaped.* ω_1 *on tibia I only slightly* bent, somewhat thickened at end. Inner lateral seta of tibia I short and thorn-like.

Other developmental stages unknown.

Material: Limosina rufilabris Stenhammar, 1854, Mor. sept., Hrubý Jeseník Mts., peat-bog Skřítek, 4 Oct. 1978, sweeping over peat-bog meadow; on the whole *surface of abdomen. Holotype + paratype.*

Derivatio nominis: The species is dedicated to Dr. J. Roháček of the Silesian Museum in Opava.

The new species is very closely related to *Myianoetus thaleri* Mahunka, 1972 from which it differs (compared with the paratypes) in the following characters: somewhat greater size (*thaleri* 195—200 μm), more rough structure (in *thaleri* hardly visible at magnification of 300 x, in *rohaceki* punctation not only on opisthosomatal shield, but also on legs I), long inner lateral seta of tarsus I and short thorn-like lateral seta of tibia I (in *thaleri*, the inner lateral seta of tarsus I is very short, thorn-like, the outer lateral seta of tibia I is long). Solenidium ω_1 of tibia I is thicker than in *thaleri*, more thickened at end. Segments of leg I are longer (in *thaleri*, femurogenu I 53, tibia 33, tarsus I 33 μm). Suckers on coxae I and III almost invisible in *M. rohaceki*, but well visible in *M. thaleri.*

The group of hypopi of the genus *Myianoetus* with a row of four spines near posterior margin of sucker plate forms a very well isolated group in the genus. Unfortunately, the prosopi of most of these species are unknown and if they are known, it is not sure that they belong to the described hypopi. For example, in the description of *M. virgatus* Scheucher, 1957 the author *herself is not sure (p. 354) whether the hypopus and prosopon belong to the* same species and in a note, most probably added later, she ascribes the female to the species *Myianoetus muscarum.*

Methodical remark: The hypopi of the genus *Myianoetus* are in most cases quite opaque and can be cleared only with KOH. The hypopus — either freshly collected or taken from Liquida (Swann, Berlese) — is placed on a slide with a drop of very strong solution of KOH and covered with cover glass. The process of clearing is followed under the microscope. It can be speeded up by putting the glass on a hot lamp-shade. For this purpose we use the microscope lamp after Šikl with a 100-W bulb, the shade of which is heated to 145 °C. The slide is left *on the shade for 10—25 sec. and then examined under the microscope. If there* are still small crystals inside the body, then the slide is heated again. The process is finished when the crystals are dissolved. Then the mite is washed under the cover glass with Oudemans' fixative which is dropped on one side of the glass and sucked off with filtration paper on the other side. After washing the mite is quickly transferred to a drop of Liquid on another slide and cover with a cover glass. Even during this process in most cases the legs, particularly the anterior two pairs, turn under the body. However, they can be straightened again on the mentioned heated lamp-shade, where small species can be left up to 10—20 sec.

During the collection of small mites — if definitive mounts cannot be made immediately — many specimens are damaged or lost if they are collected in tubes with fixative. The most suitable was found to be the method of collection in some drops of Liquid. The mite, either live or collected from collection material of insect, is put in a drop of Liquid on the slide and the drop is left to dry without cover-glass. The drop can be any time very easily moistened with a drop of water and the mite can be taken and classified at higher magnification. I obtained perfect mounts from a drop even after 15 years, when the medium was already completely crystallized. The drops can be placed even on fragments of cover glasses which are then put separately into tubes.

Myianoetus simplex Mahunka, 1977

Hypopus. Length 150 μm, width 100 μm.

Strikingly narrow species. The specimens found fully conform to the description and paratypes deposited in my collection.

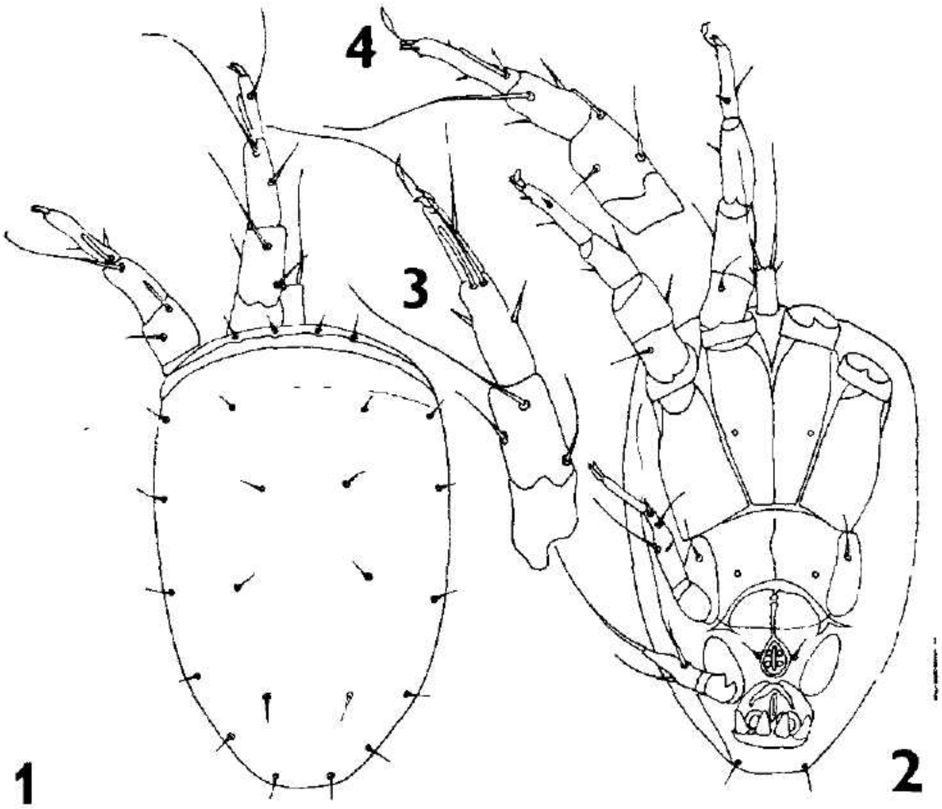

Fig. 11. *Myianoetus simplex* Mahunka, 1972, hypopus: 1 dorsal side, 2 ventral side, 3 leg I, 4 leg II.

Material: *Coproica lugubris* (Haliday, 1836) Mor. sept. Hrubý Jeseník Mts., Kopernik, peat-bog, 15. Aug. 1978, on excrement of red deer. Five specimens on the surface of abdomen.

Myianoetus zdena sp. n.

Hypopus. Length 133 μm, width 123 μm.

Body widely oval, surface very finely puctated.

Dorsum: Propodosomal setae in a well visible diadem. Outer seta (10 μm) approximately twice as long as the inner ones. Hysterosomal setae very short.

Ventral side: Basic segment of gnathosoma 13 μm, terminal setae 30 μm. Apodemes well developed, epimeres I joined in Y-shape in sternum, reaching posterior margin of sternal shield, but shortly interrupted in the last third. Epimeres II running almost directly and uniting with epimeres III. Epimerites II more developed only at root of coxae II, then bent outside and bordering sternal shield up to epimeres III with which they unite. Epimeres III and unusually strong epimeres IV connecting in middle of body on ventrum which runs through the whole ventral plate and separates coxae III and IV. Suckers on coxae I and III minute, hardly visible in the surrounding structure; on coxae I, standing at the beginning of second half of their length. Sucker plate with a pair of oblique sclerites in anterior portion, each sclerite with two crevices. Only the middle large pair of suckers with a conspicuous, thick and notched outer rim. Four discs optically active, but almost invisible with light microscope are situated under the sucker. A refractive tube is running from them posteriorly. Four sac-like, well visible structures lying behind the suckers.

Legs are typical of the genus *Myianoetus*, including the terminal doubled claw. Length of segments: I: femurogenu 36, tibia 25, tarsus 20 μm; II: femurogenu 25, tibia 16, tarsus 20 μm. Tarsus I markedly shorter than tibia, setae tough, straight, but not strikingly thickened. ω_2 long, thin, much overlapping the claws. ω_1 on base with marked genu, slightly thickened at end, reaching two thirds of tarsus length. Beside it short, peglike, well visible famulus.

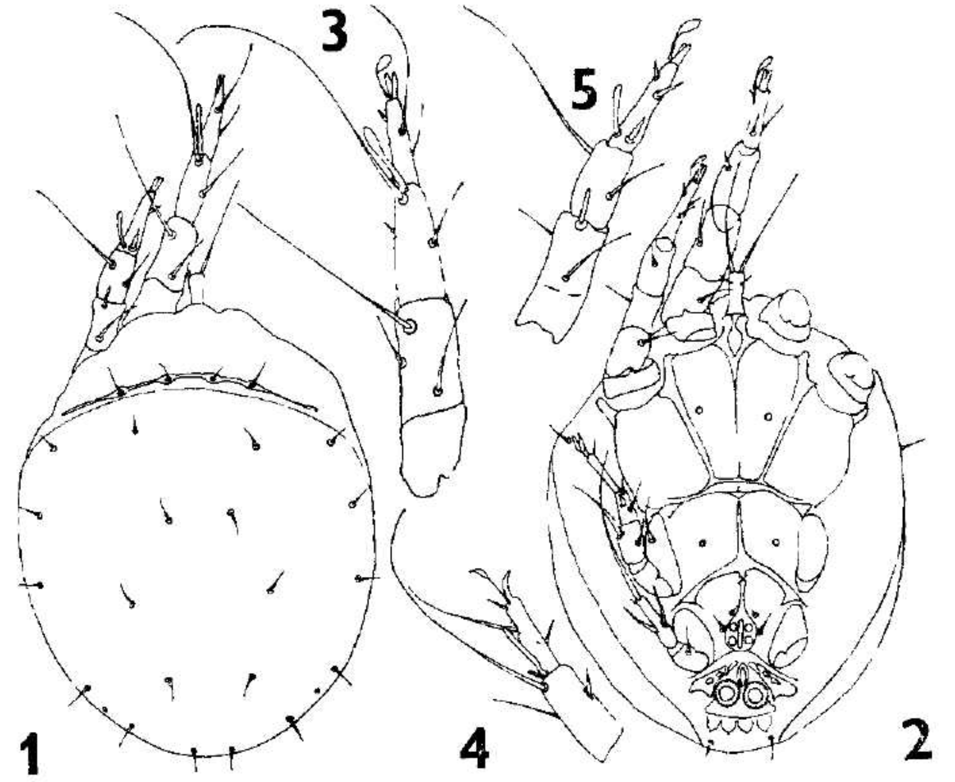

Fig. 12 *Myianoetus zdena* sp. n., hypopus: 1 dorsal side, 2 ventral side, 3 leg I from above, 4 another view of tarsus I, 5 leg II.

