VĚSTNÍK

ČESKOSLOVENSKÉ SPOLEČNOSTI

ZOOLOGICKÉ

LI

1987

2

ACADEMIA PRAHA

ISSN 0042—6595

Kčs 10,— 47 678

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ
ročník LI

Vydává Čs. společnost zoologická, Viničná 7, 128 44 Praha 2, v Academii, nakladatelství ČSAV, Vodičkova 40, 112 29 Praha 1. Tisknou Tiskařské závody, n. p. závod 5, Sámova 12, 101 46 Praha 10. — Rozšiřuje PNS. Informace o předplatném podá a objednávky přijímá každá administrace PNS, pošta, doručovatel a PNS-ÚED Praha. Objednávky do zahraničí vyřizuje PNS-ústřední expedice a dovoz tisku Praha, závod 01, administrace vývozu tisku, Kafkova 19, 160 00 Praha 6. Cena jednoho výtisku Kčs 10,—, roční předplatné (4 čísla ročně) Kčs 40,—. (Tyto ceny jsou platné pouze pro Československo).

Distribution rights in the western countries: Kubon & Sagner, P. O. Box 34 01 08 D-8000 München 34, GFR. Annual subscription: Vol. 51, 1987, (4 issues, DM 110,—).

This number issued on May 20, 1987

VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ

Roč. Tom. 51 Čís. No. 2 Květen Maius 1987

★

Bibliograficka zkratka názvu časopisu — *Věst čs. Společ. zool.*
Abbreviatio huius periodici bibliografica

OBSAH — CONTENTS

Věst. čs. Společ. zool., **51**: 81—84, 1987

Laboratory of Evolutionary Biology, Czechoslovak Academy of Sciences, Praha

THE H-ORGAN AND INNERVATION OF THE PROTHORACIC GLANDS IN GALLERIA MELLONELLA (LEPIDOPTERA, PYRALIDAE)

Samir ABOU-HALAWA

Received June 3, 1986

Abstract. A new survey of the innervation of the prothoracic glands in *G. mellonella* has been provided. The work indicates that the H-organ together with the first regular metameric perisympathetic nerve are the main sources of the neurosecretory material to supply the glands. The other somatic nerves from both the suboesophageal and prothoracic ganglia also innervate the prothoracic glands.

INTRODUCTION

Since the discovery of prothoracic gland (pg) by Fukuda (1944) intensive research in the anatomy, histology, ultrastructure and the physiological function of the gland has been made in almost all groups of insects (Fukuda, 1944; Novák, 1966; Sláma et al., 1974; Raabe, 1984). In that time when it was still viewed as a fairly firmly established fact that pg control moulting and metamorphosis in insects. Sláma (1983) stated that: "what we actually know about the physiological functions of pg is useless...". This seems to be also true in the preliminary morphological observations which were concerned with the innervation of the gland. As mentioned in a previous paper (Abou-Halawa and Sláma, 1986), most of the observations concerned with the problem either in *Galleria* (Sing and Sehnal, 1979) or in *Hyalophora* (Herman and Gilbert, 1966) were erroneous. Therefore, the present work brings a new scheme for the innervation of pg in the larvae of *Galleria mellonella*.

MATERIAL AND METHODS

Last instar larvae of *G. mellonella* were used in the moment when they started spinning (about 5 days after ecdysis). Without anaesthetization the thorax was dissected in paraffin — lined Petri-dish using insect Ringer. The alimentary canal with the adjacent dorsal organs (the fat bodies, trachea, salivary and silk glands with their ducts, muscles...etc.) were removed and the nervous system with its nerves to pg were exposed. The Ringer was poured out and the choosen structures were stained with 1% methylene blue in saline. Fixation with ammonium molybdenate for about 20 minutes during which the solution was changed three times. The drawings were made in situ and for detailed studies the whole organs were carefully transferred to a slide. Dehydration in ascending alcohol concentrations, clearing and mounting in Canada balsam were carried out as the normal procedure. Some specimens, however, were dissected in Ringer and put directly on the slide where they were fixed with methanol and stained with some vital stains as Giemsa, neutral red or with specific stains as azocarmine and paraldehyde-fuchsin according to Pflugfelder (1958) and Panov (1980).

RESULTS

The pg in the larvae of *Galleria* consist each of three branches; the proximal branch represents the longest one and appeares directed towards the head, the ventral one lies almost on the tracheal trunk with its apical part attached ventrally to the muscles. The last branch, as the previous one, lies also on the tracheal trunk but its distal part is attached dorsally to the body wall. For this reason it has been named as a dorsal branch. However, the last two branches (i. e. the ventral and dorsal ones) appear as inner and outer respectively after the dissection and spreading the dorsal body wall at both sides (Fig. 1).

The distal end of the proximal branch receives from its dorsal side two nerves. The first is a branch from the cervical nerve of suboesophageal ganglion (SG). This nerve (p1) appears free from neurosecretory (ns-) granules (Figs. 1 & 2). The second nerve, however, contains always ns-material and comes from the anterior arm of the H-organ (Ha). This nerve (p2) stains positively with azocarmine as well as with all other stains mentioned above. Furthermore, this nerve opens directly in the pg cells (Fig. 2b), and the ns-granules could be seen poured in the gland.

The third nerve which innervates this region (i. e. the most anterior part of the proximal branch), but from its ventral side, is a branch from the lateral nerve of prothoracic ganglion (T_1G). This nerve (1nP), as the cervical one, has little affinity for the various stains used. This is always clear particularly at its ends which are attached to the pg. However, at its base with the T_1G and in the area where the posterior arm of H-organ (Hp) passes over it, a few ns-granules could be always seen. This nerve (1nP) is further innervating the mid-region of the proximal branch by (P4) nerve (Fig. 1).

The last nerve (P5) goes to the distal regions of the ventral and dorsal pg branches. This nerve resulted from the union between the Hp and the transverse nerve of the first metameric perisympathetic nerve (PO1 in Fig. 1). These nerves are stained always with the specific azocarmine stains and contain axonal path-ways for the ns-material.

DISCUSSION

The present work, as well as the schemes described by other authors (Herman and Gilbert, 1966; Srivastava et al., 1977; Sing and Sehnal, 1979), indicate that the pg is innervated by at least 5 nerves. Anatomically, these nerves are of two types; the first are those which originate from the perisympathetic neurohaemal organs (Raabe, 1984) and, the second come directly from the ganglia or from their connectives. The question which arises now is: Which of the nerves were investigated in the ultrastructure studies of Benedeczky et al., (1980) on the innervation of pg in *Galleria*? In their studies, they demonstrated the presence of peptidergic granules of 100 — 300 nm. In such a case, it seems possible that this work was done in the area of perisympathetic nerves. The view which is supported by the intensive work of Raabe (1965, 1984) and many others and is further supported by the present anatomical observations and the histological ones (Abou-Halawa, 1987).

It was mentioned in the result section that the proximal of pg is innervated at its distal end by a branch from the Ha. This nerve has been named by Sing and Sehnal (1979) "the *nervus prothoracalis anterior*" which originates from the connectives between SG and T_1G. Indeed, this nerve as we pointed out

before (Abou-Halawa and Sláma, 1986) does not exist in the larvae of *Galleria*. Furthermore, this nerve does not exist, even in the other side of their scheme represented in Fig. (1). Therefore, it seems possible that such type of work appears to be rather theoretical because, on one hand the authors were able to observe the nerves to pg without detecting their neurones. And, on the other hand, they could see (with the same technique) other neurones with their fine axons inside the ganglia.

Concerning the nomenclature of the different nerves entering pg, it was rather difficult to follow that which was given by Sing and Sehnal (1979). Therefore, it was decided to use the same system as Srivastava et al., (1977) by giving numbers of these nerves which, the present author believes, it will be easier for further studies (either anatomical, histological, ultrastructure or even physiological) concerning the pg.

Acknowledgements

I am greatly indebted to Professor V. J. A. Novák for his valuable help and critical reviewing the manuscript. My sincere thanks are also due to Dr. B. Bennetová for providing laboratory facilities and useful discussions. Finally, I am greatful to the authorities of UNESCO in Czechoslovakia and the University of Assiut, Egypt for facilitating and sponsoring of the work.

REFERENCES

Abou-Halawa, S., 1987: Detailed morphological studies on the H-organ in the larvae of Galleria mellonella (Pyralidae, Lepidoptera) I. The anatomy of the organ. II. The histological structure of the organ. *Věst. čs. Společ. zool.* (in print).

Abou-Halawa, S. and Sláma K., 1986: *An overlooked neurohaemal organ in* the prothorax of Lepidoptera. *Acta ent. Bohemoslov.*, 83: 241—252.

Benedeczky, I., Malá, J. & Sehnal, F., 1980: Ultrastructure study on the innervation of prothoracic glands in Galleria mellonella. *Gen. Comp. Endocrinol.*, 41: 400—407.

Fukuda, S., 1944: The hormonal mechanism of larval moulting and metamorphosis in the silk worm. *J. Fac. Sci. Tokyo Univ.*, 6: 477—537.

Herman, W. S. and Gilbert, L. I., 1966: The neuroendocrine system of Hyalophora cecropia (L.) (Lepidoptera: Saturniidae). *Gen. Comp. Endocrinol.*, 7: 275—291.

Novák, V. J. A., 1966: Insect Hormones. Methuen & Co., London.

Panov, A. A., 1980: Demonstration of neurosecretory cells in insect central nervous system. In: N. J. Strausfeld & T. A. Miller (ed.) Neuroanatomical techniques. Springer, New York, pp 26—51.

Pflugfelder, O., 1958: Entwicklungsphysiologie der Insecten. Akad. Verlangsgeseilsch. Geest & Portig, Leipzig.

Provansal, A., 1972: Les organes périsympathiques des Lépidoptères. *C. R. Acad. Sc. Paris*, 274: 97—100.

Raabe, M., 1965: Etude des phénomènes de neurosécrétion au niveau de la chaine nervause Ventrale des Phasmides. *Bull. Soc. Zool. France, 90*: 631—654.

Raabe, M., 1984: The Neurosecretory — neurohaemal system of insects: anatomical, structure and physiological data. *Adv. Insect Physiol.*, 17: 205—303.

Sing, H. H. & Sehnal, F., 1979: Lack of specific neurons in the ventral nerve cord for the control of prothoracic glands. *Experientia*, 35: 1117—1119.

Sláma, K., 1983: Illusive functions of the prothoracic gland in Galleria. *Acta ent. bohemoslov.*, 80: 161—176.

Sláma, K., Romaňuk, M. & Šarm, F., 1974: Insect Hormones and Bioanaloques. Springer, Wien, New York.

Srivastava, K. P., Tiwari, R. K. & Kumar, P., 1977: Effect of sectioning the prothoracic gland nerves in the larva of the Lemon — butterfly Papilio demoleus L. *Experientia*, 33: 98—99.

Strausfeld, N. J., 1983: *Functional Neuroanatomy*, Springer Series in Experimental Entomology, New York, Tokyo.

Wigglesworth, V. B., 1970: Insect Hormones. Oliver & Boyd. Edenburg.
Williams, C. M., 1952: Physiology of insect diapause. IV. The brain and prothoracic glands as an endocrine system in the cecropis silkworm. *Biol. Bull.*, **103**, 120—138.

The figures 1 and 2 will be found at the end of this issue.

Author's address: Department of Zoology, Faculty of Science, University of Assiut, Egypt.

Věst. čs. Společ. zool., **51**: 85—88, 1987
ISSN 0042—6595

Institute of Entomology, Czechoslovak Academy of Sciences, České Budějovice[1])

DIAPAUSE INDUCTION AND TERMINATION IN A POPULATION OF DOLYCORIS BACCARUM (HETEROPTERA, PENTATOMOIDEA) FROM CENTRAL BOHEMIA

Zadran Habibullah BABRAKZAI and Ivo HODEK

Received March 10, 1986

Abstract. A strain of *Dolycoris baccarum* (L.) from Prague shows a homogeneous response to constant photoperiod. At 25 ± 2 °C, long daylengths (20 L : 4 D) averted diapause while short daylengths (12 L : 12 D) induced diapause within 2 weeks in all females. A back transfer of diapausing adults at age of 11—15 wks from short days to long days terminated diapause after a variable exposure to long days, with the median of 51 days. The presence of reproductively active males seems to enhance the resumption of morphogenesis in females.

INTRODUCTION

Dolycoris baccarum (L.) shows a recurrent photoperiodic response: post-diapause females collected in cereal fields in mid-May discontinued oviposition after about 3 weeks at 12 L : 12 D and 25° C, while at 18 L : 6 D and 25° C control females laid until death (Hodek, 1977). The Czech population of *D. baccarum* thus appears to be photoperiodically responsive, similarly to the Krasnodar populations from the U.S.S.R. (Perepelitsa, 1969). However, Conradi-Larsen and Sømme (1978) could not achieve contrasting results by constant short-day and long-day regimens in populations from southern Norway: at 21°, the insects entered diapause (the authors term it "arrest of oogenesis for more than 80 d in non-diapausing females") under both short days and long days. We therefore checked the role of photoperiod as a diapause-inducing and terminating cue, in a Czech population of *D. baccarum* as our former results concerned the post-diapause photoperiodic response.

MATERIAL AND METHODS

An overwintered female (P-generation) was collected in a Prague suburb in June 1984. All experiments were made with the offspring of this female, i. e. with the F_1-generation. Larvae and adults of *D. baccarum* were reared on seedlings of wheat and shelled sunflower seeds by a method used for *Aelia acuminata* L. and described in detail elsewhere (Hodek & Honěk, 1970). As the adults were kept in groups in the first experiments, only minimum or maximum values are given; 35 isolated pairs were used for the last experiment. Laboratory photoperiod and temperature were kept constant (short daylength — SD = 12 L : 12 D, long daylength — LD = 20 L : 4 D, temperature = 25° ± 2° C). The age of diapausing females at the time of transfer from SD to LD was affected by technical constraints; 8 weeks would have been more adequate.

1) The experiments were undertaken during a post-graduate stay of the first author at the Institute of Entomology, Prague

RESULTS

Oviposition after diapause

The collected female (P-generation) was reared under LD and the egg-laying was recorded for 6 weeks, till mid-August. The oviposition rate was quite high: 12 eggs per female per day. The long daylength enabled steady reproductive activity of the post-diapause female in the same way as in the control series of a previous experiment (Hodek, 1977).