Basal seta on tarsus II markedly thickened, other setae tough, not thickened Solenidium δ of leg II shorter than ω, very thin

The species is very close to *M simplex* Mahunka, 1972, which has (compared to paratypes deposited in my collection) more rough structure, the famulus on leg I is lacking, on tarsus II is shorter, suckers on coxae I and III almost invisible, sternum continous, ventrum not reaching epimeres III anteriorly Four thick, optically strongly active spines on attaching plate

Material *Elachistoma aterrima* (Haliday 1833) Slov centr Kremnicke pohorie Mts, Tuček env 850 m, 27 June 1979 on window, a single specimen, holotype, sitting dorsally on the surface of abdomen

Myianoetus virgatus Scheucher, 1957

The species was originally described from flies of the family Sphaeroceridae and Scatopsidae It is characterized by longitudinal, conspicuous ribs on opisthosomal shield The species is closely related to *Myianoetus undulatus* Hughes et Jackson, 1958 If the illustrations of both authors (I did not managed to borrow a comparative material) are exact, the two species differ from one another in the situation of suckers on coxae *I In M virgatus,* as it is visible both in the drawing by Scheucher and in my material, both suckers are situated in the first third of coxae

Material *Limosina clunipes* (Meigen, 1830), Mor sept Hruby Jesenik Mts peat-bog, 15 Aug 1979 on excrement of red deer, Mor sept H Jesenik Mts, peat-bog Rejviz, on excrement of red deer 12 Sept 1979, Mor sept H Jesenik Mts, peat-bog Skritek sifting decayed grass by runs of *M agrestis*, 16 Aug 1977 Slov centr Kremnicke pohorie Mts Turček env 22 June 1979, 23 June 1979, 27 June 1979 on excrement of red deer, Hisp mer Sierra Nevada Mts, Llado Prado 2200 m in runs of *Arvicola* sp 14 May 1979 The mites are most often sitting on upper side of abdomen on lateral sides of thorax and between roots of legs of the fly

Glyphanoetus phyllotrichus (Berlese, 1881)

Hypopus While synonymizing this species I consider the monograph by Scheucher, 1957 in which the species was synonymized with *Glyphanoetus fulmeki* Oudemans, 1929, the type species of the genus Hughes and Jackson (1958) synonymized *G fulmeki* with *Histiostoma horridum* Berlese, 1913 described from Java Our material fully conforms to the description and drawing published by Scheucher It possesses a markedly long terminal seta on tibia I, which is much shorter in the species illustrated by Hughes et Jackson Also the position of setae on hysterosomal shield is very different in the compared illustrations My material corresponds exactly to the description and drawing by Scheucher It is a species typical of manure and excrement

Material *Limosina talparum* Richards 1927 Mor sept Hruby Jesenik Mts peat-bog, Skritek 23 June 1978, sifting decayed grass by runs of *M agrestis*

Bonomoia sphaerocerae Vitzthum, 1922

Hypopus with marked structure on opisthosomal shield, originally described from flies *Sphaerocera curvipes* Latereille, 1805 (= *S subsultans* auct), where they were attached on lower side of wings Since that time reported several times on various fly species (Scheucher 1957, Samšiňak 1979)

Material *Limosina bifrons* Stenhammar, 1854, Mor sept Hradec u Opavy env 22 July 1978, on decayed vegetation, a single specimen attached to eye of fly, *Limosina talparum* Richards, 1927, Mor sept Hruby Jesenik Mts, peat-bog, Skřitek, 23 June 1978, sifting decayed grass by runs of *M agrestis* Together with *Glyphanoetus phyllotrichus* (Berlese, 1881)

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ECO-MORPHOLOGICAL ADAPTATION OF THE GILL RAKERS IN RELATION TO THE FOOD AND FEEDING HABITS OF SOME HILLSTREAM FISHES OF GARHWAL HIMALAYA

H. R. SINGH and S. N. BAHUGUNA

Received April 24, 1982

Abstract: The gill rakers of three coldwater fishes, namely, *Crossocheilus latius*, *Barilius vagra*, and *Pseudecheneis sulcatus* are examined. The study shows both interspecific and intraspecific variations in the gill rakers. The size, shape, length, distance, and the number of gill rakers vary according to the basic food and the feeding habits of these fishes.

INTRODUCTION

In fishes several organs of the body are modified according to the food and feeding habits. The gills are one of them, in which the length of the gill arches and the number of gill rakers play an important role in feeding. The adaptations of buccopharynx and gill rakers have been described by a number of workers including Evans (1948). AL-Hussaini (1949), Weisel (1962), McCart (1970), Weisel et al. (1973), and Arvindan (1980). However, this is the first report on the gill rakers' adaptation in three hillstream fishes of Garhwal Himalaya that differ in their food and feeding habits.

MATERIAL AND METHODS

Specimens of *Pseudecheneis sulcatus* (McClelland), *Crossocheilus latius latius* (McClelland) and *Barilius vagra* (Hamilton) were collected from the river Alakanada and its tributaries. They were preserved in 5 to 8% formalin solution. Each gill arch was dissected out and the gill rakers were counted following the method of Hubbs and Lagler (1964). The position of gill rakers was studied under a microscope and their length calculated with the help of the ocular micrometer. The food of fishes was studied using the methods of Hynes (1950) and **Pillay** (1952).

RESULTS

Food and feeding habits: Of the three fish species selected for this study *P. sulcatus* (carnivorous) is a bottom feeder. It consumes more than 85% animal food (insects and crustaceans) in its diet; the other food items being the aquatic weeds, sand and debris. *C. latius latius* (herbivorous) is a column feeder, taking more than 90% plant food (algae, diatoms and aquatic weeds, etc.). *B. vagra* (omnivorous) is a surface feeder and takes approximately equal amount of plant and animal food.

Pattern of gill rakers: In *C. latius latius* (herbivorous) the gill rakers are long, pointed, soft, and closely set but in *P. sulcatus* (carnivorous) the gill rakers are long, pointed, and hard with more distance in between the two rakers. In *B. vagra* (omnivorous) the gill rakers are small, hard, closely set, and less pointed as compared with those of the other fishes included for this study.

Variations in the length of gill arches: In the carnivorous fish *P. sulcatus* the length of gill arches is minimum, while it is maximum in the herbivorous *C. latius latius*. But in the omnivorous *B. vagra* the arches are of moderate length (Table 1 and Fig. 1).

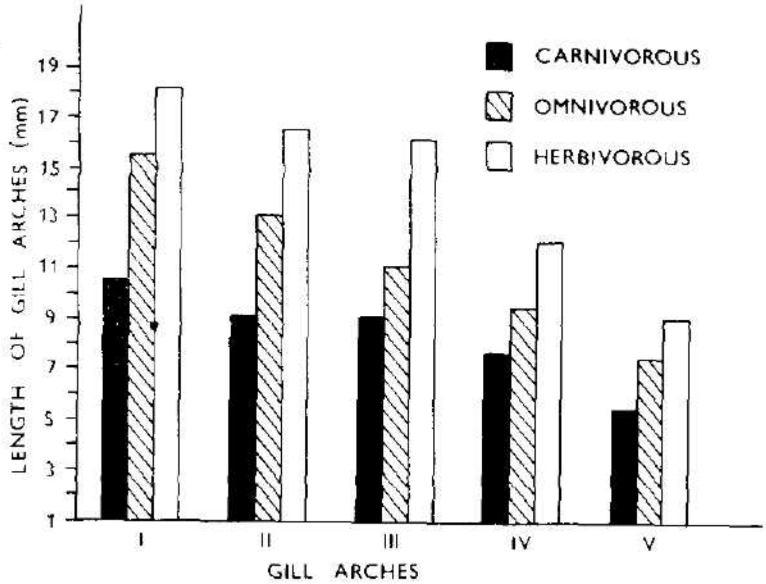

Fig. 1. The length of different gill arches in the three fishes studied.

Variation in the number of gill rakers: In *P. sulcatus* (carnivorous) the total number of gill rakers is minimum (55), it is maximum (179) in *C. latius latius* (herbivorous), and intermediate (119) in *B. vagra*. Thus, the total number of gill rakers gradually increases from carnivorous to omnivorous to herbivorous (Table 2) and the difference in increase in number ranges from 60 to 64.

Variation in the length of gill rakers: The mean length of gill

Table 1. Length of gill arches (mm) in different fishes

GILL ARCH	*Pseudecheneis sulcatus* (Carnivorous)	*Barilius vagra* (Omnivorous)	*Crossocheilus latius latius* (Herbivorous)
I	10.5	15.5	18.0
II	9.0	13.0	16.5
III	9.0	11.0	16.0
IV	7.5	9.5	12.0
V	5.5	7.5	9.0
Total length	41.5	56.5	71.5

Table 2. Number and position of gill rakers in different arches

GILL ARCH	*Pseudecheneis sulcatus* (Carnivorous)	*Barilius vagra* (Omnivorous)	*Crossocheilus latius latius* (Herbivorous)
I	10 one side (upper)	22 both sides	42 both sides
II	10 one side (upper)	25 both sides	46 both sides
III	10 one side (lower)	28 both sides	40 both sides
IV	17 both sides	33 both sides	38 both sides
V	8 one side (upper)	11 one side (upper)	13 one side (upper)

rakers is maximum in *P. sulcatus* and less in *C. latius latius* and *B. vagra*. The average length ratio difference is 23—25 μm (Table 3).

Filtering adaptation: The filtering adaptation of each gill arch is recorded as follows:

$$\frac{\text{Number of gill rakers}}{\text{Length of gill arch}}$$

Thus, Fig. 2 shows that in *P. sulcatus* (carnivorous) the gill rakers are less adapted for filtration than in *B. vagra* (omnivorous) and *C. latius latius* (herbivorous). The figure also indicates the relative importance of the different arches in filtration. In all the three fishes the 4th gill arch is more adapted for filtration.

Table 3. Mean length (μm) of individual gill rakers in different fishes

GILL ARCH	*Pseudecheneis sulcatus*	*Crossocheilus latius latius*	*Barilius vagra*
I	1700	1300	625
II	1650	1100	520
III	1500	1050	440
IV	1300	700	380
V	1050	500	300
Total length	7200	4650	2265
Ratio	72.0	46.50	22.65

DISCUSSION

It is well known that the gill rakers taste, filter, or prevent the escape of the food material (Iwai 1963, 1964; Kapoor 1965). There exists a remarkable connection between the number and structure of gill rakers and the feeding habits of fishes. Khanna and Mehrotra (1970) pointed out that the gill raker equipment may vary in fishes with identical modes of feeding.

The gill arches of *P. sulcatus* (carnivorous) are small as compared with those of *B. vagra* (omnivorous) and *C. latius latius* (herbivorous). Of the three fishes studied, the longest gill arches are found in *C. latius latius*.

In these fishes the pattern of gill rakers is also modified in relation to their food and feeding habits. When the food consists of large and hard forms such as the insects and crustaceans, the gill rakers are long, pointed, hard, and less closely set as in *P. sulcatus* (carnivorous). Such type of gill rakers are modified to prevent the escape of food. These results support the findings of Verighina (1969) in cat-fishes.

On dividing the total number of gill rakers by the length of the gill arch interesting results are obtained. Thus, the fourth gill arch of each fish appears to be more adapted for the filtration of food. The study also shows that the filtering adaptation increases considerabely from carnivorous to omnivorous to herbivorous fishes studied by the authors.

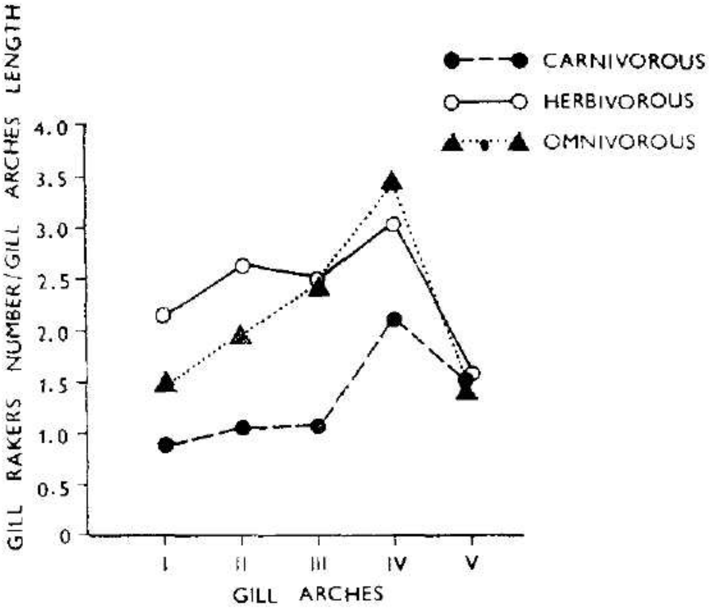

Fig. 2. Relationship between the number of gill rakers and the length of different gill arches.

The variation in the number and the size of gill rakers is recorded not only in the fishes of different feeding habits but also in the individuals of the same species. Such intraspecific variations in the gill rakers may be attributed to the differences in the size and the food and feeding niches of the individuals of the same species.

Acknowledgements

Thanks are due to the Department of Science and Technology, New Delhi for providing financial assistance.

SUMMARY

In *C. latius latius* the gill rakers are long, pointed, soft and closely set; but in *P. sulcatus* the gill rakers are long, pointed and hard with more distance in between the two rakers. In *B. vagra* the gill rakers are small, hard, closely set and less pointed as compared with those of the other two fishes.

The total number of gill rakers gradually increases from carnivorous to omnivorous to herbivorous fish and the difference in increase in number ranges from 60 to 64.

In the three fishes the fourth gill arch appears to be more adapted for filtration.

Intraspecific variations in the gill rakers may be attributed to the differences in the size and the food and feeding niches of the individuals of the same species.

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SPACIAL ACTIVITY OF SMALL MAMMALS (RODENTIA) IN AREAS OF LARGE-SCALE LIVESTOCK PRODUCTION FARMS

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Abstract. The movements of small mammals marked by toe-clipping (*Mus musculus* — 429 specimens, *Microtus arvalis* — 416 sp., *Apodemus sylvaticus* — 41 sp.) were studied by recapturing in the area of two livestock production farms in South Bohemia in 1978. Throughout the year only low numbers (1.7%) of *M. musculus* specimens were recaptured in buildings different from those at first capture. In this way the ability of inhabiting new locations in other buildings and re-invading the buildings in which the original populations had been eradicated by deratization measures was demonstrated. The movements of two other species into buildings depended on the type of occurrence and population density in the immediate vicinity of buildings. *M. arvalis* enter the farm buildings nearly all over the year (except July). The occurrence of *A. sylvaticus* inside buildings was recorded mainly in autumn and winter. The movements of small mammals between the farm buildings and the surrounding biotopes may also be of great epizootiological importance.

Industrialization of livestock production associated with the high concentration of animals brings with itself, among others, certain hazards in transmitting diseases to large-scale breedings. From this aspect, mainly ectoparasites of small mammals as vectors of pathogenic agens may be of great importance. Within the framework of parasitological investigation the occurrence and movements of small mammals were studied to serve as a basis for a detailed study on the epizootiological importance of ectoparasites of small mammals under conditions of large-scale breedings.

The community of small mammals in the farm areas comprises both eusynanthropic species (*Mus musculus, Rattus norvegicus*) and species originating from the biotopes of the wild. In autumn these species enter the buildings to return to fields in spring. Although many authors were engaded in this problem, it cannot yet be considered solved (Rosický and Kratochvíl 1953, Rosický et al. 1965, Belyaev 1972, Schepotev et al. 1968, Porkert and Vlasák 1968, Vlasák and Porkert 1973, Schepotev and Levitski 1974, Porkert 1975, Andrzejewski et al. 1978, Hodková and Vlček 1978, Pelikán and Nesvadbová 1979, Vlček 1982). The process of synanthropization of small mamals is particularly important mainly from the epidemiological aspect (Rosický 1978, 1979). A detailed knowledge of spatial activity of small mammals in farm areas is of great importance not only from this aspect, but is associated also with the possibility of consistent controlling harmful rodents. Summarized in this paper are the data on the migration of small mammals obtained in the livestock production farms in South Bohemia.

MATERIAL AND METHODS

Investigation of small mammals was conducted in large-scale pig fattening farms (the localities of Vranín and Mazelov, capacity 5000 and 10 000 animals) situated in the Třeboň basin in South Bohemia. The farm areas under study, each totalling 2–3 ha^2, comprise several (7–10) piggeries situated in the immediate environs of grasland divided by asphalt roads connecting individual buildings. Around the perimeter of the two farms areas there is a 5–10 m wide rim of uncultivated grassland with sporadic shrubs and trees neighbouring area cultivated by agriculture.

The movements of small mammals in the farm areas were studied by a method of live-trap recapturing (traps baited with apples) in 1978. In the localities of Vranín and Mazelov a total of 16 and 11 two-day trappings were conducted from February to December. Inside the buildings in food-mixing stations on average 31 traps (16–66) were laid in the locality of Vranín and 31 traps (24–65) in the locality of Mazelov, outside the buildings, around the perimeter of piggeries 45 and 47 traps were laid, respectively, representing a total of 2304 traps in the former and 1610 traps in the latter locality per night. The traps were inspected daily in the morning hours. Small rodents captured were individually toe-clipped and released at the site of capture. A total of 429 specimens of *Mus musculus*, 416 specimens of *Microtus arvalis* and 41 specimens of *Apodemus sylvaticus* were marked in this way in the two localities. Recapturing data on individual species are summarized in Tables 1–6. Evaluating the catches in various biotopes, we computed the relative density (i. e., the number of individuals captured, multiplied by 100 and divided by the number of traps laid).

RESULTS

I. Movements of small mammals in farm areas

Fluctuations in spatial activity of small mamals residing in individual biotopes of the farm areas were observed throughout the year. The animals moved within the border of their own home range, less frequent were the movements to other sites. Home range and the intensity of movements changed during the year according to a change in ecological conditions. Spatial activity differed also between males and females of each species. Of great epizootiological importance may be the movements of small mammals within the areas of fattening farms. From this aspect, the most significant populations are those occurring in the largest numbers in the farm areas. These were mainly *Mus musculus, Microtus arvalis* and *Apodemus sylvaticus* in our observation.

Mus musculus L.

The data on the movements of the house mice are summarized in Tables 1 and 2. It can be seen from Table 1 that female mice are bound more to the site of first capture (37/156, i. e. 23.7%) than males (14/132; 10.6%). Similar findings were revealed in both localities under study. In contrast, males were recovered the more often in locations far from those at first capture. Out

Table 1. Movements of *Mus musculus* first caught inside piggeries (food-mixing stations)

Locality	Mazelov		Vranín		Total	
Number of individuals	♂	♀	♂	♀	♂	♀
Marked	30	27	102	129	132	156
Recaptured in same building	4	6	10	31	14	37
Recaptured in others buildings	0	1	1	3	1	4
Recaptured outside buildings	0	0	2	0	2	0

Table 2 Movements of *Mus musculus* first caught around the perimeter of piggeries

Locality *Number of individuals*	Mazelov ♂	Mazelov ♀	Vranín ♂	Vranín ♀	Total ♂	Total ♀
Marked	9	6	76	50	85	56
Recaptured outside buildings	2	0	9	6	11	6
Recaptured inside buildings	0	0	6	2	6	2

of the overal number of mice recaptured in both localities, migrating males constituted 5,2%, migrating females 6,9%. Out of 288 specimens captured for the first time inside the buildings only 5 individuals (i. e. 1.7%) were recaptured in different locations throughout the year (1/57; 1.7% in the locality of Mazelov. 4/231; 1.7% at Vranín).

The movements of *Mus musculus* in the vicinity of buildings are surveyed in Table 2. In the surroundings of buildings males were recovered more frequently than females (85 : 56, i. e. 60.5% of males). Recaptures of males were more frequent as well. These findings suggest that the male mice move within larger individual home range and have greater migration activity than females.