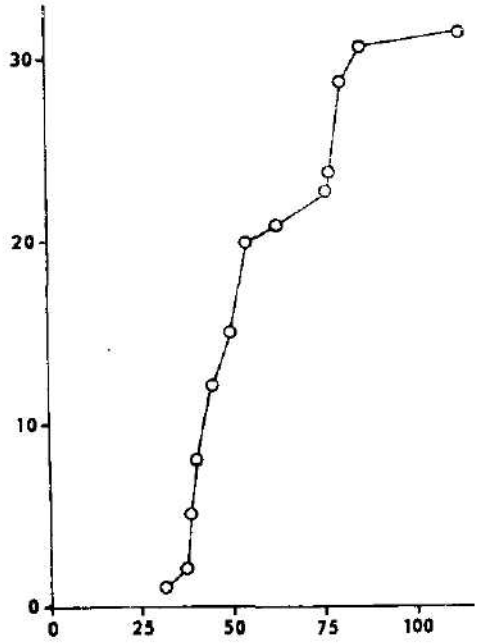


Fig. 1. Resumption of oviposition at 20 L : 4 D after 11 weeks at 12 L : 12 D (25 ± 2° C, n = 35).
Horizontally: duration of photoperiodic activation (days); vertically: cumulative incidence of ovipositing females (number).

Non-diapause development at constant LD

Both the larvae and adults of F_1-generation were reared under LD. The females began ovipositing early, after 9—11 days. The short pre-oviposition period indicated that constant 20 L : 4 D prevented diapause in our strain of *D. baccarum* at 25° C.

Diapause induction in ovipositing females

Four groups of adults were transferred to SD at different ages (Table 1). In three groups of older adults (A, B, C) the females continued to lay eggs under SD for at most 12—14 days. In the D group of the youngest females which did not start laying eggs under LD, only a very low proportion of females oviposited under SD, as is shown by the very low oviposition rate. Evidently only the oldest individual(s) of this group oviposited, in which repro-

Table 1. Effect of change from LD to SD on *Dolycoris baccarum* females of various age[1])

Group	Age at transfer (days)	n	Minimum duration of pre-oviposition period (days)		Maximum duration of oviposition period[2]) (days)	Oviposition rate eggs/female/day)
			LD	SD		
A	28—33	35	9		12	3.5
B	21—28	41	11		12	2.3
C	7—21	34	11		14	2.5
D	0—10	35		17	3	0.2

[1]) F_1-generation reared at 25 ± 2 °C and 20L : 4D, transferred to 12L : 12D
[2]) after the transfer to SD (A, B, C); after the oviposition onset (D)

duction was induced by the previous exposure to LD. In all females the transfer to SD inhibited oviposition within 2 weeks.

Transfer of old diapausing adults from SD to LD

The F_1 adults used in the previous experiment were kept under SD and 25° for 11 wks. No eggs were laid during that period. They were then transferred to LD at the age of 11—15 weeks (early November) and isolated into 35 pairs. In majority of pairs (30) the females laid eggs, after a delay ranging from 31 to 107 days, with the median of 51 days (Fig. 1).

Sometimes the delay in oviposition was apparently caused by the condition of the male. In several cases the female started to oviposit when the male in the couple had died and was replaced by another.

DISCUSSION

The preliminary laboratory experiments on diapause induction and termination made with one strain of the Czech population of *D. baccarum* indicate that a facultative diapause is involved, regulated mainly by photoperiod. Our strain responded homogeneously to the photoperiods used: constant 20 L : 4 D prevented diapause and terminated it, while constant 12 L : 12 D induced diapause in all females.

In the homogeneity of response, *D. baccarum* resembles e. g. *Pyrrhocoris apterus* L. (Hodek, 1971) but not another common species of the superfamily Pentatomoidea, *Aelia acuminata* L., occuring together with *D. baccarum* on cereal crops for a part of the season (Hodek, 1979).

The photoperiodic response of Czech populations of *D. baccarum* seems to be similar to populations from Krasnodar also in the regulation of diapause onset (Perepelitsa, 1969). In Israel, the annual cycle of *D. baccarum* is unknown (Yathom, 1980).

The Norwegian populations might enter the diapause "obligatorily". Alternatively, failure of Conradi-Larsen and Sømme (1978) to prevent a facultative diapause in populations from southern Norway by LD may be due to a relatively short "long" photophase used (16 L : 8 D) and to the low temperature of 21° C. The critical photoperiod and the effect of temperature on it

have still to be ascertained. There was also difference in food, our feeding conditions (without honey solution and yeast extract) being much poorer. It cannot be a priori excluded that food rich in glycids may represent one factor enhancing diapause induction also in *D. baccarum* similarly to *Anthonomus grandis* Boh. (Earle, Newsom, 1964; Tingle, Lloyd, 1969), *Leptinotarsa decemlineata* Say (de Wilde, Ferket, 1967) or some coccinellids (Hagen, 1962; Iperti, Hodek, 1974). In the climate of Bohemia, the increase in the content of glycids in cereals coincides with the period of diapause induction in *D. baccarum*.

Our observation that the pre-oviposition period was longer in some females due to a supposed reproductive inactivity of males is not unique. Action of this factor was experimentally proved in two lygaeid heteropterans, *Lygaeus equestris* (L.) (Sillén-Tullberg, 1984) and *Oncopeltus fasciatus* (Dallas) (Hayes, Dingle, 1983).

REFERENCES

Conradi-Larsen, E.-M., Sømme, L., 1978: The effect of photoperiod and temperature on imaginal diapause in Dolycoris baccarum from southern Norway. *J. Insect Physiol.*, 24: 243–249.

Earle, N. W., Newsom, L. D., 1964: Initiation of diapause in the boll weevil. *J. Insect Physiol.*, 10: 131–139.

Hagen, K. S., 1962: Biology and ecology of predaceous Coccinellidae. *Annu. Rev. Entomol.*, 7: 289–326.

Hayes, J. L., Dingle, H., 1983: Male influence on the duration of reproductive diapause in the large milkweed bug, Oncopeltus fasciatus. *Physiol. Entomol.*, 8: 251–256.

Hodek, I., 1971: Termination of adult diapause in Pyrrhocoris apterus (Heteroptera: Pyrrhocoridae) in the field. *Entomol. Exp. Appl.*, 14: 212–222.

Hodek, I., 1977: Photoperiodic response in spring in three Pentatomoidea (Heteroptera). *Acta Entomol. Bohemoslov.*, 74: 209–218.

Hodek, I., 1979: Intermittent character of adult diapause in Aelia acuminata (Heteroptera). *J. Insect Physiol.*, 25: 867–871.

Hodek, I., Honěk, A., 1970: Incidence of diapause in Aelia acuminata (L.) populations from southwest Slovakia (Heteroptera). *Věst. Čs. Společ. Zool.*, 34: 170–183.

Iperti, G., Hodek, I., 1974: Induction alimentaire de la dormance imaginale chez Semiadalia undecimnotata Schn. *Ann. Zool. – Écol. Anim.*, 6: 41–51.

Perepelitsa, L. V., 1969: The breeding of Dolycoris baccarum in the laboratory. *Zool. Zh.*, 48: 757–759. (In Russian.)

Sillén-Tullberg, B., 1984: Copulation as a determinant of non-diapause development in female Lygaeus equestris. *Entomol. Exp. Appl.*, 36: 261–264.

Tingle, F. C., Lloyd, E. P., 1969: Influence of temperature and diet on attainment of firm diapause in the boll weevil. *J. Econ. Entomol.*, 62: 596–599.

de Wilde, J., Ferket, P., 1967: The host-plant as a source of seasonal information. *Meded. Rijksfac. Landbwet. Gent*, 32: 387–392.

Yathom, S., 1980: An outbreak of Dolycoris baccarum L. (Heteroptera: Pentatomidae) on sunflower in Israel. *Israel J. Entomol.*, 14: 25–28.

Authors' address: Z. H. Babrakzai, RNDr. I. Hodek, CSc., Entomologický ústav ČSAV, Branišovská 31, 370 05 České Budějovice, Czechoslovakia.

Věst. čs. Společ. zool., **51**: 89—96, 1987
ISSN 0042—6595

Czechoslovak Academy of Sciences, Institute of Landscape Ecology,
České Budějovice

DESCRIPTION OF LARVAE OF STAPHYLINUS SIBIRICUS, OCYPUS ITALICUS AND OCYPUS FUSCOAENEUS (COLEOPTERA, STAPHYLINIDAE)

Jaroslav BOHÁČ

Received March 13, 1986

Abstract. Detailed descriptions are given for larvae of *Staphylinus sibiricus* Gebler, *Ocypus italicus* Aragona and *Ocypus fuscoaeneus* Solsky. The egg has been described for *Staphylinus sibiricus* Gebl., and the pupa for *Ocypus italicus* Arag. The duration of the development of individual stages of species is assessed and the relation of developmental type with relation to other close species is discussed. The subgenus *Dinothenarus* Thoms. belongs from the taxonomical point of view to the genus *Staphylinus* L.

The knowledge of developmental stages and bionomics of staphylinids of the genera *Abemus* Muls. & Rey, *Staphylinus* L. and *Ocypus* Sam. is very poor with the exception of Europe and N. America. Nothing is known about the ontogenesis of species of this genera from the Mediterranean region, the Middle East, Central Asia and Siberia. At the same time the knowledge of the developmental stages and bionomy of staphylinids from these regions can facilitate the setting up of a natural system of this group and the knowledge of the developmental types of staphylinids.

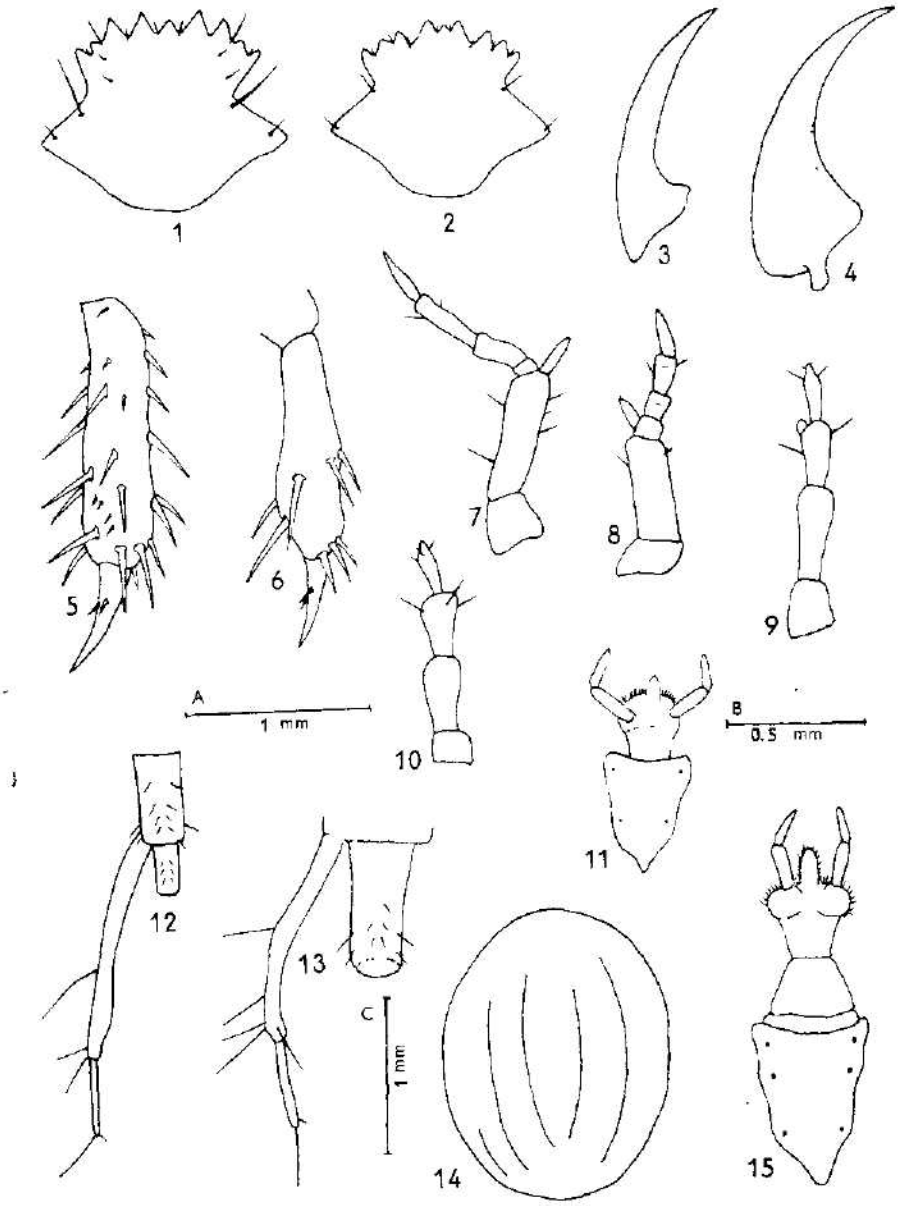
During my excursions to Italy and Central Asia I collected breeding pairs and larvae of staphylinids and I reared them in the stock. The method of rearing is described by Boháč (1982). The larvae of three species, which were unknown, are described in this paper.

Staphylinus (Dinothenarus) sibiricus Gebler, 1830

Materials: 15 eggs, 15 L I, 1 L II, 2 exuviae L I. Larvae were obtained by breeding in our stock, cultural pairs from the USSR (Tajikistan, Hissar Mts., Takob, 3000 m).

Description of the larva

L II. Head: Quadrate, length to width 1.1 : 1, slightly narrowed toward neck, temporal corners rather conspicuous. Nasale (Fig. 1) length to width 1 : 1.2. Nine teeth on anterior margin of nasale divided in one central and two marginal triplets. Middle tooth smallest, flanking most conspicuous, as long as width at base. The similar situation by teeth of lateral triplets. Teeth of lateral triplets less marked. Setae between teeth, longest seta between third and second lateral tooth. Two additional setae below third and second lateral tooth, third seta below articulation of antennae, a fourth at broadest part of nasale. Epicranial sulcus 1.5 times as long as nasale. Antennae (Fig. 9) short,



Figs. 1 — 15. *Staphylinus sibiricus:* 1 — nasale L II, 2 — nasale L I, 3 — mandible L I, 4 — mandible L II, 5 — anterior tibiotarsus L II, 6 — anterior tibiotarsus L I, 7 — maxilla L II, 8 — maxilla L I, 9 — antenna L II, 10 — antenna L I, 11 — submentum, praementum and labial palp L I, 12 — abdominal segments 9 and 10, and urogomphi L I, 13 — abdominal segment 9 and urogomphi L II, 14 — egg, 15 — submentum, praementum and labial palp L II. Scale a) for 5, 6, 12, b) for 1, 2, 3, 4, 7, 8, 9, 10, 11, 15, c) for 13, 14.

as long as mandible. Length ratio of atennal segments (I : II : III : IV) 1 : 1.7 : : 1.1 : 1. Antennal segment 3 with feebly developed appendage and setae, segment 4 with 3 long and 2 short setae. Segment 1 as long as broad. segment 2 2.6 times as long as broad, segment 3 twice as long as broad, segment 4 as broad as 1/3rd of width at base of segment 3. Mandible (Fig. 4) as long as epicranial sulcus, relatively broad at base and sharp at apex, slightly crooked. Maxilla (Fig. 7) with stipes 2.2 times as long as cardo. Cardo as long as wide. Stipes conical, mid-ways constricted, 3 times as long as wide, with 5 setae. Galea 2 times shorter than palpifer. Palpifer long, as long as 1/3rd of length of stipes. One seta each on galea and palpifer. Length ratio of individual segments of maxillary palps (I : II : III) 1 : 1.5 : 1.1. Submentum (Fig. 15) a triangle. Apex sharp. Slightly narrowed to 2/3rd its length, then sloping into apex, with ratio of length to width 1.6 : 1. Length ratio of labial palps (Fig. 15) (I : II) 1 : 0.8. Width of head capsule 1.40 mm.