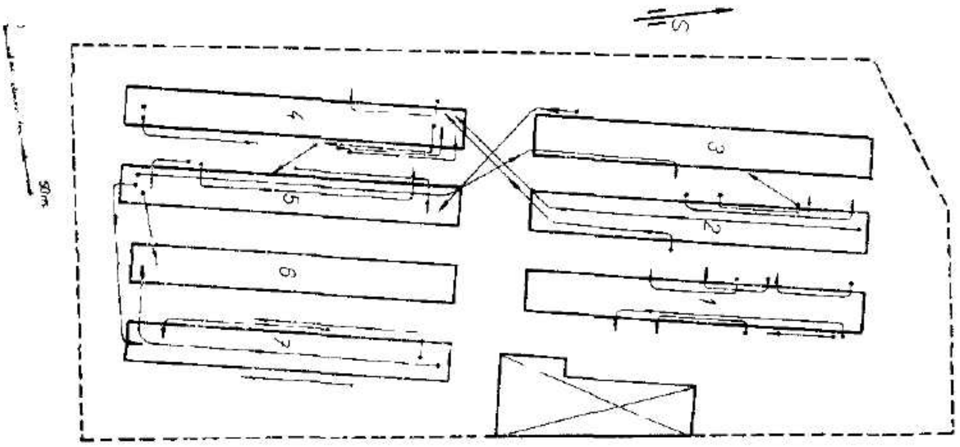

Fig 1 Migration of *Mus musculus* specimens in the buildings of a large-scale pig-fattening farm at Vranín recorded in 1978 (Nos 1—7 indicate the individual buildings of a farm, dashed line — the outer fencing of the farm)

Changes in the living site, though they occur in small parts of *M. musculus* populations only (1.7%), are of great importance mainly in inhabiting new space in other buildings or re-invading the buildings in which considerable portions of original populations had been eradicated by deratization measures. The movements of *Mus musculus* recorded at Vranín throughout the year are shown in Fig. 1. It can be seen from the figure that the movements of mice occur also between individual piggeries that can be important mainly from the epizootiological aspect. The movements of the house mice in both localities under study correlate with the fluctuations in the population density of this species inside the buildings in the food-mixing stations. Figure 2 shows that the most of the migrating individuals were recorded in the period from April to August, i. e. in the period of the dynamic increase in the population density inside the piggeries. Decline in the density of *M. musculus* populations inside the piggeries (in autumn) is accompanied by the decreasing numbers of the migrating individuals.

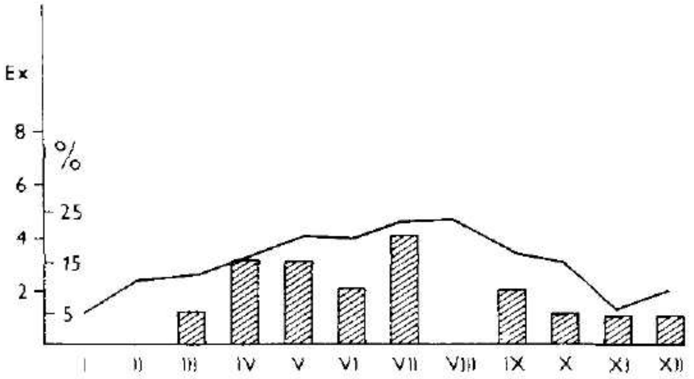

Fig. 2. The range of *Mus musculus* migration in comparison with the relative population density (Columns: number of migrating specimens, line: relative *M. musculus* population density in the food-mixing stations).

Microtus arvalis (Pall.)

Recapturing data on *Microtus arvalis* specimens are summarized in Tables 3 and 4. It can be seen from Table 3 that the majority of individuals were recaptured in grassland surrounding the piggeries. Only a minor part of *M. arvalis* population enters the buildings (1/389; 0.3%). Males and females are bound to the site of first capture to the same degree (females 39/220; 17.7%, males 26/169; 15.4%), however, more males move to locations remove from those of the first capture. Out of the overall number of individuals recaptured in the localities under study (94). migrating males constituted 19.1 %, but migrating females only a half of this number, i. e. 10.6%. The migrating part of population comprises mainly males (19/29; 65.5%). In general, a great part of *M. arvalis* population changes the original living site under conditions of farm areas (28/389; 7.2%).

Having entered the food-mixing stations inside the piggeries (mainly in the winter months). the field voles are greatly bound to these locations. It is demonstrated by the high percentage of individuals recaptured right at these

Table 3. Movements of *Microtus arvalis* first caught around the parimeter of piggeries

Locality Number of individuals	Mazelov ♂	 ♀	Vranin ♂	 ♀	Total ♂	 ♀
Marked	80	118	89	102	169	220
Recaptured near same building	10	20	16	19	26	39
Recaptured near other building	5	4	13	6	18	10
Recaptured inside buildinas	*1*	*0*	*0*	*0*	*1*	*0*

Table 4. Movements of *Microtus arvalis* first caught inside piggeries (food-mixing stations)

Locality Number of individuals	Mazolov ♂	Mazolov ♀	Vranín ♂	Vranín ♀	Total ♂	Total ♀
Marked	8	8	0	1	8	9
Recaptured in same buildings	3	2	0	0	3	2
Recaptured in vicinity of buildings	4	1	0	0	4	1

sites (5/17; 29.4%), or in the immediate vicinity of the buildings (5/17; 29.4%). These very stations or their immediate neighbourhood are inhabited permanently by the majority of the individuals of *M. arvalis* that had been first captured there (10/17; 58.8%). The biotope of food-mixing stations serves as a suitable overwintering site during unfavourable winter period, expecially if permanent movements involving voles leaving buildings and visiting or residing in areas outside them or vice versa, are possible (via badly fittin or damaged door, etc.).

In *Microtus arvalis* populations, the movements of individuals in grassland within the farm areas are very extensive.

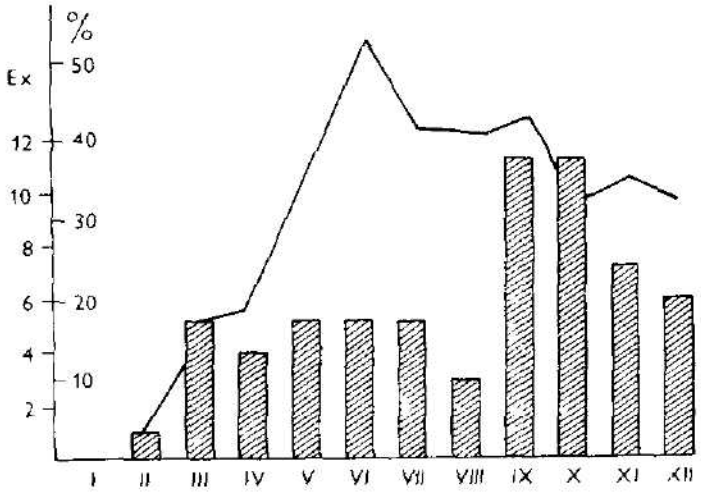

Fig. 3. The range of *Microtus arvalis* migrations in comparison with the relative population density in the farm areas.

It can be seen from Fig. 3 that the movements of the field voles are more and more frequent in early spring, maintaining about the same intensity level in summer, followed by further increase in autumn. More frequent movements of the field voles in spring are connected with the onset of reproductive activity accompanied by the distribution of population and inhabiting new sites. Increase in the migration activity in autumn is associated with the onset of adverse climatic conditions and search for sites suitable for overwintering.

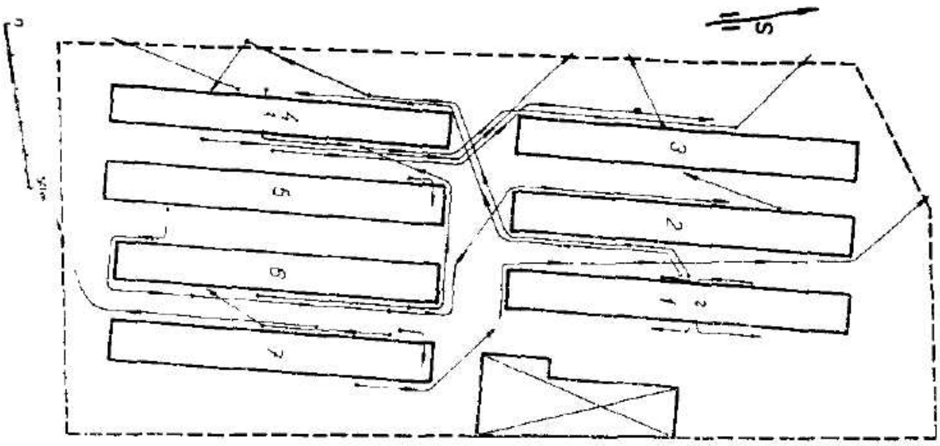

Fig. 4. Movements of *Microtus arvalis* specimens in the area of a large-scale pig fattening farm at Vranín recorded in 1978.

Under conditions of large-scale breedings the movements of the individuals of *Microtus arvalis* may be of great epizootiological importance. Figs. 4 and 5 show that *M. arvalis* move both within and beyond the boundaries of the farm areas. In the cool months of the year large numbers of the field voles enter the buildings, creating a prerequisite for transmitting diseases from exoanthropic to eusynanthropic mammals *(Mus musculus)* residing permanently in the buildings of piggeries. From them, diseases can be transmitted to the farm animals.

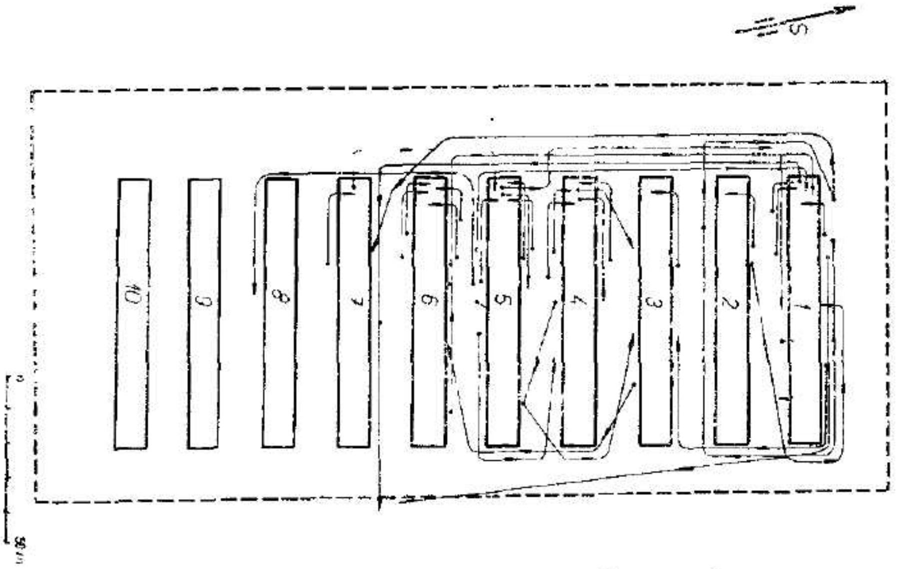

Fig. 5. Movements of *Microtus arvalis* (full arrows) and *Mus musculus* (dotted arrows) in the area of a large-scale pig fattening farm at Mazelov (Buildings Nos 7–10 including their vicinity were not examined regularly).

Apodemus sylvaticus (L.)

Immigration of this species to the immediate vicinity of buildings is seasonal. In the immediate environs of buildings the wood mice occur from August till the end of April. Immigration into the piggeries depends on the population density of this species in the biotopes surrounding the buildings (Vlček 1982). In the food-mixing stations the species does not occur until October or November, the maximum number of immigrants being recorded in January (Fig. 6). The biotopes of piggeries are left by the wood mice at the beginning of warm weather in spring.

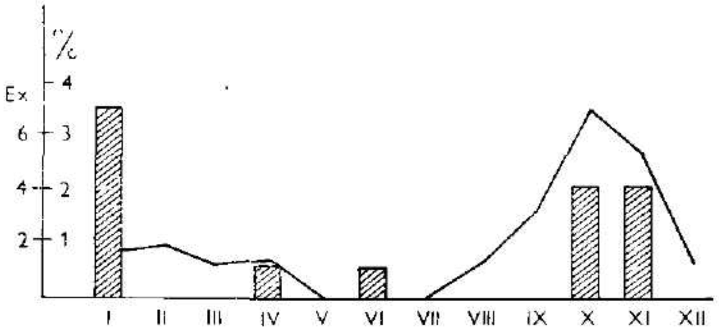

Fig. 6. Comparison of the abundance of *Apodemus sylvaticus* specimens immigrating into the food-mixing stations (columns) with the relative population density in the surroundings of the buildings.

In the localities studied only a limited number of mice could be marked (see Table 5). Out of the overall number of marked individuals only 6 and 1 specimens were recaptured in the localities of Vranin and Mazelov, respectively, most of them in locations identical to those at first capture. The most prolonged stay in a single living site was recorded in the locality of Vranín (from February 2 to April 6, 1978, i. e. 63 days). Owing to low numbers of the wood mice marked we did not succeed in revealing their movements to other sites.

II. Penetration of *Apodemus sylvaticus* and *Microtus arvalis* into the buildings

As mentioned above, the occurrence of *Microtus arvalis* and *Apodemus sylvaticus* inside the buildings was recorded throughout the year. The movements of small mammals into piggeries were studied in two pig fattening farms differing in both the technology of animal breeding and the construction of piggeries. It can be seen from Fig. 7 that the rodents reside in piggeries all

Table 5. Movements of *Apodemus sylvaticus* first caught in the vicinity of buildings

Locality Number of individuals	Mazelov ♂	 ♀	Vranin ♂	 ♀	Total ♂	 ♀
Marked	8	6	10	12	18	18
Recaptured in same building	0	1	2	4	2	5

the year round, except July. While the movements of *Microtus arvalis* into the premises were observed nearly throughout the year, the presence of the wood mice inside the buildings was restricted mainly to the autumn and winter months that is related to the occurrence of these species in the biotopes neighbouring the buildings. *Microtus arvalis* resides permanently in grassland surrouding the buildings. however, the wood mice is a seasonal inhabitant only, occuring just during migrations there. The intensity of movements of small mammals into the buildings is dependent not only whether they occur in the immediate vicinity of buildings, but also on the way the buildings are protected against direct penetrating of these species. This is demonstrated by the course and intensity of immigrations into the buildings in the localities under study (Table 6). In the locality of Vranín these species constitute a minor part of overall populations of small mammals occupying the buildings of piggeries (1.6% on the average, max. 7.7% in the winter months). In contrast, in the locality of Mazelov these species constitute about 1/4 (22.0%) of small mammal populations inhabiting the food-mixing stations in piggeries. During the winter months the proportion of these species increases up to 1/3 (34.8%), maintaining rather high level throughout the year (minimum in summer: 10.2%). Comparing the relative density values these differences were even more manifest. In the locality of Vranín (702 trap nights) the relative density of exoanthropic species *(Apodemus sylvaticus, Microtus arvalis)* was 0.86 individuals per 100 traps, exceeded by more than 6 times (5.32 specimens) in the locality of Mazelov (732 trap nights). With regard to the fact that the density of the two species inhabiting grassland in the vicinity of buildings is similar in both localities under study, it is evident that the differences intensity of immigrations correspond to the degree the buildings are protected against direct penetrating of small mammals.

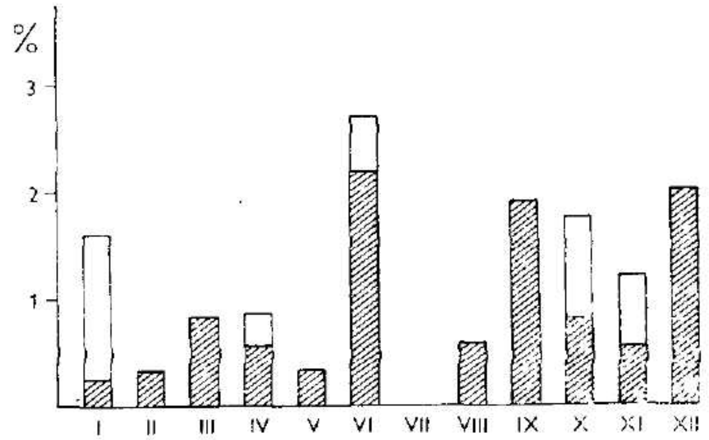

Fig. 7. The relative density of *Microtus arvalis* (dark columns) and *Apodemus sylvaticus* (white columns) inside the buildings.

From this aspect, the more suitable construction of buildings as used in the locality of Vranín. i. e. brick-built premises with properly set and close-fitting

Table 6. Composition of small mammal populations in food-mixing stations in the localities of Vranin (*V*) and Mazelov (*M*) throughout the year

Season		XII—II		III—V		VI—VIII		IX—XI		Total (I—XII)	
Locality		V	M	V	M	V	M	V	M	V	M
Mus musculus	n	36	17	130	39	88	44	53	42	297	142
	%	92.3	65.4	100.0	84.8	98.9	89.8	98.0	68.9	98.4	78.0
Apodemus sylvaticus	n	2	5	0	0	0	1	1	7	3	13
	%	5.1	19.2	0.0	0.0	0.0	2.0	1.0	11.5	0.8	7.2
Microtus arvalis	n	1	4	0	7	1	4	1	12	3	27
	%	2.6	15.4	0.0	15.2	1.1	8.2	1.0	19.6	0.8	14.8
Σ	n	39	26	130	46	89	49	55	61	303	182
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

door may be recommended. In such buildings the occurrence of exoanthropic small mammals is greatly limited. In contrast, the buildings constructed from corrugated aluminium plates (in the locality of Mazelov) are protected against entering of small mammals to a minimum degree. Aluminium plates forming the walls of a building do not fit closely to the foundation brickwork, allowing thus small mammals to enter the buildings via numerous interstices and a polysterene heat shielding layer. In addition, the door of the food-mixing stations is badly fitting and so much damaged in the majority of buildings it cannot be closed at all. It is evident that the food-mixing stations open to small rodents during the whole year become the sites inhabited permanently by hemisynanthropic rodents, providing both shelter and food for them. Less frequent is penetrating of hemisynanthropic small mammals to buildings via other routes (waste channels or shafts for central heating, etc.).

DISCUSSION

Synanthropic *Mus musculus* populations inhabiting permanently the farm buildings differ in the migration activity of both sexes. The male mice tended to range more often and further than females. Similar findings may be observed in *Microtus arvalis* populations residing permanently in grassland surrounding the buildings. It is clear that the intensity of movements of small mammals is greatly influenced by the reproductive activity. The migrating part of the population comprises mainly male mice (Naumov 1955, Larina and Golikova 1960, Rowe et al. 1963, Radda 1969, Aristova 1970, Rödl 1974, Schepotev and Levitskyi 1974. Lidicker 1976).

The authors engaged in the studies of spatial activity of *Mus musculus* agree in stating that the migration activity of this species is very great (Lavrova and Naumova 1955, Soldatkin et al. 1959, Nikitina et al. 1976). From this aspect, the species may play an important role in transmitting pathogenic agens (Rosický and Kratochvíl 1953, Rosický et al. 1965, Belyaev 1972, Lankin et al. 1978, etc.). The movements of the house mice between isolated *Mus musculus* populations are rare within particular buildings (1.7%), nevertheless, a prerequisite is created for the distribution of this species into other buildings Rowe and Swinney 1977, Tannert 1975).

Under farm conditions, the intensity of movements of *Mus musculus* reaches the peak during the spring and autumn months. In this period, also the number of migrating individuals increases in the wild, as recorded by **Rosický** et al. 1965, **Zejda** 1974, **Pelikán** and **Nesvadbová** 1979, **Hodková** and **Vlček** 1978, **Vlček** 1982. The migration activity of *Microtus arvalis* increases in early spring (**Chelkowska** 1978) in the connection with the dispersion of overwintering populations in the onset of reproductive activity. Further increase in the movements of this species occurs at the beginning of cool and rainy autumn weather (**Varschavskyi** 1937), **Naumov** 1955) when the number of specimens immigrating into buildings increases as well.

The intensity of movements of rodents into buildings depends not only on scepial climatic conditions — i. e. air temperature below 10 °C in the beginning of cool and rainy weather in our country (**Vlasák** and **Porkert** 1973), but to a great extent also on the way the buildings are protected against undesirable penetration of these species. These immigrations are conditioned by the presence of large numbers of rodents in areas close to the buildings. Therefore, measures must be conducted with the aim of restricting the numbers of exoanthropic small mammals in the farm areas, mainly maintaining good order and the park arrangement of the farm areas. The effects of deratization measures conducted in unmaintained, weedy areas are of short duration only, since the decrease in the numbers of rodents is complemented rapidly both by increased reproduction of the remaining populations and by the migration of small mammals from the adjoining uncultivated regions in the neighbourhood (**Schilova and Schilov** 1977).

SUMMARY

An investigation of small mammals migrations was carried out by live-trap recapturing in areas of two large-scale pig farms situated at the Třeboň basin (South Bohemia). A total of 3914 traps were exposed and 429 specimens of *Mus musculus*, 416 specimens of *Microtus arvalis*, 41 specimens of *Apodemus sylvaticus* were marked.

Only a small fraction (1.7%) of 288 specimens of *Mus musculus* marked in the buildings was recaptured in other buildings, which may be of importance primarily during the colonization of uninvaded buildings or recolonization of buildings in which initial populations had been eliminated by deratization meassures. The intensity of *Mus musculus* movements increased with an increasing population density, reaching a yearly maximum from April to August.

Under conditions of farm areas considerable portion of *Microtus arvalis* population (7.2%) changed its original sites. Only a small part of *Microtus arvalis* population (0.3%) penetrated into the buildings.

Immigration of *Apodemus sylvaticus* to the farm buildings and their vicinity had a distinct seasonal pattern: The species occured in the vicinity of buildings from August to April, inside buildings from October to April (maximum in January). The species left the areas in May.

Intensity of invasion of species *Apodemus sylvaticus* and *Microtus arvalis* to the farm buildings depends both on their density in the vicinity of buildings and efficiency of meassures preventing them from penetration inward. Long-lasting elimination of exoantropic small mammals in the vicinity of piggeries may be attaind by careful maitaining of park arragement in the farms. Regular

mowing of grass both inside and outside the areas of farms, and deratization meassures, are advised.