Thorax: Length to width 1.4 : 1. Length ratio of pro-, meso- and metanotum 1.3 : 1 : 0.8. Legs with femur 1.4 times longer than tibiotarsus. Femur with 20 spines, tibiotarsus (Fig. 5) with 22 spines. Brush setae not developed. Claw with 2 spines. Trochanter with one long seta and with 5 spines.

Abdomen: Basal tergites 3 times as broad as long. Tergite 7 and 9 twice as broad as long, tergite 9 attenuating to apex. Tenth abdominal segment conical, 3 times as long as wide at base. 8 setae on ventral side in two rows. Urogomphi (Fig. 13) 2-segmented, with curved I segment. Length ratio of segment I : II 2.8 : 1, three setae on apex of segment I, two setae in mid-area, one long and one short apical setae on segment II.

Body length 14.2 mm. Head and mandible yellowish brown, thorax and abdominal tergites brownish yellow, mouthparts, legs and urogomphi pale yellow.

L I. Head: Length to width 1.1 : 1, its lateral margins more parallel running than by L II. Form of nasale (Fig. 2) similar as by L II. Antennae (Fig. 10) with length ratio of segments (I : II : III : IV) 1.3 : 1.3 : 1.1 : 1. II segment twice as long as wide, III segment 1.8 times as long as wide. Last segment 3 times longer than wide. Mandible (Fig. 3). Maxilla (Fig. 8) with stipes 2.8 times as long as cardo. Galea as long as I segment of maxillary palps. Palpifer twice as long as wide. Cardo and stipes wider than by L II. Length of maxillary palps (I : II : III) 0.5 : 0.7 : 1. Segments wider than by L II. Submentum (Fig. 11) as with L II. Length ratio of labial palp (Fig. 11) (I : II) 1 : 0.8. Width of head capsule (17 spec.) 1.41 mm (1.37—1.50 mm). Thorax: Length to width 1.6 : 1, length ratio of pro-, meso- and metanotum 3 : 1.3 : 0.7. Legs proportions as with L II. Femur with 12 spines, tibiotarsus (Fig. 6) with 8 spines. Trochanter with 1 seta and 4 spines.

Abdomen: Length to width of basal tergites 4 : 1. 8 segment 2.4 times as broad as long, 9 segment 1.7 times as broad as long. Tenth abdominal segment 2.5 times as long as broad with 6 setae in two rows on ventral side. Urogomphi (Fig. 12) 2 segmented. Length ratio of segments 2.2 : 1.1. I segment curved with 4 setae, II segment with 2 setae.

Body length 6.55 mm (15 spec.) (5.90—6.60 mm). Similar coloured as L II.

Egg. Ovoid, length 2.3 mm, width 1.8 mm (15 spec.), white. Chorion with long incorrect grooves along of length of egg (Fig. 14).

Bionomic notes

Geographical distribution of *Staphylinus sibiricus* Gebl.: Central Asia, Siberia (Coiffait, 1977). We know regrettably little of the bionomy of this species. It was found in mountainous areas (mainly 2,500—3,500 m), occasionally in 5,000 m (Pamir Mts.). It colonizes relatively wet habitats such watercourses, woods in valleys, grasslands. Here it is often found under stones, leaves, under various plant debris and in dung.

Copulations in the field and in our stock occurred from mid-April to early May.

Oviposition occurred from 27.—30. April. The optimal number of eggs laid by one female was 4. Females laid 2—3 eggs at the time in a depth of several cm.

We assessed the duration of the development of the individual stages of our stock under condition of a long day: egg — 5 days (3—6 days at the average temperature of 20 °C, 15 spec.), L I — 9 days (the average temperature 20 °C, 1 spec.).

Our stock consisted of 17 pairs. Egg mortality was 13 %.

Remarks

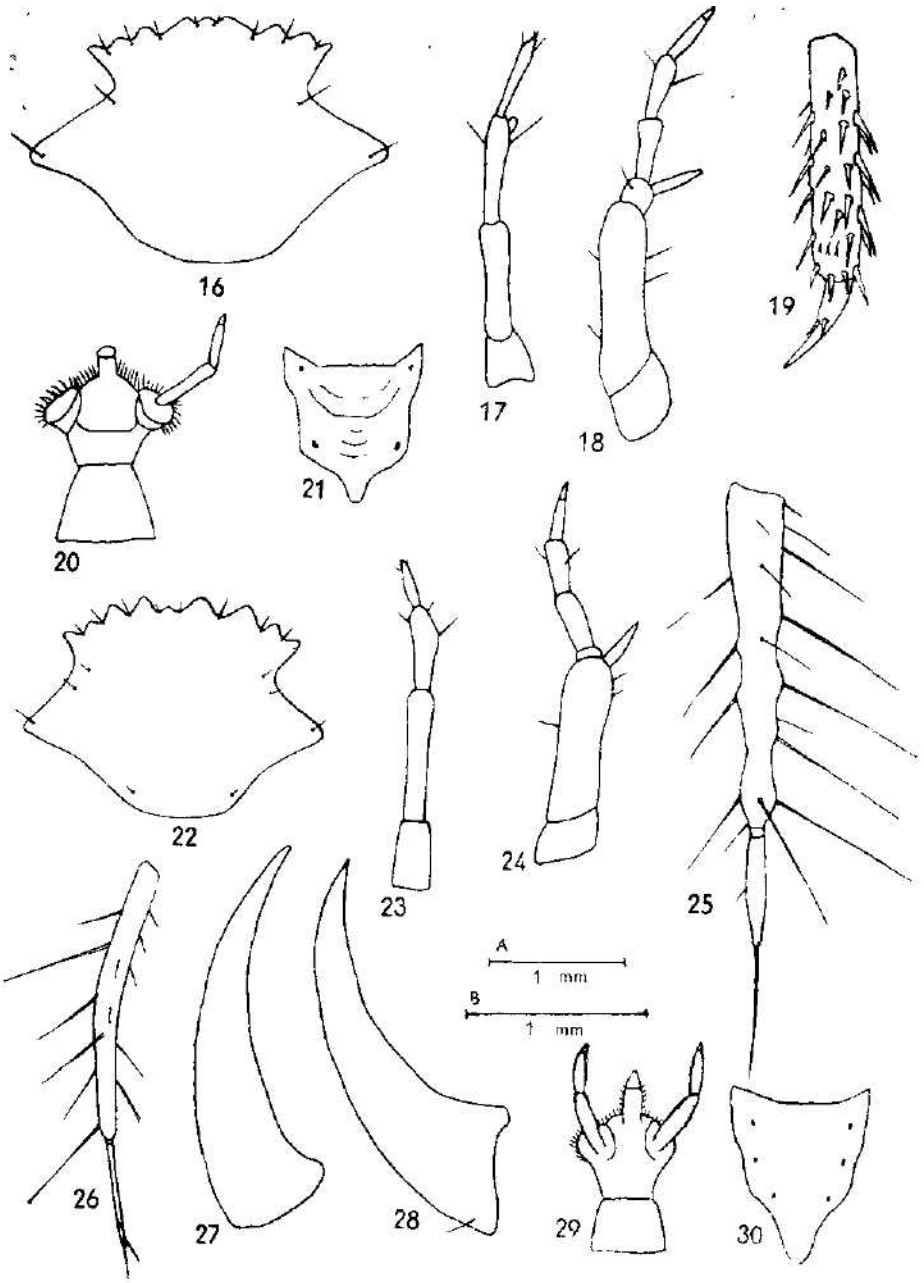
Staphylinus sibiricus Gebl. belongs to the subgenus *Dinothenarus* Thoms. The larva of *Staphylinus pubescens* De Geer was described by Paulian (1941) from this subgenus. This description differs from our reared larva of *S. sibiricus* Gebl. by small teeth in middle triplet of nasale (Paulian's larva has central tooth bigger than marginal teeth), shorter antennae, thicker maxilla, shorter I segment of labial palps, absence of brush setae on anterior tibiotarsus, 2-segmented urogomphi (3-segmented urogomphi by Paulian's larva). Our described larva is closely related to the larva of *Staphylinus (Parabemus) fossor* Scop. It is similar in the form of nasale and legs. It differs from the larva of *S. fossor* Scop. by thinner legs, shorter and wider maxillary and labial palps, curved I segment of urogomphi, slender mandible and wider submentum. Larvae of the subgenus *Staphylinus* s. str. remind of our larva with sharp mandible, long antennae and curved I segment of urogomphi. Our larva differs from them by sharp teeth on anterior margin of nasale (by species of the subgenus *Staphylinus* s. str. are teeth dull) and by shorter antennae and maxilla. Our results of the study in the morphology of the larva of *Staphylinus sibiricus* Gebl. suggests the subgenus *Dinothenarus* Thoms. to be retained as the independent subgenus of the genus *Staphylinus* L. as in Smetana (1958).

Ocypus (*Ocypus* s. str.) *italicus* Aragona, 1830

Materials: 1 exuvia L III, 1 fragment of pupa; larva from N. Italy (Bergamo) was reared to the adult stage.

Description of the larva

L III. Head: Length to width 1.7 : 1, quadrate, temporal corners rounded. Surface with poor microsculpture. Nasale (Fig. 16) length to width 0.7 : 1. Anterior margin with 9 teeth, one triplet in the middle, two at the margins. Middle tooth of mid-triplet inconspicuous, two flanking teeth bigger. Teeth of marginal triplets conspicuous, not blunk, as long as broad. Length ratio of nasale to epicranial sulcus 8.0 : 1. Antennae (Fig. 17) slender, half as long as head capsule. Length ratio of antennal segments (I : II : III : IV) 1 : 2.3 : 1.8



Figs. 16 — 21. *Ocypus italicus* L III: 16 — nasale, 17 — antenna, 18 — maxilla, 19 — anterior tibiotarsus, 20 — praementum and labial palp, 21 — submentum. Figs. 22 — 24. *Ocypus fuscoaeneus* L III: 22 — nasale, 23 — antenna, 24 — maxilla. Fig. 25. *Ocypus italicus* — urogomphi L III. Figs. 26 — 27. *Ocypus fuscoaeneus* L III: 26 — urogomphi, 27 — mandible. Fig. 28. *Ocypus italicus* — mandible L III. Figs. 29—30. *Ocypus fuscoaeneus* L III: 29 — praementum and labial palp, 30 — submentum. Scale a) for 19, 25, 26, b) for remaining.

: 1.1. Second segment 4 times as long as broad at apex, third segment dilated below apex, with 3 setae and one sensory appendage. Fourth segment with 3 long and 2 short setae. Mandible (Fig. 28) stout, 3.7 times as long as wide at base. Apex sharp. Maxilla (Fig. 18) with length ratio of cardo and stipes 1 : 1.3. Stipes 4 times as long as broad at base. Galea as long as cardo. Palpifer as long as half of segment I of maxillary palp. Length ratio of segments of maxillary palps (I : II : III : IV) 1 : 1.2 : 0.9 : 0.2. Two setae on third segment. Ratio of length to width of submentum (Fig. 21) 05 : 1. Submentum almost parallel-sided, with shallow indentation from 2/3rd of its length, sharply sloping toward apex. Apex rounded. Surface with waves shaped impressions. Labial palp (Fig. 20) with length ratio of segments (I : II : III) 8 : 5 : 1 Width of head capsule 3.5 mm (1 spec.).

Thorax: Twice as long as wide. Length ratio of pro-, meso- and metanotum 2.2 : 1 : 1. Length of coxa, femur and tibiotarsus by all pair of legs identical. Trochanter long as half length of tibiotarsus. Femur with 20 spines, tibiotarsus (Fig. 19) with 30 spines, claw with 3 setae. Brush setae present on inner side of anterior tibiotarsus. Coxa, femur and tibiotarsus of second and mainly third pair of legs elongate. Tibiotarsus of third pair by 1/5th longer than that of anterior pair.

Abdomen: Length to width of basal tergites 1 : 3. Tenth abdominal segment twice as long as broad at base, with 3 rows of setae on ventral side. Urogomphi (Fig. 25) 3 segmented, length ratio of segments 3.2 : 0.1 : 1.2. Segment 1 with 19 setae, segment 2 with one long and two short setae.

Length of body 29.5 mm (1 spec.). Head, pronotum and abdomen blackish brown. mouthparts. antennae. urogomphi and unsclerotized parts of abdomen yellowish brown.

Pupa. Mesonotum with lateral alar appendages. Their length as long as distance between its posterior corners. Triangular process in mid-area rounded. Metanotum triangular. Setae on sides of last two abdominal tergites. Fragments of 1 pupa were available for study.

Bionomic notes

Geographical distribution of *Ocypus italicus* Arag.: three subspecies of this species ar known. *O. italicus italicus* Gebl. (the subspecies of the larva described) is largely distributed in the northern and central Apennines and in the Alpes Maritimes. *O. italicus silensis* Fiori is known from the southern Appennines, and *O. italicus garganicus* Fiori occurrs in the Gargano Mts. and in Umbria (Coiffait, 1977). The species lives in the mountains and is found there under stones, in moss, in debris, etc.

Data on copulation, oviposition and fertility not available.

The L III found in Bergamo (Italy) on April 22 pupated on May 12, the imago hatched on May 18.

In our stocks the pupa completed its development within 6 days under condition of a long day, average temperature 21 °C.

Remarks

The larva of *Ocypus italicus* Arag. has typical characters of the larvae of the subgenus *Ocypus* s. str. and is closely related to the larvae of *Ocypus olens* (Müll.). *O. tenebricosus* (Grav.) and *O. biharicus* (G. Müll) (Boháč, 1982). It differs from the larva of *O. olens* (Müll.) by the structure of submentum

(by *O. olens* the transverse waves are sparse and indistinct), by sharp apex of mandible (by *O. olens* is apex of mandible rounded), by slender tibiotarsus and by posterior legs, *which are not elongated so distinctly. The larva of O. italicus* Arag. differs from the larva of *O. tenebricosus* (Grav.) by the thicker and shorter I segment of urogomphi, by the shorter submentum whose apex is rounded (in *O. tenebricosus* is apex of submentum sharp). It differs from *O. biharicus* (G. Müll.) by more elongated submentum (in *O. biharicus* the ratio of length to width of submentum is 1.6 : 1, in *O. italicus* 2 : 1. I segment of urogomphi in *O. italicus* has 19 setae, in *O. biharicus* 12 setae.