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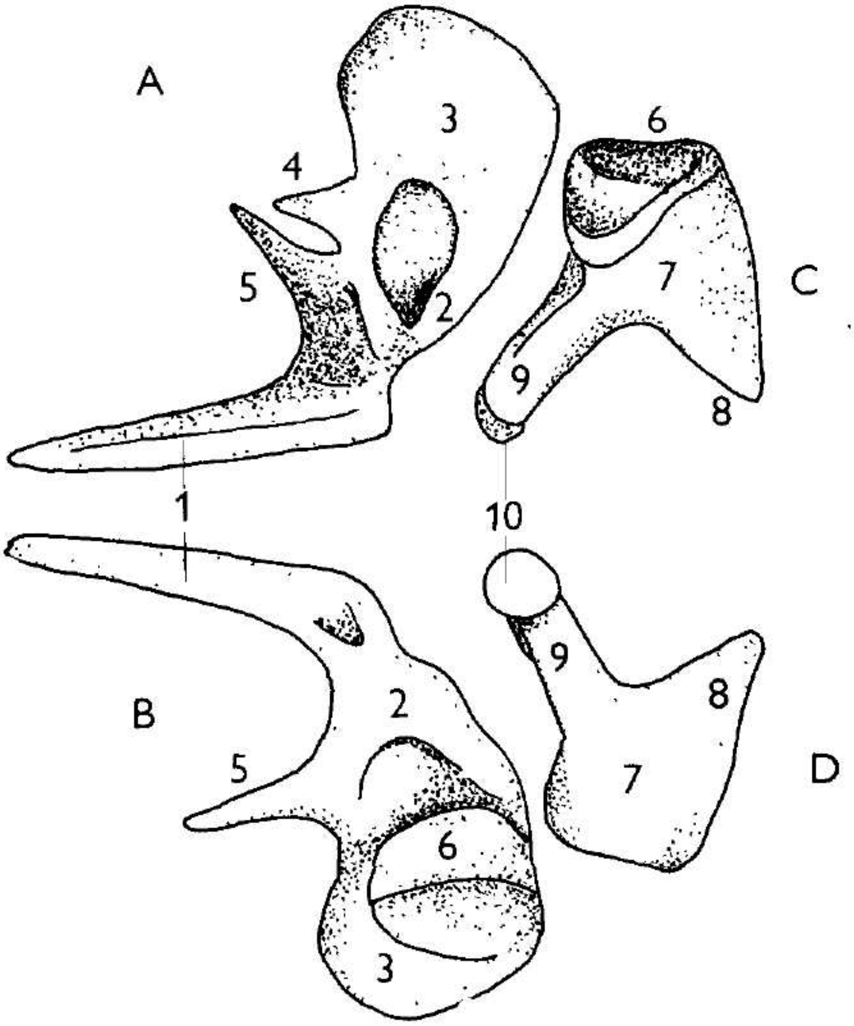
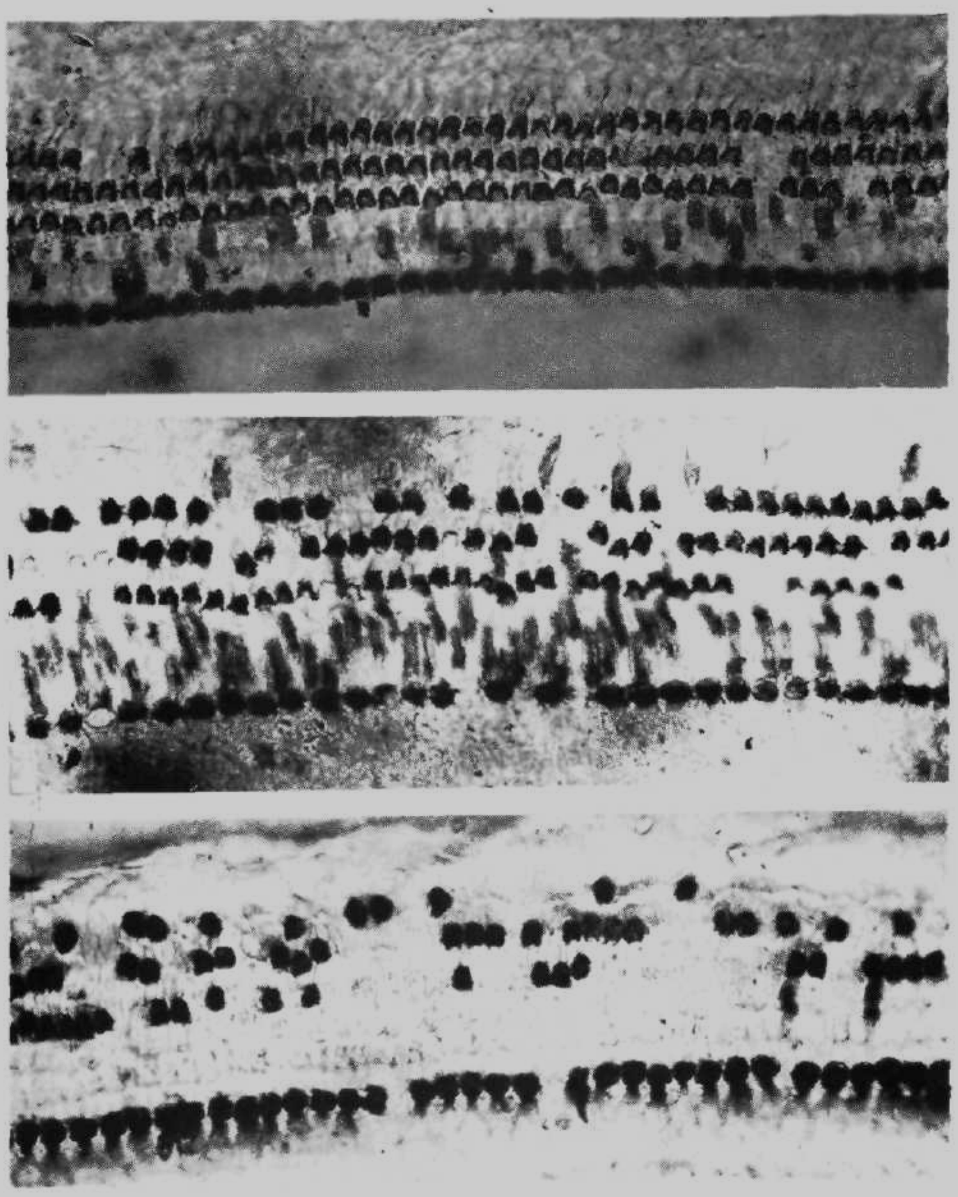
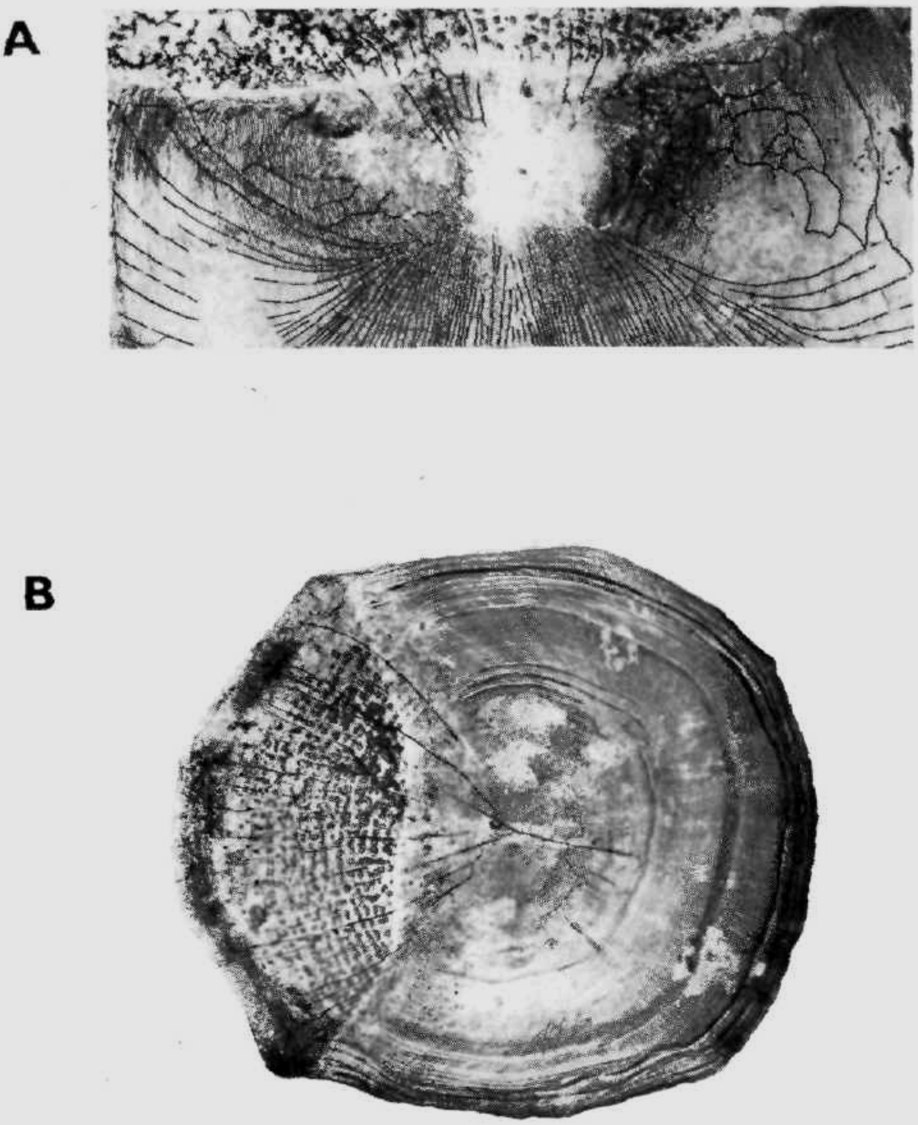


Fig. 1. Left malleus (A, B) and incus (C, D) of the tiger in ventral (A, C) and dorsal (B, D) views 1 — manubrium mallei, 2 — collum mallei, 3 — caput mallei, 4 — processus rostralis, 5 — processus lateralis, 6 — articulatio incudomallearis, 7 — corpus incudis, 8 — crus breve, 9 — crus longum, 10 — processus lenticularis. (11×).