Ocypus (Pseudocypus) fuscoaeneus Solsky, 1871 (Fig. 31)

Materials: 1 L III, 1 exuvia L III; larva from Tajikistan (Hissar Mts., Varzob val.) was reared to the adult stage.

Description of the larva

L III. Head: Length to width 1.1 : 1, lateral margins parallel, temporal corners rounded. Surface with weakly expressed, undistinct microsculpture. Microsculpture on nasale is more distinct. Nasale (Fig. 22) ratio length to width 0.8 : 1. Its anterior margin arched, with nine sharp teeth. Middle tooth smallest. Setae between teeth, longest seta between third and second lateral tooth. Length ratio of nasale to epicranial sulcus 1 : 2. Antennae thin (Fig. 23), by 1/11th shorter than mandible. Length ratio of antennal segments (I : II : III : IV) 1 : 2 : 1.4 : 1.2. First antennal segment by 1/4th longer than broad at base, conical, narrowed to apex. Segment II 4 times longer than broad at apex, extended to apex Segment III 4.5 times longer than broad at base, from base to 2 3rd of its length extended, to apex narrowed, with 3 setae. Segment IV. 3.5 times longer than broad at base with 3 long and 2 short setae. Mandible (Fig. 27) 4 times longer than wide at apex, with sharp apex. Maxilla (Fig. 24) with length ratio of cardo to stipes 1 : 2.5. Cardo with 1 short seta on outside margin. Stipes 2.5 times longer as wide at base. Palpifer long as 1/4 th of length of I segment of maxillary palp, with 1 seta. Galea long as 3/4th of length of I segment of maxillary palp, to apex conicaly narrowed. Langth ratio of individual segments of maxillary palps (I : II : III : IV) 5.4 : 5.1 : 4.2 : 1.22 segment with 2 setae. 3 segment as wide as 3/4th width of penultimate segment. Last segment minute, pointed. Submentum (Fig. 30) triangular, its ratio length to width 1.2 : 1. Margins slightly narrowed to 2/3rd its length, than archied. Ratio length of labial palps (Fig. 29) (I : II : III) 11.5 : 9.0 : 1. Last segment minute, indistinct. 2 segment as wide as 4/5th of length of penultimate segment. Width of head capsule 2.05 and 2.00 mm.

Thorax: Length to width 1.6 : 1. Length ratio of pro-, meso- and metanotum 1 : 0.6 : 0.6. Anterior coxa as long as tibiotarsus. Tibiotarsus as long as 3/4th of length of femur, with 28 spines. Brush setae present on inner side of anterior tibiotarsus. Femur with 20 spines in 2 rows on ventral side. Claw with 3 spines.

Abdomen: Length to width of basal tergites 1 : 2.5. Epipleurit with 2 long and 6 short setae. Sternite with long setae on anterior and posterior margins. Tenth abdominal segment 3 times as long as wide at base, slightly narrowed to apex. Ventral side with 2 rows of setae and with marginal setae. Urogomphi (Fig. 26) as long as length of pro- and mesonotum together. Length ratio of their segments (I : II : III) 25.5 : 1 : 13.5. I segment long and strong, curved, with

20 setae. II segment minute, III segment as wide as 1/4th of length of I segment at base, on apex with one long and one short setae.
Length of body 18 mm (1 spec.). Head, pronotum and abdomen blackish brown, mouthparts, antennae, urogomphi and unsclerotized parts of abdomen yellowish brown.

Bionomic notes

Geographical distribution of *Ocypus fuscoaeneus* Solsky: Central Asia, Kazachstan (Tichomirova, 1973). The species lives in the mountains (about 2.000 m). It was found in relatively dry habitats as grasslands, pastures, etc. Often under stones, trunks, in debris, etc.

Data on copulation, oviposition and fertility not available.

L III found on April 25 in Tajikistan (Hissar Mts., Varzob vall., 2.000 m) pupated on May 10. The imago hatched on May 20.

In our stock the pupa completed within 10 days under the condition of a long day, average temperature 20 °C.

Remarks

The larva has typical characters of the subgenus *Pseudocypus* Muls. & Rey (nasale with sharp teeth on anterior margin, urogomphi with long setae). The larva of *O. fuscoaeneus* Solsky is closely related to the larva of *O. fuscatus* Grav. (Boháč, 1982). It differs from the latter by distinct teeth of nasale, longer urogomphi and larger size. It differs from *O. picipennis* F., which is also distributed in Central Asia, by slender labial palp and slender tibiotarsus. Nothing is known about the larval stages and bionomy of other related species from Central Asia (*O. helleni* G. Müll., *O. graeseri* Epp.). The larva of *O. fuscoaeneus* Solsky differs from the palaearctic species *O. aeneocephalus* De Geer by slender antennae and maxillary palp, shorter tibiotarsus and by submentum which has a stouted apex.

Acknowledgements

The author wishes to express his thanks to the directorate of the Institute of Evolutionary Morphology and Ecology of Animals, Academy of Sciences of the USSR (Moscow), for the opportunity to work in the mountain base of the institute in Tajikistan.

REFERENCES

Boháč, J., 1982: The larval characters of Czechoslovak species of the genera Abemus, Staphylinus and Ocypus *Studie ČSAV*, 4, Academia, Praha, 96 pp., 27 pl.
Coiffait, H., 1974: Coléopteres Staphylinidae de la region palèarctique occidentale. II. Sous famille Staphylinidae, tribus Philonthini et Staphylinini. Publ. Nouv Rev Ent., Toulouse, 591 pp.
Paulian, R., 1941: Les premiers états des Staphylinoidea. Étude de morphologie comparée. *Mém. Mus. Hist. Nat. Paris, N. S.*, 15: 1—361.
Smetana, A., 1958: Drabčíkovití — Staphylinidae I, Staphylininae Fauna ČSR 12, NČSAV, Praha, 437 pp.
Tichomirova, A. L., 1973: Morfologitscheskye osobenosti i filogenez stafilinid s katalogom fauny SSSR (Morphology and ecology of staphylinid beetles with catalogue of the fauna of the USSR). Nauka, Moscow, 191 pp. (in Russian).

The Fig. 31 will be found at the end of this issue.

Author's address: RNDr. Jaroslav Boháč CSc., Czechoslovak Academy of Sciences, Institute of Landscape Ecology, Na sádkách 7, 370 05 České Budějovice, Czechoslovakia.

Věst. čs. Společ. zool. **51**: 97—119, 1987
ISSN 0042—6595

Department of Systematic Zoology, Charles University, Praha

OLFACTORY SENSITIVITY TO ACETIC ACID BY THE LESSER WHITE-TOOTHED SHREW (CROCIDURA SUAVEOLENS; SORICIDAE, INSECTIVORA, MAMMALIA)

Marie CÍZOVÁ[1])

Received February 28, 1986

A b s t r a c t. Olfactory organ sensitivity of *Crocidura suaveolens* was tested by an olfactometer and experimental apparatus constructed by S e d l á č e k (1986). Five intact shrews (4 ♂♂ and 1 ♀) and 2 blinded males were trained by operant conditioning to prefer a trapdoor in front of which emanated air enriched with vapours of acetic acid. The following above-threshold values were determined by gradually lowering the concentration of the acid in 825 experiments during which the animals made 9899 choices: 2.2 . 10^7 molecules of CH_3COOH per cm^3 of air for the intact and 5.16 . 10^6 molecules of CH_3COOH for the blind shrews. These results were compared with those in the literature, obtained by anatomical and morphometric methods, and were functionally interpreted.

INTRODUCTION

The object of this study was to determine the sensitivity of the olfactory organ of the lesser white-toothed shrew *(Crocidura suaveolens)* to acetic acid. Similarly, N e u h a u s (1957) tested olfactory sensitivity in dogs, as did B r e t t i n g (1972) in the hedgehog *(Erinaceus concolor)* and S e d l á č e k (1986) in the common shrew *(Sorex araneus)*. Operant conditioning produces relatively objective data on the sensitivity of mammals to some chemically pure compounds. If, moreover, the same compound and apparatus are used, interspecific comparison of results gives us at least a general idea of interspecific differences. This method, combined with morphological and/or electrophysiological analysis, helps elucidate the organisation and function of the olfactory organ.

Although the structure and function of the olfactory organ have been investigated by many authors, its importance in the life of shrews has not been fully explained. The soricid olfactory organ is anatomically well developed (W ö h r m a n n - R e p e n n i n g 1975, Z í m a 1976, S i g m u n d 1986), as are the well differentiated and relatively large olfactory centres in the brain (Le G r o s C l a r k 1932, S t e p h a n 1967).

But rating olfaction in both adult (H o l l i n g 1958, G r ü n w a l d 1969) or juvenile individuals (V l a s á k 1970) has been subjective. P o d u s c h k a (1976) indicated that shrews differed in their olfactory capacities. He rated *Crocidura olivieri* and *Sorex araneus* high in this respect, but did not substantiate this opinion.

S h i b k o v (1979) first tested shrews (including blinded ones) in a labyrinth by the method of operant conditioning, and stated that shrews are able to

1) The subject was chosen and work on the thesis supervised by RNDr. Leo Sigmund CSc. The thesis is a part of Project VI-1-11/5.

Table 1. The shrews subjected to tests

Shrew No.	Date of capture (Prague ZOO)	Date of birth in laboratory	Sex
a) intact			
28	20. 9. 1982	—	♂
29	—	5. 7. 1982	♀
30	2. 10. 1982	—	♂
31	8. 10. 1982	—	♂
32	8. 10. 1982	—	♂
b) deprived of eyesight			
25	—	20. 7. 1982	♂
27	—	20. 7. 1982	♂

smell an obstancle at 25—30 cm. However, he did not find any difference in the olfactory capacity of the intact and enucleated shrews. Grünwald's (1969) observations agree with those of Shibkov, but he worked only with *Crocidura rusulla* and *C. olivieri*, not with a *Sorex* sp.

Lesser white-toothed shrews have been used in our laboratory for several years as model representatives of primitive terrestrial insectivores. They markedly differ from Soricines in ontogeny (Vogel 1972), life style (Vogel 1980), chronobiology (Sigmund et al., 1986), physiology (Nagel 1980, 1985), in retinal structure (Sigmund and Claussen, 1986) and in the structure of the organ of Corti (Bruns, pers. comm.).

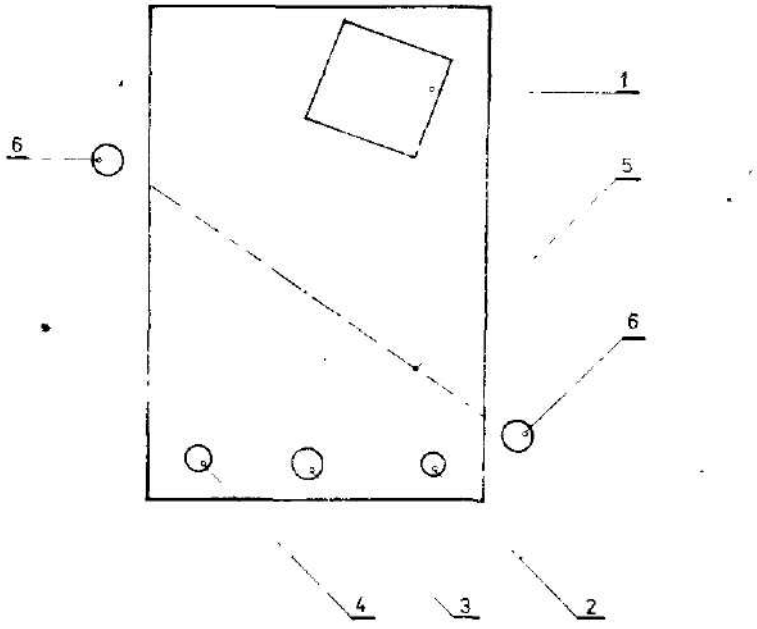


Fig. 1. Floor plan of the terrarium. 1 — nesting box, 2 — water dish, 3 — meat dish, 4 — dish containing mealworms, 5 — photocell ray, 6 — photocell.

The objects of this paper are to contribute to our understanding to olfactory capacity of soricids. and to facilitate comparisons between representatives of Palaeotropical Crocidurines and Holarctic Soricines.

MATERIAL AND METHODS

Shrews caught in the Prague Zoo and three animals borne by females that had been gravid when captured were used. Experiments involved seven *C. suaveolens*, five of them intact and two deprived of sight. Details on the experimental animals are given in Table 1.

None of the seven shrews died during the time when the experiments were made, and they were in good health judging by their body weight (checked weekly)[1] and by long-term daily records of their locomotor activity.

The shrews were kept in glass terraria (29 × 49 × 29 cm), each furnished with a wooden box (10 × 10.5 × 9.5 cm) with one entrance. Hay (or cottonwool in winter) was occasionally replenished. Humidity varied (70—85 %) as did mean temperature (16° winter, 20° summer). Light was constant (80 Lux; 12 : 12; 7.00—19.00). The terrarium is shown in Fig. 1.

Water and food (minced pork liver, heart, kidneys and spleen enriched with a vitamin mixture Roboran H) were available ad libidum. Once a week the shrews were given water enriched with liquid B vitamins (10 drops of Spofa B-complex pro inj. per 500 ml of water). Five Tenebrio molitor larvae, also used as a reward in the tests, were given daily to each shrews.

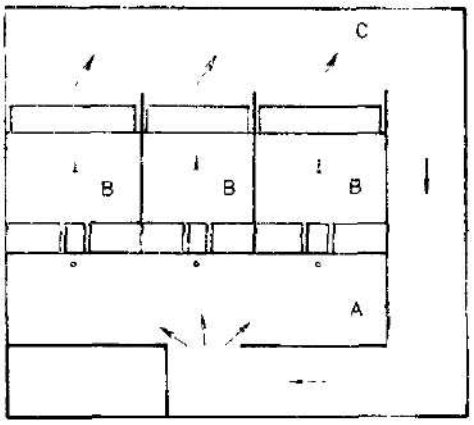


Fig. 2. Ground plan of the experimental apparatus. A — test chamber, B — reward compartment, C — corridor.

Each terrarium bottom was covered with about 1 cm of moist peat. The space between the nest and food was monitored by means of photocells (see Fig. 1), and all movements within this space were graphically recorded with a twelve-channel recorder (ZiRG 160 Metra Blansko) and printed hourly (Ascota). Locomotor activity was assessed with a computer K 15 10 VEB Robotron.

The peat was regularly moistened with water and replenished whenever necessary.

Each shrew was transported from the terrarium to the experimental apparatus in its own box (5.5 × 8 × 7 cm) with a detachable front wall. Only the blind animals were always transferred into the experimental apparatus in their nesting boxes. The bottom of each transportation box was covered with unchanged cottonwool, thus furnishing an olfactorily familiar environment for each animal.

The experiments were made in the same room where the shrews were kept, thus

1) Data are available from the author.

minimizing visual, auditory, or olfactory stress. The air above the silon floor of the test apparatus was, however, 1 °C lower than the room temperature.

Acetic acid, which was used by Neuhaus (1953) in his experiments with dogs, is one of the compounds found in the excretion of sweat glands. Acetic acid was also used for testing the olfactory capacities of mammals by Gruch (1957) in laboratory rats (*Rattus norvegicus*), by Bretting (1972) in the hedgehog, by Sedláček (1986) in the common shrew, and by Schmidt (1975) in the vampire *Desmodus rotundus*. I chose this compound because of the possibility to compare my results with those of others, and used dilutions of acetic acid of P. A. purity prepared by Dr T. Trnka CSc., Charles University.

I omiteed tests involving propionic and butyric acids used in addition to acetic acid by Neuhaus (1953), Bretting f1972), Schmidt (1975) and Sedláček (1986), because threshold concentrations could not be accurately determined from their aqueous solutions.

For determining the sensitivity of the olfactory organ of *C. suaveolens* I used an olfactometer producing a constant air flow, and an experimental apparatus where the animals were trained. The olfactometer had been constructed by Sedláček (1986) after Gruch (1957) and Neuhaus (1953), and the test apparatus also by Sedláček (1986) after Bretting (1972). The design of the experimental apparatus in shown in Fig. 2. For detailed descriptions of it and the olfactometer see Sedláček (1986).

Sedláček (1986) also tested the most suitable flow of air through the apparatus. Using smoke to make air visible he found the optimal air flow of 20 cm^3 s. He also checked the accuracy of his calculations of concentrations by testing the olfactometer with a Hewlett-Packard 5700 A gas chromatograph using n-amyl acetate.

A required acid concentration was obtained by passing charcoal-filtered air through a polystyrene plug containing a 92 μm diameter capillary with acetic acid. Unlike Sedláček (1986), I did not measure the column of the acid in the capillary with a microscope placed on the olfactometer, but did so when the capillary had been removed from the T-tube. Acid loss in the horizontal capillary was measured using a calibrated stereoscopic microscope.

The filling of capillaries with acid and their placing in the apparatus was done by Sedláček's (1986) method. Concentrations were also calculated by Sedláček's (1986) formula:

$$C = \frac{L \times \rho \times N}{V \times M}$$

C = number of molecules of compound per cm^3 of air
L = volume of evaporated compound in mm^3
ρ = density of acetic acid in g mm^3
N = Avogadro constant 6.023 $\times$ 10^{23}/mol
V = volume of air flow in cm^3
M = molar weight of acetic acid: 60.05.

Threshold concentration was taken as the nearest higher concentration of the test compound at which the proportion of correct choices and errors is statistically different from random (X^2 test). Considering the technical limits of the equipment, the values resulting from my experiments are not interpreted as threshold concentrations but as the last ascertained above-treshold concentrations of acetic acid.

I trained the shrews to respond to the odour of acetic acid by the method of operant conditioning. Bretting (1972) used it to train hedgehogs and Sedláček (1986) common shrews to show preference for the one of three doors in front of which air enriched with vapours of the test compound emanated from a tube. Only this door could be opened by the animal, the other two not. If the animal made a correct choice, it entered another part of the apparatus, a so-called reward compartment (Fig. 2) where it received a piece of mealworm. The mealworm reward had been place there beforehand and the animal could snatch it immediately on entering the room. The shrews thus learned to prefer the door marked with odour. The apparatus had to be constructed in a way enabling the experimenter to mark any of the doors with odour whenever a change seemed fit to prevent stereotypes.

When the animals had learned to prefer the door marked with odour it was possible to begin to test the sensitivity of their olfactory organs by gradually lowering

the concentration of the test compound to the value when the animals were unable to discern it and to choose the door marked with odour. The so-called random choice then occured, which meant $^1/_3$ of correct choices in the apparatus with three doors. Errors included cases when the animal tried to pass through a door in front of which a current of clean air was blowing from a tube. Contrary to the tests conducted by Sedláček (1986) in common shrews and by Bretting (1972) in hedgehogs, only one of the three doors associated with odour could be opened.

The experiments were generally made once a day, in the dark phase of the day. Before each trial, the apparatus was checked and the source of air, a vacuum cleaner, was switched on. Then the air flow through the olfactometer was set as 20 cm^3/sec. and checked by means of built--in flow meters and by individually attaching the filter tubes to another flow meter with a metal float. Immediately before each trial the test capillary was filled with acid and the amount was measured. The capillary was then inserted into the T-tube and acid evaporation timed with a stop watch. After a shrew was introduced to the apparatus, the positions of the filters (and sated capillary were changed and the respective doors were opened and closed during the experiment, when the shrew was eating its reward, to minimize disturbing noises.

In the apparatus the shrews would run from the corridor into the room of choice, then into one of the three compartments where they would be rewarded, and from there back into the corridor (see Fig. 2). The floor on which the shrews ran was silon netting covering the glass tubes through which flowed some of the clean air produced by the vacuum cleaner. The tubes were positioned to guide air upwards, which ensured that the animal moved in clean, odourless air (except for the space near the door marked with the acid odour). Any possibility of adaptation of the olfactory organ to the smell of the acid was thus excluded.

The shrews had to run through the apparatus as many times as had been planned. The stop watch was switched off and the shrew was taken back to its terrarium in the transportation box. Evaporation from the capillary was measured and the experiment was assessed. Finally, the apparatus was washed with hot water (no detergent) to minimize any olfactory disturbance.

RESULTS

1. Performance assessment and behaviour of the shrews in the apparatus

The training of the shrews was roughly divided into two phases. First, all three doors leading to the reward compartments were open and the olfactometer was not switched on. The behaviour of the animals was exploratory. From the very beginning they explored the whole apparatus, apparently by smell, and therefore it was necessary to minimize disturbing odours in various

Table 2. The first phase of training

Shrew No.	Sex	Number of tests	Number of choices
a) intact			
28	♂	6	85
29	♀	6	60
30	♂	6	69
31	♂	6	104
32	♂	6	72
b) enucleated			
25	♂	12	167
27	♂	9	134

parts of the apparatus in order to make the test chamber the main source of olfactory information.

The behaviour of the shrews suggested an intensive activity of their olfactory organs while choosing the door marked with odour. They always pawed their

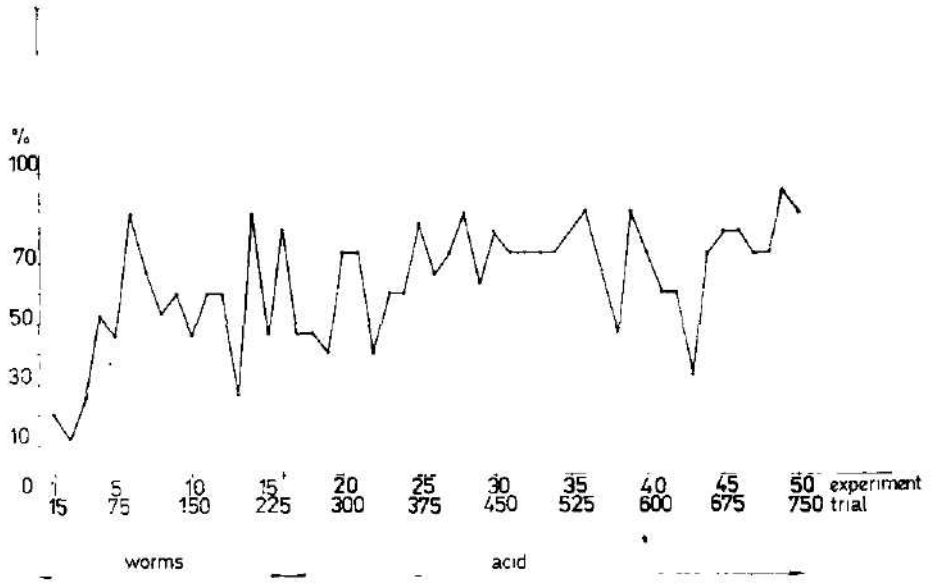


Fig .3. Performance of male No. 28 during the second phase of training.
Legend to Figs. 3—9: axis x — trial number; each animal made 15 (intact shrews) or 5 (enucleated shrews) choices during one trial; axis y — proportion of correct choices.

snouts in the test chamber or immediately before entering it. At high acid concentrations this was probably an attempt to get rid of the strong odour, but at the terminal above-threshold concentrations it presumably stimulated the olfactory organ.

Table 3. The second phase of training

Shrew No.	Sex	Number of tests	Number of choices
a) intact			
28	♂	54	800
29	♀	54	733
30	♂	50	735
31	♂	50	753
32	♂	50	744
b) enucleated			
25	♂	31	297
27	♂	30	270

Table 4. The second phase of training
P: trial No; A: percentage of correct choices; B: duration of trial (minutes)

P	Shrew No. 28		Shrew No. 29		Shrew No. 30	
	A	B	A	B	A	B
1	20	56	26.6	31	13.3	21
2	13	81	40	28	40	26
3	26	47	40	26	46	26
4	53	35	40	27	40	25
5	46 6	51	60	38	53	20
6	86	42	66	23	46	17
7	66	46	33	30	53.3	15
8	53 3	43	66.6	37	53.3	22
9	60	51	40	31	50	13
10	46 6	23	53.3	19	53.3	20
11	60	29	66.6	20	40	22
12	60	31	73	16	20	19
13	26 6	35	53.3	21	40	21
14	86 6	49	40	28	53.3	23
15	46 6	44	40	33	40	21
16	81.8	54	60	29	46.6	24
17	46 6	48	60	34	33.3	27
18	46.6	51	33.3	28	46.6	27
19	40	81	60	23	40	25
20	73	51	73	42	66.6	21
21	73.3	34	60	70	53.3	23
22	40	41	73.3	32	53.3	14
23	60	40	53.3	39	40	11
24	60	39	73.3	30	66.6	12
25	83.3	34	58.3	36	53.3	25
26	66.6	44	26.6	35	66 6	21
27	73.3	53	80	44	60	20
28	86.6	35	53.3	33	60	16
29	63 6	33	60	34	66.6	25
30	80	22	60	33	60	21
31	73.3	29	73.3	30	73.3	25
32	73.3	32	66.6	34	53.3	25
33	73.3	39	40	43	53.3	18
34	73.3	52	66.6	43	53	17
35	80	31	53.3	36	40	22
36	86 6	26	46.6	28	73.3	22
37	66 6	45	40	42	40	17
38	46 6	21	53.3	28	66.6	14
39	73.3	32	46.6	33	46.6	22
40	53.3	33	66 6	17	66 6	15
41	60.0	33	53.3	20	73.3	16
42	60	38	73.3	24	53.3	23
43	33.3	30	60	20	73.3	22
44	73.3	45	60	27	66.6	21
45	80	36	40	31	73.3	19
46	80	40	66.6	32	86.6	15
47	73.3	40	73.3	22	26.6	14
48	73.3	37	66.6	24	53.3	24
49	93.3	41	53.5	23	60	26
50	86.6	39	86.6	24		

Table 4 continued

P	Shrew No. 31		Shrew No. 32		P	Shrew No. 31		Shrew No. 32	
	A	B	A	B		A	B	A	B
1	26.6	23	40	25	26	40	11	80	31
2	40	28	33.3	46	27	60	17	60	30
3	20	20	46.6	53	28	66.6	19	80	30
4	60	18	60	44	29	66.6	15	86,6	44
5	53	20	80	37	30	53.3	20	86.6	43
6	33	15	33.3	32	31	66.6	18	80	34
7	46.6	28	46.6	32	32	60	19	93.3	32
8	33.3	24	46.6	26	33	60	17	86.6	27
9	53.3	20	80	28	34	46.6	13	60	33
10	53.3	22	93 3	24	35	60	21	66.6	32
11	53.1	16	46	30	36	53.3	31	80	15
12	53	20	33	33	37	80	14	86.6	16
13	13.3	22	80	29	38	40	18	86.6	14
14	53.3	21	86.6	40	39	73 3	12	86.6	25
15	73.3	19	80	38	40	53 3	12	93.3	15
16	46.6	15	73.3	36	41	60	14	86.6	44
17	46 6	17	80	41	42	60	20	100	16
18	46	20	66.6	38	43	60	16	93 3	24
19	66.6	29	73.3	45	44	73.3	17	93.9	23
20	46.6	18	80	37	45	73.3	21	94.9	23
21	46 6	16	80	31	46	80	21	93.3	30
22	60	10	73.3	39	47	60	17	73.3	50
23	46.6	17	100	39	48	60	19	93.3	38
24	33.3	16	86.6	40	49	60	16	60	19
25	53.32	21	73.3	27	50			66.6	27

P	Shrew No. 25		P	Shrew No. 27	
	A	B		A	B
20	33	14	16	11	13
21	33	10	17	66	11
22	44	7	18	44	7
23	44	5	19	55	6
25	44	7	21	77	7
26	54	3	22	44	12
27	44	4	23	88	5
28	66	4	24	85	8
29	66	10	25	55	11
30	76	11	26	55	8
31	76	10	27	55	7
32	76	5	28	66	14
33	66	6	29	66	10
34	76	6			
35	76	7			

The fact that at the final above-threshold concentrations each shrew repeatedly sniffed at each door before it made the choice and cleaning its snout between, can be considered as strongly indicating the animals' reliance on the test odour in the apparatus. During these final trials they often made short twittering noises in the test chamber.

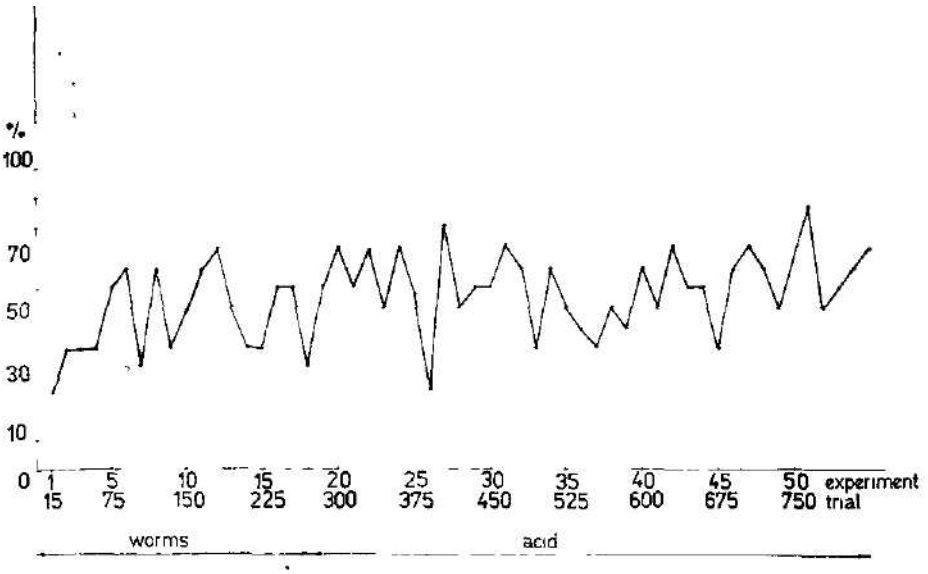


Fig. 4. Performance of female No. 29 during the second phase of training.