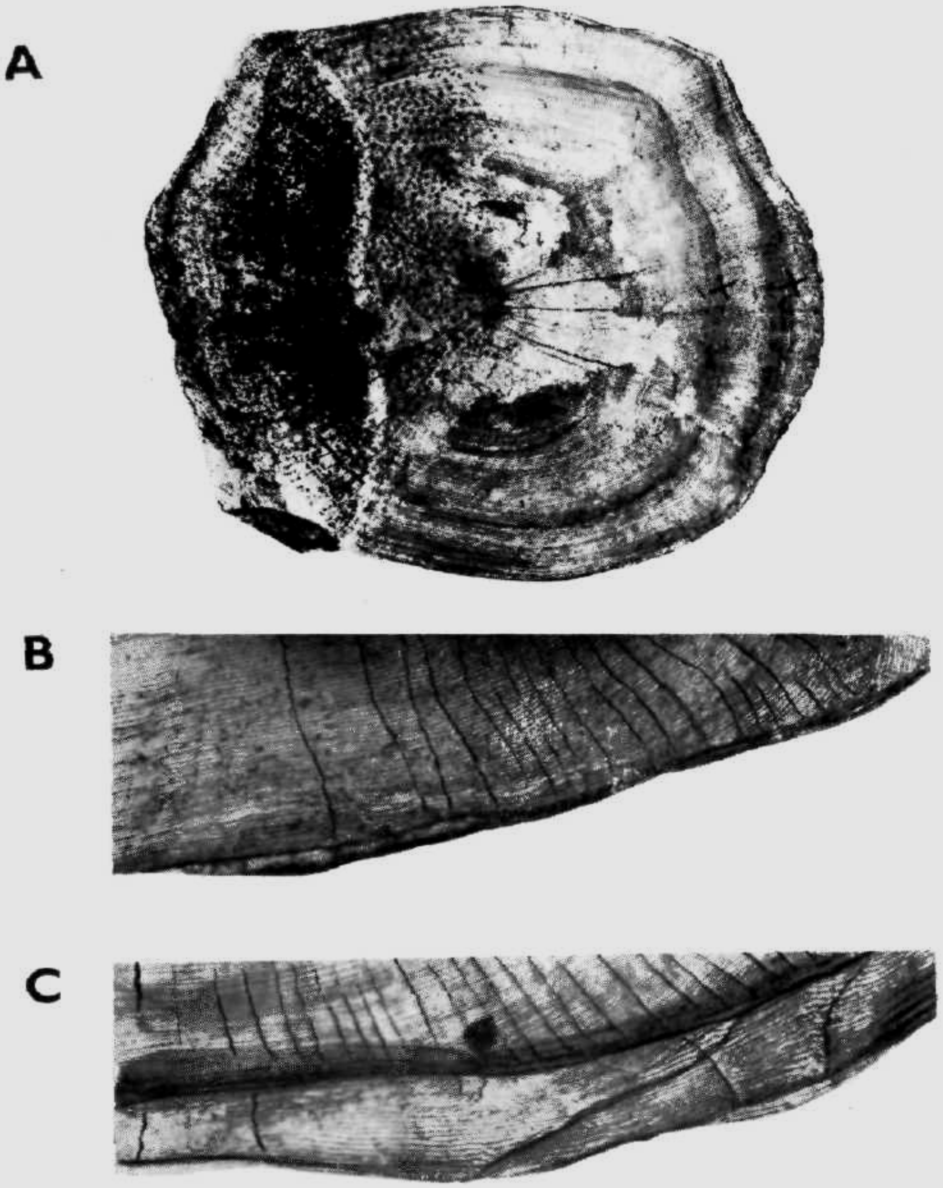


Figs. 2—4. Total surface specimens of the organ of Corti of the tiger (above — a more basal segment, middle — a segment from somewhat a more apical region) and of the jaguar (below). Geometrical pattern consists of three rows of outer hair cells separated by the tunnel of Corti from a single row of inner hair cells. Many hair cells are missing on account of the process of ageing of the neuroepithelium (see the text). Haematoxylin, 375×.



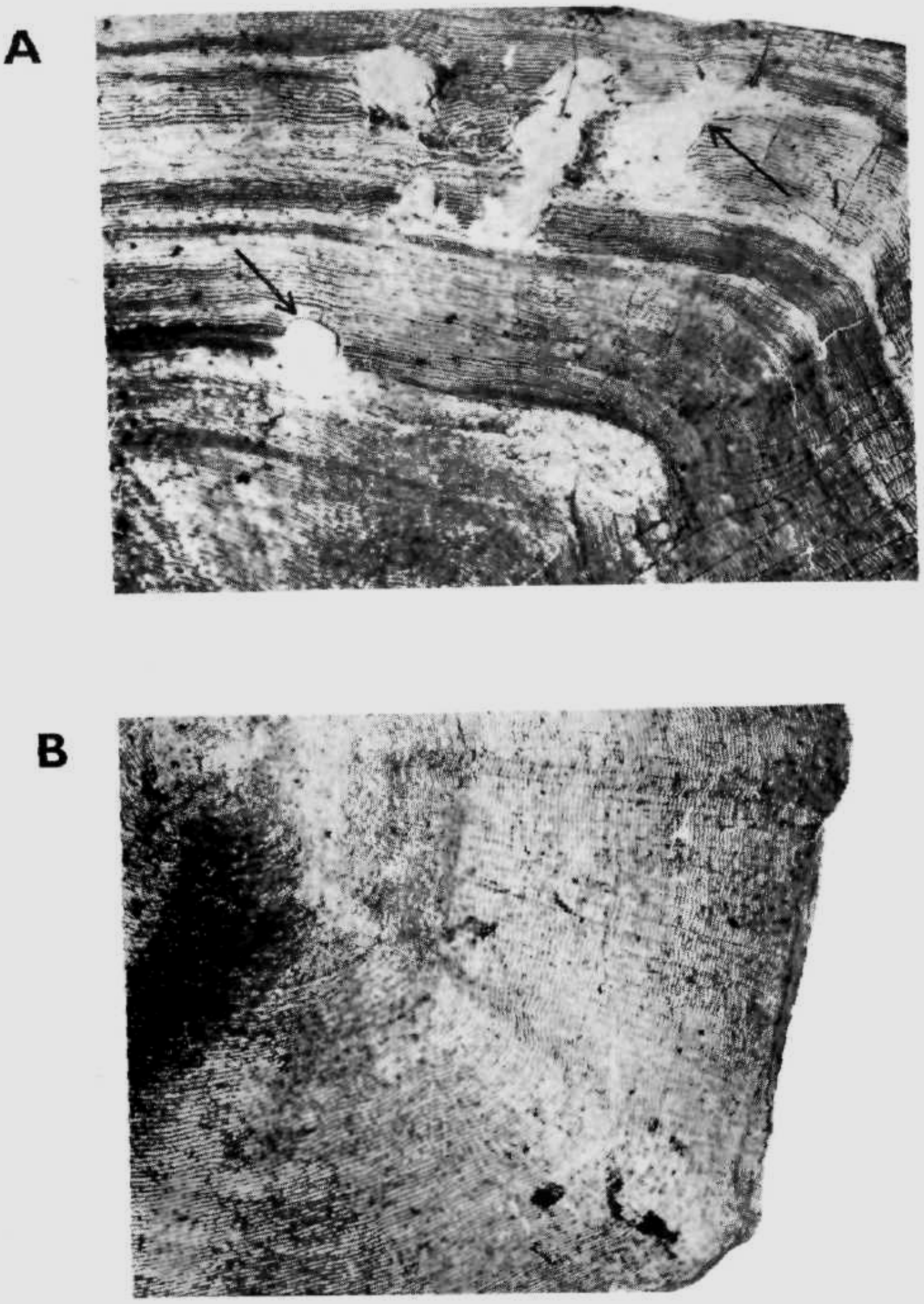
A) The scale of the common carp, *Cyprinus carpio*, the Gobindsagar reservoir, 30. 5. 1980, TL=700, SL=570 mm, weigth 6000 g, female, age 7+, the view on the scale centre, above caudal, below the oral sector of the scale. Very numerous radial canals are apparent in the oral part, the bent-up radial canals penetrate into the caudal scale sector. This density of radial canals and such bendings was not observed in the central European common carp. The scale surface broken on many places, which again was not observed in several hundreds of scales of the central European common carp studied.
B) Scale of the common carp, the Gobindsagar reservoir, 11. 9. 1980. TL=740, SL==600 mm, weigth 6600 g, sex unknown, age 4+; the whole shape of the scale is rounded, almost circular, such shape is not known again in the so called "representative" common carp scales in central Europe.

Johal M. S., Novák J., Oliva O.: Notes on the growth of the common carp (*Cyprinus carpio*) in northern India and in central Europe