To create for the shrews conditions resembling natural ones and thus speed up the second phase of training, air enriched with the odour of mealworms was guided to one of the doors through a filter containing 25 live mealworms. As soon as the shrews learned to respond to the scent of mealworms, the filter was replaced by another with the capillary containing acetic acid. However, this was done only with the intact shrews; the blind ones were trained to

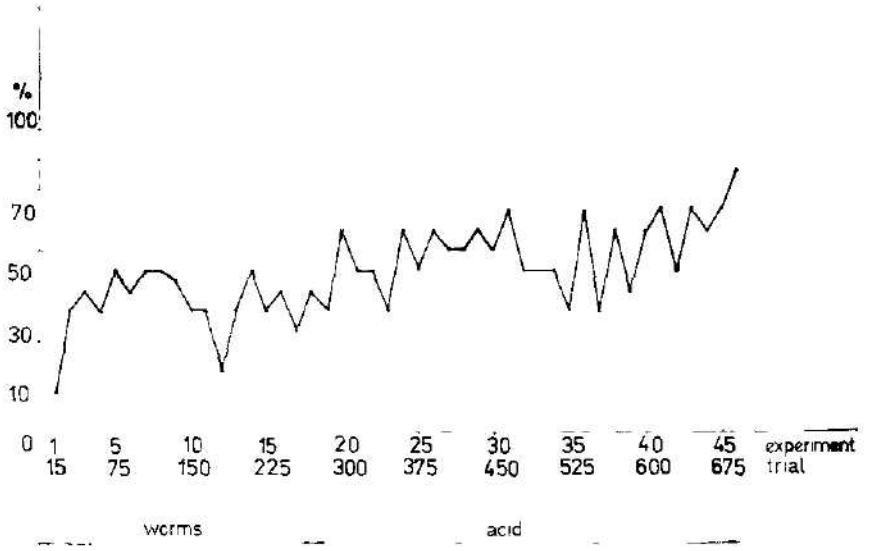


Fig. 5. Performance of male No. 30 during the second phase of training.

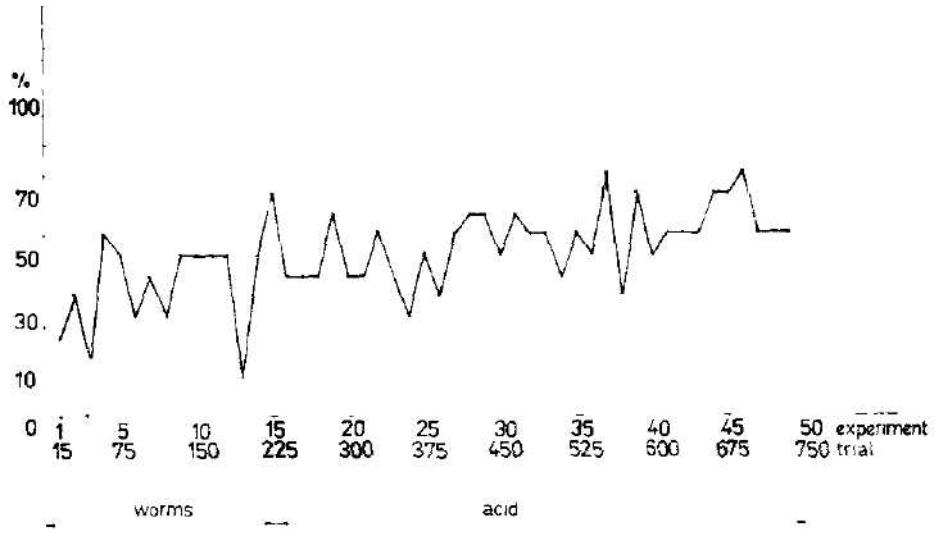


Fig. 6. Performance of male No. 31 during the second phase of training.

respond only to the acid odour. The total number of trials in the two training phases is given in Tabs. 2 and 3. The results of trials in the second phase of training are presented in Table 4 and in Figs. 3—9.

The diagrams show that all the shrews learned to perform reasonably well during 10 trials involving 150 choices, as more than 40 % of their choices were correct.

When the odour of mealworms had been replaced by that of acetic acid there was a sudden drop in correct choices, but the shrews quickly adapted themselves to the smell of the acid.

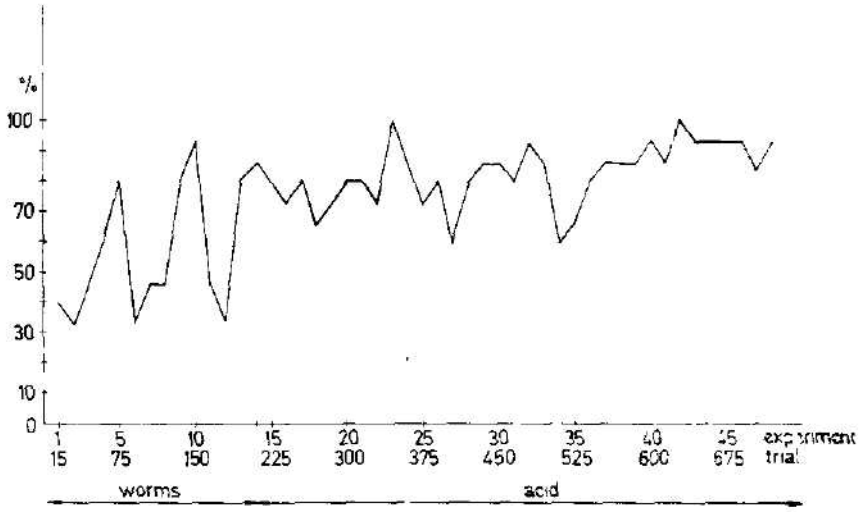


Fig. 7. Performance of male No. 32 during the second phase of training.

As for the course of learning, it is difficult to evaluate the initial variability of performance reflecting differences among individul animals. Later on the percentage of correct choices reached a relatively high level; shrews No. 32 performed best of all.

Figs. 8 and 9 show that there was also a difference between the two males deprived of eyesight: there was no substantial variability in the performance of No. 25, the percentage of correct choices was increasing, and after 30 trials involving 270 choices it attained 75 % level. The performance of No. 27 greatly varied in the second phase of training. but on the average it made 60 % of correct choices.

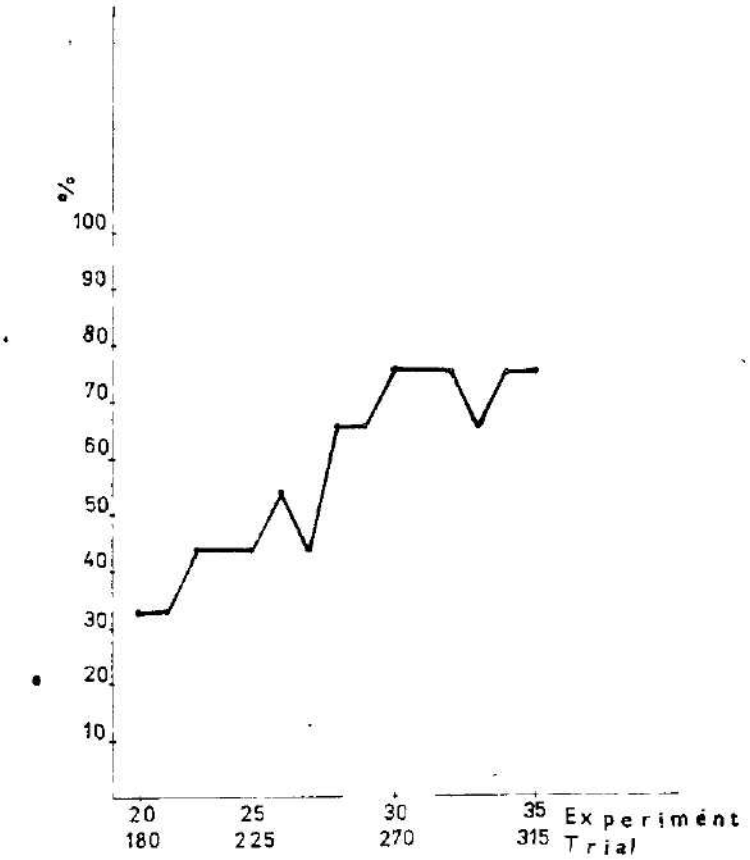


Fig. 8. Performance of the blind male No. 25 during the second phase of training

Extremely low individual percentages of correct choices can be explained by the influence of various negative factors, e. g. stress from food deprivation (experiment 38, shrews 28 and 31; experiment 34, shrew 32), change of air source (experiment 26, shrew 29). or the occurence of mites in the terrarium (experiment 43, shrew 28 and exp. 49, shrew 29). Moulting also seemed to affect the condition of the shrews and, possibly, the results of trials.

Table 5. The first series of tests on intact animals

Shrew No.	Sex	Number of tests	Number of trials
28	♂	83	932
29	♀	70	834
30	♂	70	835
31	♂	75	878
32	♂	78	936

Another negative factor (concerning only the blind shrews) was that some of the time-consuming experiments had to be made during the light phase of the day, i. e. during the resting period of the animals. They often ignored the reward during the second phase of training, so that only some of their trials were included in the diagram showing the course of learning (Figs. 8 and 9). On the other hand, experience gathered during work with intact animals could be applied to experiments with blind ones, so that concentrations were lowered earlier for the latter.

On the whole, there was no conspicuous behavioural difference between the intact and blind animals or in their ability to learn.

Trials were conducted with the intact shrews in two series, between which there was a 38-day interval of rest. The animals readily responded to the odour of acetic acid even after the long interval, and there was no change in their behaviour inside the apparatus. This is in keeping with Braniš's (personal communication) observation of *C. suaveolens*, after an interruption of his tests of its visual organ, and with the findings of Gross & Gross (1982) on the learning ability of the mole *(Talpa europaea)* in a special labyrinth. These authors recorded the time needed by the animal to pass one test, and they found that less and less time was required as the tests continued. Also this conclusion has been confirmed by my results, as at the beginning it took 30—50 minutes for the white-toothed shrews to run 15 times through the apparatus, whereas later only about 20 minutes. Shrews deprived of sight moved about the apparatus in the same way as the intact ones. Although they had never been inside the apparatus before enucleation, they perfectly remembered its interior. This indicates a good spatial memory and orientation ability

Table 6. The ultimate above-threshold concentrations ascertained in the first series of tests

Shrew No.	Molecules of CH_3COOH per cm^3 of air	Percentage of correct choices by which the concentration was determined
28	$2.3 \cdot 10^8$	44
29	$0.8 \cdot 10^8$	55
30	$2.2 \cdot 10^7$	44
31	$1.7 \cdot 10^8$	44
32	$3.4 \cdot 10^8$	44

Table 7. The second series of tests on intact animals

Shrew No.	Sex	Number of tests	Number of choices
28	♂♂♀♀♂	11	99
29		11	99
30		11	99
31		11	99
32		11	99

of *C. suaveolens*, in keeping with Grünwald's (1969) results in *Crocidura russula*.

2. Effects of locomotor activity on learning behaviour by intact and enucleated animals

Experiments with shrews were always made at the time of intensive locomotor activity to prevent its rhythm from affecting the results.

The presumption that it is better to test the shrews during their active locomotor phase has been confirmed in experiments with the blind animals during their inactive phase. The proportion of correct choices was always higher when the animals were active. For instance, male No. 27 made 77 % correct choices at $6.15 \cdot 10^6$ molecules of acetic acid per cm^3 of air, but only 55 % when tested during his phase of locomotor inactivity (Tab. 10).

Locomotor activity of the experimental animals was therefore recorded and evaluated. Siegmund & Sigmund (1983) found that most locomotor activity in shrews occurs in the dark phase of day and that light is principial timer of the locomotor activity rhythm. Fig. 10 shows that this rhythm is deeply ingrained and cannot be altered by regular feeding.

Conversely, a change in light intensity strongly affects locomotor activity. The present data show that locomotor activity mostly occurs in the dark phase of day, so I conducted experiments at night. As they could not be done in darkness, the room was lighted with a 60 W lamp placed on a table. Fig. 10 A shows that the light impaired the locomotor activity of the shrews, so that it extended into the light phase of the day. The original rhythm was resumed only when the bulb had been replaced by a 25 W one and the lamp placed on the floor under the terraria (Fig. 10 B).

Table 8. The ultimate above-threshold concentrations ascertained in the second series of tests on intact animals

Shrew No.	Molecules of CH_3COOH per cm^3 of air	Percentage of correct choices by which the concentration was determined
28	$4.3 \cdot 10^7$	77
29	$2.3 \cdot 10$	55
30	$2.2 \cdot 10^7$	44
31	$2.9 \cdot 10^7$	55
32	$3.6 \cdot 10^7$	55

Special attention was given to locomotor activity rhythm in blinded shrews. I found, as did Siegmund & Sigmund (1983) that they developed a free-running rhythm of locomotor activity, behaving as intact shrews in constant darkness (Fig. 11). Their peak locomotor activity was qualitatively comparable with the nocturnal period of locomotor activity of the intact shrews.

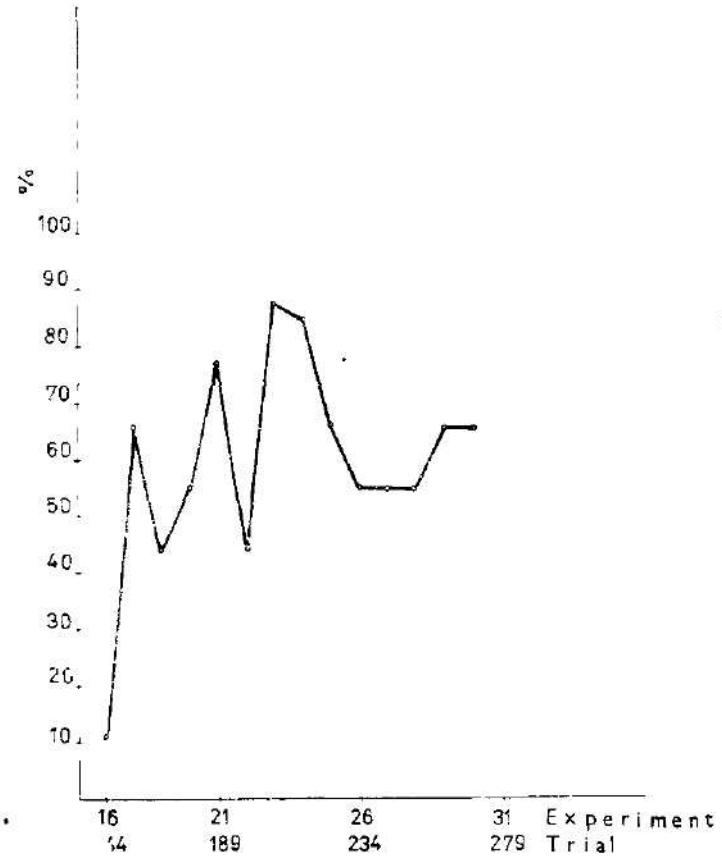


Fig. 3. Performance of the blind male No. 27 during the second phase of training.

3. Determination of above-threshold concentrations

All doors were open in the first phase of training, and the olfactometer was not switched on; shrews explored the apparatus. The results are shown in Table 2.

In the second phase, only one door was open and marked first with the odour of mealworms, later of highly concentrated acetic acid: in the order of magnitude of 10^{14} molecules/cm^3 of air for the intact animals, and 10^{11} molecules and less for the blind shrews. The latter were trained to respond only to the odour of acetic acid. The results are shown in Table 3.

In subsequent experiments the concentration of acetic acid was gradually lowered to concentrations which elicited no response in the animals. The results of these experiments are presented in Table 5. Acetic acid at the concentrations of 0.001 and 0.0001 % was used in the first series of experiments, and the ultimate concentration of 0.0005 % in the second series.

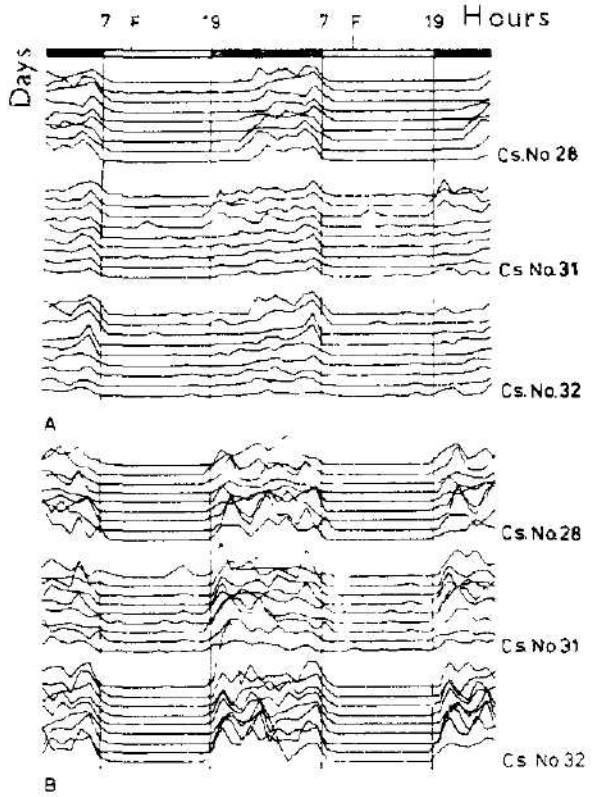


Fig . 10. An example of the rhythm of locomotor activity in *Crocidura suaveolens*. A — from 12 to 21 November 1982 (adult male No. 28, adult male No. 31, adult male No. 32); B — from 12 to 21 December 1983; F — feeding at 10 a. m.

The first series consisted of 634 trials including 88180 choices. The ultimate above-threshold concentrations in the first series are given in Table 6.

Table 7 shows the results of the second series of experiments with the intact shrews (77 trials, 495 choices).

Table 9. Enucleated animals — numbers of trials and choices

Shrew No.	Sex	Number of trials	Number of choices
25	♂	38	342
27	♂	37	333

The final above-threshold concentrations in the second series of tests are summarized in Table 8.

Table 9 shows the number of tests and choices involving shrews deprived of sight; the results were used for determining the final above-threshold concentration eliciting response in these animals. The last ascertained above-threshold concentrations are given in Table 10. The periods when the experiments were carried out are in Table 11.

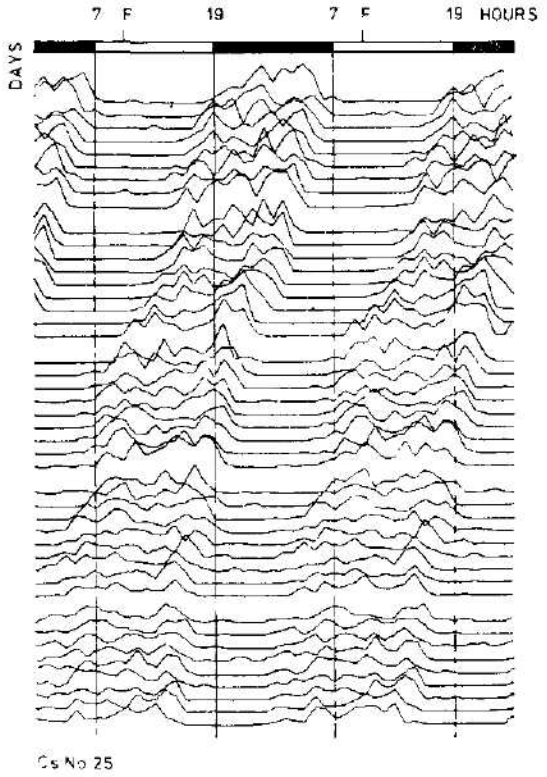


Fig. 11. An example of the free-running rhythm of locomotor activity in *C. suaveolens* deprived of eyesight (male No. 25) from 11 April to 20 May 1983. LD = 12 : 12 (white light 80 : 0 lux); L — 7 a. m. — 7 p. m.; F — feeding at 10 a. m.

Table 10. The ultimate above-threshold concentrations ascertained for enucleated animals

Shrew No.	molecules of CH_3COOH per cm^3 of air	percentage of correct choices by which the concentration was determined
25	$5.16 \cdot 10^6$	77
27	$6.15 \cdot 10^6$	77 (active phase) 55 (inactive phase)

Table 11. Periods of training and trials

Shrew No.	1st phase of training	2nd phase of training	lowering of the concentration of acetic acid
28, 29, 30, 31, 32	12. 10. – 18. 10. 1982	19. 10. – 27. 12. 1982	28. 12. 1982 – 13. 5. 1983, 20. 6. – 3. 7. 1983
25*	4. 5. – 15. 7. 1983	22. 8. – 22. 10. 1983	23. 10. 1983 – 4. 2. 1984
27*	24. 5. – 15. 7. 1983	22. 8. – 22. 10. 1983	23. 10. 1983 – 4. 2. 1984

* Date of enucleation: 6. 1. 1983

The sensitivity of the olfactory organ of the lesser white-toothed shrew to acetic acid was evaluated by the same method as had been used by Bretting (1972) in the hedgehog and by Sedláček (1986) in the common shrew. These authors did not determine threshold concentrations as arithmetic means, but selected from each group the individual displaying the highest sensitivity to the test compound. In this respect there is no difference between the results of the two series of tests involving the intact animals, the final above-threshold concentration being $2.2 . 10^7$ molecules of acetic acid per cm^3 of air.

The intact animals were subjected to the total of 689 tests (averaging 137.8/animal) with 8675 choices (1735 choices/animal). The average of choices per test was 12.59 (not including the tests in the first phase of training).

Both groups (totalling 7 shrews) underwent a total of 825 tests and made 9899 choices.

4. Statistical evaluation of results

Since the capillary had to be removed from the T-tube for measuring acid loss, and the measured column of the acid had to be in horizontal position, it was practically impossible to expose all animals to exactly the same concentration. Therefore, concentrations were divided for the purpose of statistical evaluation into ranges roughly corresponding to the orders of magnitude of the molecules of acetic acid. In the X^2 test, the values within one range of concentration were then pooled for all animals.

The results involving concentrations were evaluated separately also within one order of magnitude. For instance, the ultimate above-threshold concentration for shrew No. 32 in the second series of tests was $3.6 . 10^7$ molecules of CH_3COOH per cm^3 of air. This finding and all the higher concentrations in this order of magnitude were included in group A within the 10^7 (10^7A) order of magnitude, all the lower ones into group 10^7B.

A null hypothesis assuming that the animals do not respond to the odour of the acid was statistically evaluated. If the null hypothesis cannot be rejected ,it cannot be said that the animals do perceive the smell of the acid.

If the critical value X^2 for 1 degree of freedom at an 0.05 % level of significance is lower than the calculated value X^2, the null hypothesis is rejected at an 0.005 % level of significance. The ensuing distribution of choices is then substantially different from that at random choice (at that concentration the animal showed preference for the door associated with odour). The null hypo-

Table 12. χ^2-test for both series of experiments on intact animals

χ^2	Concentration	total number of choices	number of correct choices	number of error choices	percentage of correct choices	2/3 of the total number of choices	1/3 of the total number of choices	level of significance
36.35	10^9	189	102	87	53.96	126.06	62.93	0.0005
34.91	10^8	243	110	133	44.4	162.08	80.91	0.0005
17.37	10^7 A	214	100	114	46.72	142.73	71.26	0.0005
0.1209	10^7 B	36	11	25	31.28	24.01	11.98	0.8

Table 13. χ^2-test — animals deprived of sight

χ^2	Concentration	Total number of choices	number of correct choices	number of error choices	percentage of correct choices	2/3 of the total number of choices	1/3 of the total number of choices	level of significance
24.14	10^9	54	35	19	64.81	17.98	36.01	0.0005
32.76	10^8	108	64	44	59.26	35.96	72.03	0.0005
66.50	10^7	281	158	123	56.22	93.57	187.42	0.0005
12.5	10^6 A	117	57	60	48.71	38.96	78.03	0.0005
0.294	10^6 B	63	23	40	33.5	20.97	42.02	0.6

thesis cannot be rejected at a 60 % level of significance, from which it can be deduced that the shrew did not show preference for the door associated with odour. This was considered a fairly reliable criterion of subthreshold concentrations. The results of the X^2 tests are summarized in Tables 12 and 13.

The hypothesis that there would be no difference between the intact and enucleated animals in the proportion of correct choices of the door marked with odour at 10^7 molecules of CH_3COOH per cm^3 of air was also tested as follows:

Comparison of choices at 10^7 concentration	Correct choices	Errors	Total
intact shrews	111	139	250
enucleated shrews	158	123	281
total	269	262	531

X^2 ... 7.4
X^2 7.4 $\leq$ .01 so that at the concentration of 10^7 the enucleated animals performed statistically significantly better than the intact ones.

DISCUSSION

The results of tests for the sensitivity of the olfactory organ of *C. suaveolens* can be compared only with the results obtained by authors who made similar experiments by the same method (operant conditioning) using the same compound (acetic acid). However, the comparison may not be quite accurate owing to differences in the construction of experimental apparatuses.

Experiments with acetic acid are summarized in Table 14 and Fig. 12. The survey shows that C. suaveolens is highly sensitive to acetic acid. The values of the last above-threshold concentrations ($2.2 . 10^7$ molecules of acetic acid per cm^3 of air for animals deprived of sight) place it second only to dogs. These values are also the lowest among the insectivores tested so far. Particularly

Table 14. Experiments using acetic acid

Species	Threshold concentration of acetic acid (number of molecules per cm^3 of air)	Author
Desmodus rotundus	$1.1 . 10^{14}$	Schmidt 1975
Man	$5.0 . 10^{13}$	Passy 1892 ex Neuhaus 1952
Rattus norvegicus	$1.7 . 10^{13}$	Gruch 1957
Sorex araneus	$1.0 . 10^{13}$	Sedláček 1986
Erinaceus europaeus	$4.0 . 10^{10}$	Bretting 1972
Crocidura suaveolens		
a) intact	$2.2 . 10^7$	
b) enucleated	$5.1 . 10^6$	
Dog (foxterrier)	$5.0 . 10^5$	Neuhaus 1953

Note: With *Crocidura suaveolens* these were the ultimate above – threshold concentrations; *Desmodus rotundus* was not subjected to operant conditioning

surprising is the difference by six to seven orders of magnitude from the common shrew tested in the same apparatus by Sedláček (1986).

It should also be taken into account that the lesser white-toothed shrew differs from the common shrew e. g. in the zoogeographic, ethologic and morphologic respects as well as metabolically.

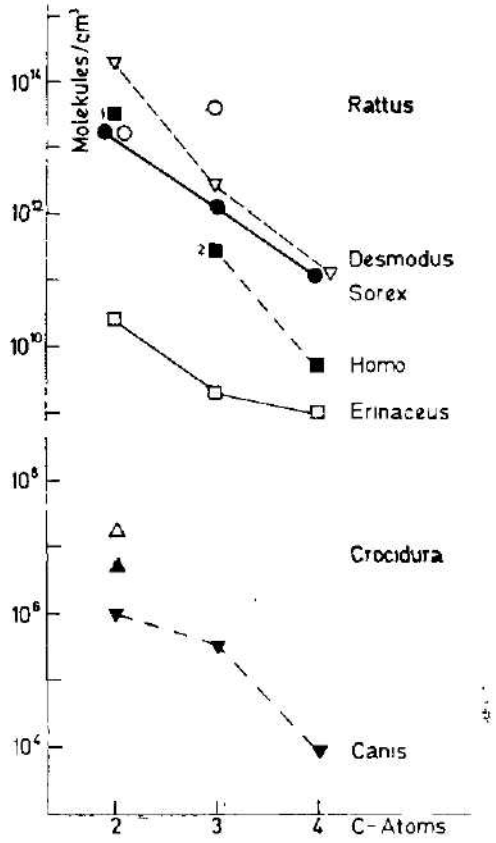


Fig. 12. The results of tests for sensitivity to acetic acid (△ intact animals, ▲ enucleated animals) and their comparison with data in literature. *Rattus* ex Gruch 1957, *Homo:* 1) Passy ex Neuhaus 1953, 2) ex Skramlik 1948, *Desmodus* ex Schmidt 1975, *Sorex* ex Sedláček 1986, *Erinaceus* ex Bretting 1973, *Canis* ex Neuhaus 1953.

According to Nagel (1980), the average body temperature is 34.8° C in *C. suaveolens* and 38.3° C in *Sorex araneus. C. suaveolens* can become lethargic under unfavourable conditions, with body temperature dropping to 21.6° C, whereas *S. araneus* lacks this faculty. Oxygen consumption is 2.81 ml of O_2/g. h. in *C. suaveolens* and 7.43 ml of O_2/g. h. in *S. araneus*, and there is a corresponding difference in heartbeat: 371 pulses/min. in *C. suaveolens* and 627 in *S. araneus.*

The fact that *C. suaveolens*, in contrast to *S. araneus*, is a social species might have some unknown bearing on its olfactory sensitivity.