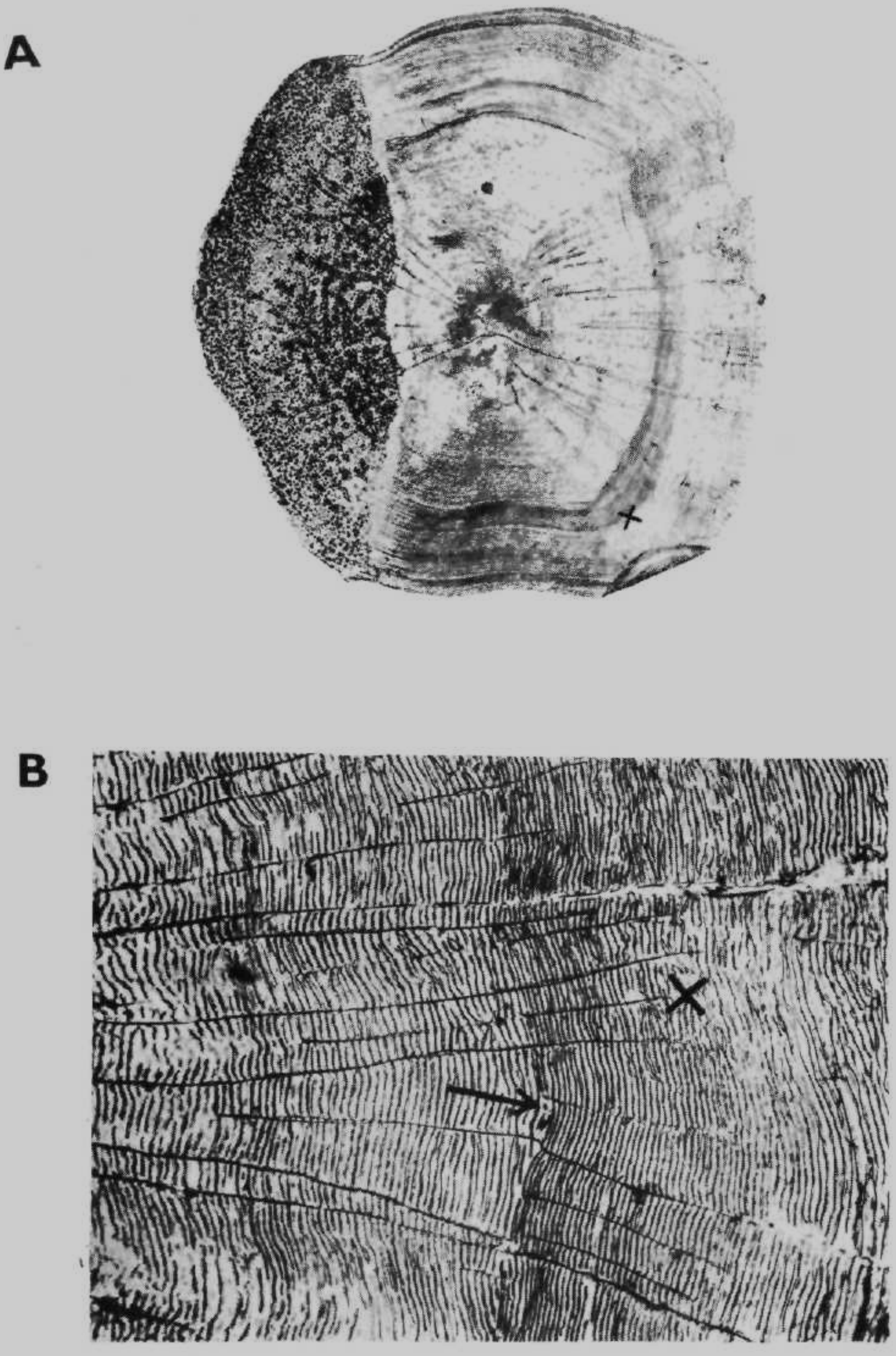
A) The scale of the common carp, Nangal lake, 21. 12. 1978, TL=620, SL=510 mm, weight and sex unknown, age 2+, the surface of the scale shows many errosions (arrow!) in the centre and in the oral part. Annuli marked with cross (x).
B) The sector of the same scale, detail of the scale margin in the dorsal part of the oral sector towards the diagonal lobe. The interesting oblique course of circuli right below on the photo is not identified with the annulus.
C) The margin of the scale *(oral sector)* of the common carp from the Ghagar river, *16. 2. 1979, TL=830, SL=690 mm, 10 000 g, 7 annuli, age 8, sex unknown,* the scale is broken on the upper oral lobe, the course of circuli is different behind the break (fracture).

Johal M. S., Novák J., Oliva O.: Notes on the growth of the common carp (Cyprinus carpio) in northern India and in central Europe

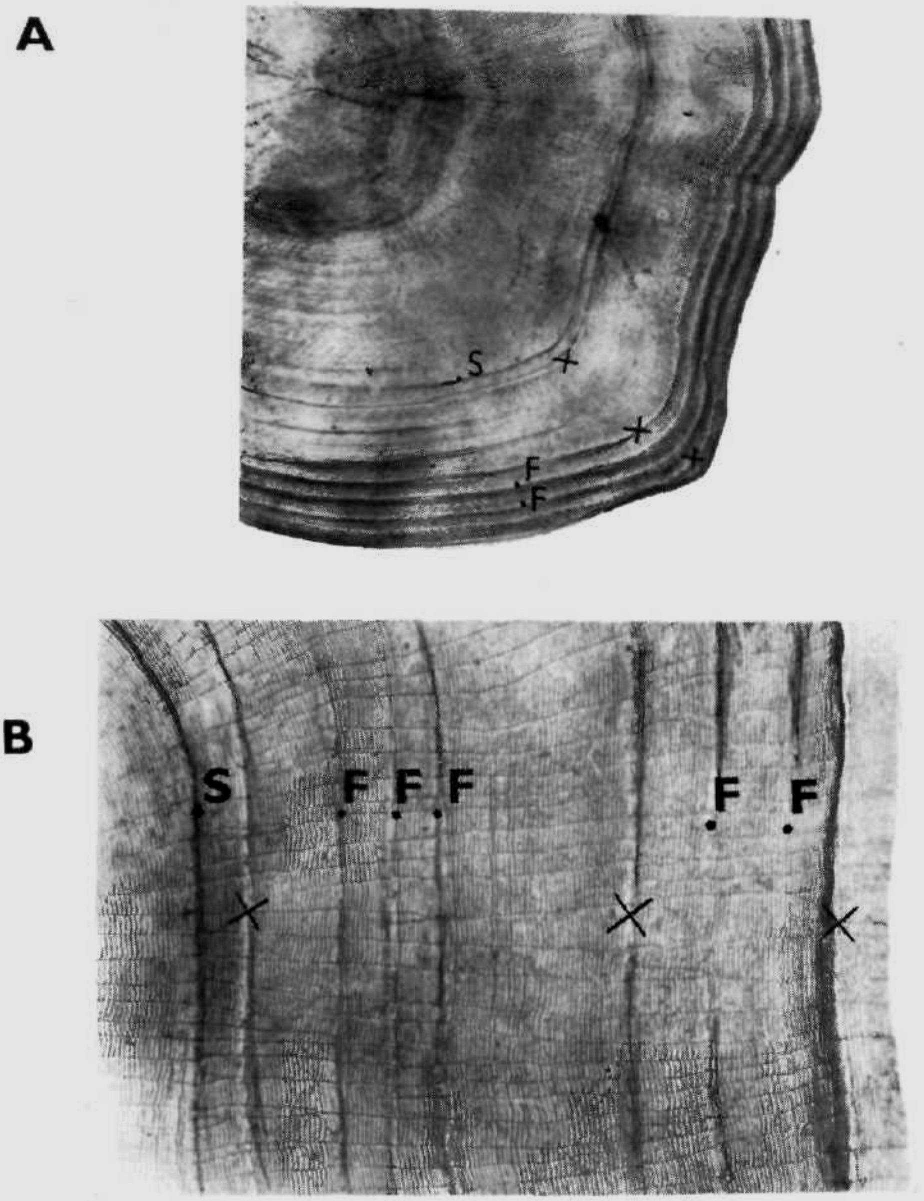


A) The scale of the common carp from Nangal Lake, 10. 9. 1980, TL=570, SL==450 mm, weight 2000 g, sex unknown, age 2+, a partial view on the lower *sector* of the oral part of the scale;errosions interrupting the course of circlli are *evident* (*marked* with arrows). Similar phenomena were not observed in the central *European* carp.

B) The scale of the common carp from Nangal Lake, 11. 9. 1980, TL=280, SL=220 mm.

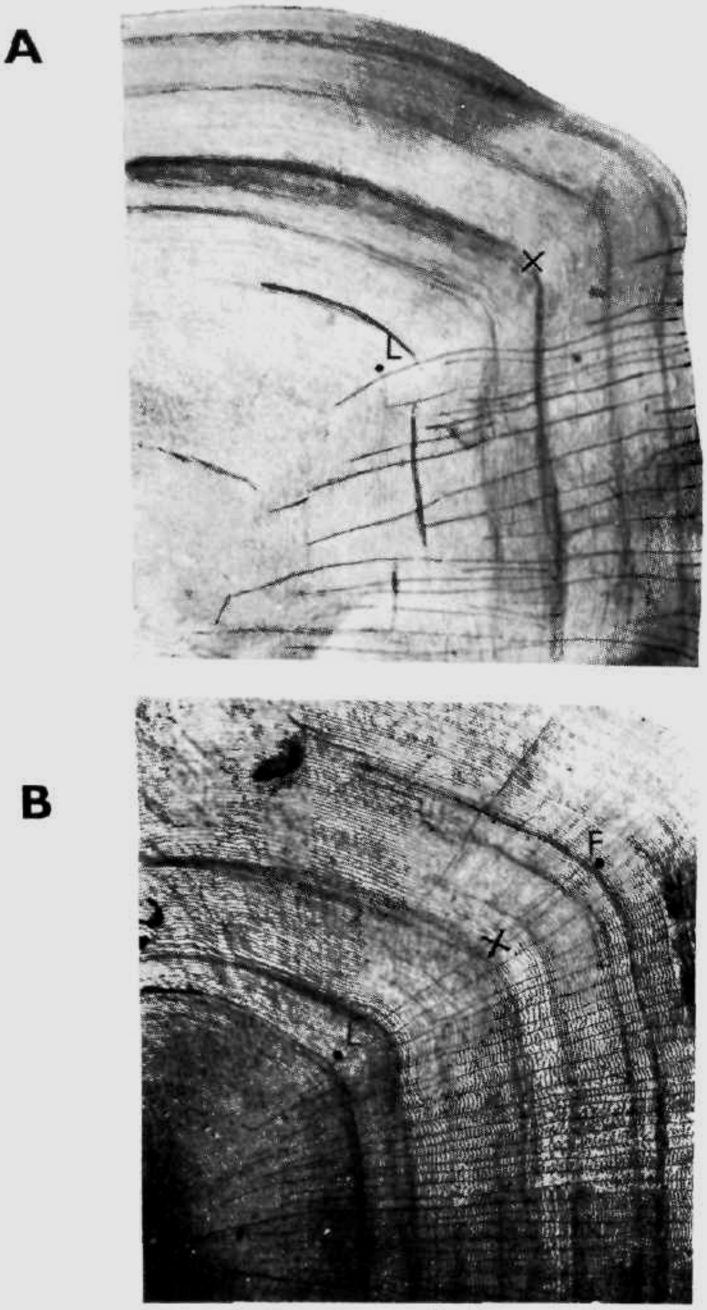


A) The scale of the common carp from Nangal Lake, 26. 9. 1979, TL=340, SL=280 mm, weight 600 g, sex unknown, age 1+, annulus marked with cross (x).
B) The part of the oral sector of the same scale. Note the typical annulus, which



A) The scale of the common carp from the Gobindsagar reservoir, 30. 5. 1980, TL=630, SL=500 mm, sex and weight unknown, age 3+; annuli marked with cross (x), between the false annuli are visible (F); S=pressumed spawning mark.
B) The *same* scale, a *sector of the oral part, the legend the same as* above, some false annuli (F) are probably identical with spawning marks.

Johal M. S., Novák J., Oliva O.: Notes on the growth of the common carp (Cyprinus carpio) in northern India and in central Europe



A) The scale of the common carp from Nangal Lake, 30. 5. 1980, TL=390, SL=290 mm, weight and sex unknown ,the second annulus newly formed at the scale margin (diagonal lobe), with "L" probable locations of the larval annulus are marked
B) The scale of the common carp from the Gobindsagar reservoir, 11. 9. 1980, TL=380, SL=300 mm, weight 900 g, age 1+. L=larval annulus, x=true annulus. F=false annulus.

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