Table 15. Morphometric data on the olfactory organ

Species	A (regio olfactoria in mm²)	B (total number of olfactory cells)	A/B	Author
Man	150–500	10–20 . 10^6		Hensel 1966
Rattus norvegicus		6 6 . 10^6		Neuhaus 1957
Sorex araneus	224.38	*14.3 . 10^6	63 740	*Zima 1976 Sigmund and Sedláček 1985
Crocidura suaveolens	149.61	*7.98 . 10^6	53 400	* Zima 1976 Sigmund 1985
Erinaceus concolor	1954.50	82.1 . 10^6	42 000	Zima 1976
dog (foxterrier)	8350	147.2 . 10^6	17 630	Neuhaus 1957

The two species also differ in the type of locomotor activity (Siegmund & Sigmund 1985): *C. suaveolens* is active almost exclusively at night while in *S. araneus* the periods of activity and rest alternate practically throughout 24 hours.

Anatomical and morphological studies (Ganeshina & Voroncov 1957, Wöhrmann-Repenning 1975, Zíma 1976, Sigmund & Sedláček 1985) have shown that the olfactory epithelium is very well developed in representatives of the whole family of soricids, with the regio olfactoria occupying a substantial part of the nasal cavity. Significant morphometric data presented in Table 15 document a lack of correlation of the results obtained in *C. suaveolens* by neuroethological methods with morphometric data on the gradation of density of olfactory cells (Sigmund & Sedláček 1985).

The results obtained by neuroethological methods and by morphometry of the structures of olfactory epithelium, and perhaps also the principle of its organisation at submicroscopic level (Moulton, 1967), must be verified by further research.

Allison & Warwick (1949) pointed out the importance of the number of olfactory receptors per glomerulus of the olfactory bulbus, as this value might also play a certain role. A study by von Holst (1985) of scent glands and marking behaviour gives evidence of the importance of communication by odour in the lives of insectivores; an excellent sense of smell presumably is its prerequisite.

Schmidt & Schmidt (1982) reported interesting findings on the olfactory organs of *Mus musculus* females in various stages of the ovarian cycle. There was a geraniol sensitivity difference of roughly 5 orders of magnitude between females in metoestrus (5 . 10^{12} molecules/cm³ of air) vs. prooestrus (5 . 10^7 — 5 . 10^8 molecules/cm³ of air).

The results obtained with the intact and enucleated animals indicate that the latter were about 4 times more sensitive to the odour of acetic acid. This finding is comparable with that of Starlinger (1981) who found blind humans more sensitive than sighted persons to high frequency noise.

SUMMARY

Ultimate above-threshold concentrations of acetic acid perceived by lesser white-toothed shrews were determined by operant conditioning in an experi-

mental apparatus constructed by Sedláček (1986) after Bretting (1972).

Seven shrews were used for the experiments, five (4 ♂♂ and 1 ♀) intact and two (2 ♂♂) deprived of eyesight.

Locomotor activity, which was thoroughly recorded in all the test shrews, did not differ from the activity of animals observed by Siegmund & Sigmund (1983) under laboratory conditions. My experiments were made at the periods of maximum locomotor activity of the shrews.

There was no substantial difference between the intact and blind animals either learning abilities or behaviour in the experimental apparatus. Experiments with the blind shrews confirmed Grünwald's (1969) assumption that the spatial memory of Crocidurinae is excellent.

Intact animals were subjected to 689 trials including 8675 choices; the last ascertainable above-threshold concentration was $2.2 . 10^7$ molecules of acetic acid per cm^3 of air.

Enucleated shrews made 1224 choices in 136 trials; the ultimate above-threshold concentration was $5.16 . 10^6$ molecules of acetic acid per cm^3 of air.

Blind shrews were then roughly 4 times more sensitive to the odour of acetic acid than the intact ones.

The species of mammals tested so far for sensitivity to acetic acid can be placed in the following descending order: 1. dog *(Canis familiaris)*, 2. lesser white-toothed shrew *(Crocidura suaveolens)*, 3. hedgehog *(Erinaceus concolor)*, 4. common shrew *(Sorex araneus)*, 5. Norway rat *(Rattus norvegicus)*, 6. man *(Homo sapiens)*, 7. vampire *(Desmodus rotundus)*.

ACKNOWLEDGEMENTS

I am indebted to Dr Leo Sigmund CSc. for supervising my work on the thesis and for critical comments on the manuscript; to Dr F. Sedláček for the loan of the experimental apparatus and olfactometer; to Dr R. Siegmund, Reader in Zoology, Biology Section of the Humboldt University, Berlin for kind permission to reprint Figs. 10 and 11 and for valuable advice.

My thanks are due to Prof. Dr. Z. Veselovský DrSc. for his assessment of my work and for permitting me to take the shrews from the Prague Zoo; to Dr T. Trnka CSc. for supplying me with chemically pure acetic acid; and to Dr M. Josífko CSc. for helping me with the statistical processing of data. I am grateful to Prof. Gill Dryden, Slippery Rock University, Pennsylvania, USA for improving the English of the manuscript.

LITERATURE

Allison, A. C. and R. T. T. Warwick, 1949: Quantitative observations on the olfactory system of the rabbit. *Brain*, 72: 186–197.

Bretting, H., 1972: Die Bestimmung der Riechschwelle bei Igeln (Erinaceus europaeus L.) für einige Fettsäuren. *Z. Säugetierkunde*, 37: 286–311.

Clark, W. E. Le Gros, 1932: The brain of the Insectivora. *Proc. Zool. Soc. London*, 2, 102: 975–1013.

Ganeshina, L. V., N. N. Vorontsov and V. I. Chabovsky, 1957: Comparative morphological study of the nasal cavity structure in certain representatives of the order Insectivora. *Zool. Zh.*, 36: 122–137. (In Russian.)

Gruch, W., 1957: Über die Riechfähigkeit bei Wanderratten. *Zool. Jb., Abt. Allg. Zool. und Physiol.*, 67: 65–80.

Grünwald, A., 1969: Untersuchungen zur Orientierung der Weisszahnspitzmaus (Soricidae — Crocidurinae). *Z. vergl. Physiol.*, 65: 191–217.

Hensel, H., 1966: Allgemeine Sinnesphysiologie. Hautsinne, Geschmack, Geruch. Lehrbuch der Physiologie. Heildelberg.

Holling, C. S., 1958: Sensory stimuli involved in the location and selection of sawfly cocoons by small mammals. *Can. J. Zool.*, 36: 633–653.

Holst, D. v., 1985: Potential Scent Glands and Presumed Marking Behaviour in

Mammalian Groups of the Eutherian Stock: Insectivora, Macroscelidea and Scandentia: In: Social odours in Mammals. D. MacDonald and R. E. Brown, Eds.
Johannesson-Gross, K. and H. Gross, 1982: Lernversuche mit Maulwürfen (Talpa europaea L.) unter Anwendung einer speziellen Labyrinthmethode. *Z. Säugetierkunde*, 47: 277–282.
Moulton, D., 1967: Olfaction in mammals. *Am. Zoologist*, 7: 421–429.
Nagel, A., 1980: Sauerstoffverbrauch, Temperaturregulation und Herzfrequenz der europäischen Spitzmäuse (Soricidae, Mammalia). Diss. Tübingen. 86 pp.
Nagel, A., 1985: Sauerstoffverbrauch, Temperaturregulation und Herzfrequenz bei europäischen Spitzmäusen (Soricidae). *Z. Säugetierkunde*, 50: 249–266.
Neuhaus, W., 1953: Über die Riechschärfe des Hundes für Fettsäuren. *Z. vergl. Physiol.*, 35: 527–552.
Neuhaus, W., 1957: Unterchiede in der Riechschärfe bei Hunden. *Z. vergl. Physiol.*, 40: 65–72.
Schmidt, U., 1975: Vergleichende Riechschwellenbestimmungen bei neotropischen Chiropteren (Desmodus rotundus, Artibeus lituratus, Phyllostomus discolor). *Z. Säugetierkunde*, 40: 269–298.
Schmidt, C. and U. Schmidt, 1980: Changes of the olfactory sensitivity during the estrus cycle in female laboratory mice. *Chem. Sens.*, 5: 359–365.
Sedláček, F., 1986: Sensitivity of the Olfactory Organ of the Common Shrew (Sorex araneus) to Some Fatty Acids. *Věst. čs. Společ. zool.*, 50: 136–148.
Shibkov, A. A., 1979: The role of sensory systems in the proximal orientation of shrews of the genera Sorex and Neomys. *Zool. Zh.*, 58: 76–81. (In Russian.)
Siegmund, R. and L. Sigmud, 1983: Circadian oscillations of locomotor activity in Crocidura suaveolens (Soricidae, Insectivora, Mammalia). *Z. Säugertierkunde*, 48: 185–187.
Sigmund, L., 1985: Anatomy, morphometry and function of sense organs in shrews (Soricidae, Insectivora, Mammalia). *Fortschritte Zool.*, 30. Duncker/Fleischer (Eds.), Vertebrate Morphology: 661–665.
Sigmund, L. and C.-P. Claussen, 1986: Zur Ultrastruktur der Retina von Waldspitzmaus (Sorex araneus) und Gartenspitzmaus (Crocidura suaveolens). *Verhandl. Anat. Ges.*, 80.
Sigmund, L. and F. Sedláček, 1985: Morphometry of the olfactory organ and olfactory thresholds of some fatty acids in Sorex araneus. *Acta Zool. Fennica*, 173: 249–251.
Sigmund, L., R. Siegmund and C.-P. Claussen, 1986: Bau und Funktion der optischen Sinnesorgane bei der Waldspitzmaus (Sorex araneus) und der Gartenspitzmaus (Crocidura suaveolens) und ihre Beziehung zum Verhalten. *Zool. Jahrb., Abt. Physiologie* (in press).
Skramlik, E., 1948: Über die minimalen Erregungen des menschlichen Geruchs- bzw. Geschmacksinnes notwendigen Molekülmengen. *Pflügers. Arch. Physiol.*, 249: 702–716.
Starlinger, I., W. Niemeyer, 1981: Do the blind hear better? Investigations on Auditory Processing in Congenital or Early Acquired Blindness. *Audiology*, 20: 503–515.
Stephan, H., 1967: Zur Entwicklungshöhe der Insektivoren nach Merkmalen des Gehirns und die Definition der „Basalen Insektivoren". *Zool. Anz.*, 179: 177–199.
Vlasák, P., 1970: The biology of reproduction and post-natal development of Crocidura suaveolens Pallas, 1811 under laboratory conditions. *Acta Univ. Carol., Biol.:* 207–292.
Vogel, P., 1972: Beitrag zur Fortpflanzungsbiologie der Gattungen Sorex, Neomys und Crocidura (Soricidae). *Verh. Naturforsch. Ges. Basel*, 82: 165–192.
Vogel, P., 1980: Metabolic levels and biological strategies in shrews. In: Comparative Physiol.: Primitive Mammals: 170–180. Ed.: Schmidt-Nielsen, K., Cambridge Univ. Press (London).
Wöhrmann-Repenning, A., 1975: Zur vergleichenden makro- und mikroskopischen Anatomie der Nasenhöhle europäischer Insektivoren. *Gegenb. Morphol. Jb.*, 12: 689–756.
Zima, J., 1976: Quantitative Anatomic Study on the Olfactory Organ in Insectivora. Diss. Prague. (In Czech.)

Author's address: RNDr. Marie Cízová, Institute of Physiology, Czechoslovak Academy of Sciences, Vídeňská 1083, Praha 4 - Krč, ČSSR.

Věst. čs. Společ. zool., **51**: 120—124, 1987
ISSN 0042-8736

Cultural Section of the District National Committee in Benešov
and Department of Systematic Zoology, Faculty of Sciences,
Charles University, Prague

FURTHER NOTES ON THE GROWTH OF THE CHUB (LEUCISCUS CEPHALUS, PISCES, CYPRINIDAE) IN THE KLÍČAVA RESERVOIR

Lubomír HANEL

Received May 20, 1986

Abstract. Age and growth of 135 specimens of the chub, *Leuciscus cephalus* (Linnaeus, 1758), collected during the years 1981—82 in the Klíčava reservoir (Bohemia) were studied using the scale method. Current growth indicators were ascertained and compared with the data from the same locality concerning the years 1976—80.

MATERIAL AND METHODS

All material studied has been collected into gill nets in catching periods of May, 14, and September, 9, 1981, and May, 14, 18—19, 22—23, 1982. In 1981, 60 specimens were collected (110—410 mm, ave. 249 mm of the body length), and in 1982, 75 specimens (190—340 mm, ave. 252 mm of the body length). On the scale method used see Hanel (1980, 1984).

RESULTS AND DISCUSSION

For the review of authors who studied the length growth of the chub see Hanel (1982). The length growth in the Klíčava reservoir in the years 1981—1982 is given in Tables 1 and 2. The average length growth in 1981—82 was calculated on the base of 48 females (age from 2+ to 8+) and 46 males (age from 3+ to 8+) as follows (females/males; in mm of the body length): l_1 — 43/46, l_2 — 106/116, l_3 — 166/172, l_4 — 208/202, l_5 — 234/215, l_6 — 252/239, l_7 288/252, l_8 — 299/279. In the same reservoir, Holčík (1965) and Pecl (1969) found also a more rapid length growth in females. The average length growth of the chub calculated from both sexes (1655 specimens) in the Klíčava reservoir during the period of 1967—1982 was found as (in mm of the body length): l_1 — 54, l_2 — 123, l_3 — 179, l_4 — 214, l_5 — 241, l_6 — 263, l_7 — 281, l_8 — 303, l_9 — 320, l_{10} — 346, l_{11} — 362, l_{12} — 388, l_{13} — 383.

In this reservoir gillnetted specimens were found of 437 mm of the body length weighing 1825 g, age 10+ (Holčík, 1965) and of 410 mm of the body length weighing 1420 g, age 12+, in 1981. Ford-Walford theoretical value (L_∞) (see Ricker, 1975) informed on the maximum length reached in the Klíčava reservoir was calculated as 439 mm of the body length. The longest angled specimens of the chub in Czechoslovak waters were found in the river Berounka (Bohemia). In 1982, a chub of 790 mm of the total length (= 658 mm of the body length) weighing of 3020 g was caught here (angler Jiří Jelínek from Řevnice), and in 1984, a specimen of 790 mm of the total length and

Tab. 1. Length growth of the chub in the reservoir Kličava (in mm of the body length).
Specimens gillnetted in the year 1981; *n* — number of examined specimens, t — body length in the time capture

Age	n	t	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	l_{12}
1+	3	115	59											
		(110–120)	(38–70)											
2+	2	135	51	129										
		(130–140)	(48–53)	(123–134)										
3+	1	165	46	75	131									
4+	28	236	47	113	175	211								
		(192–280)	(33–61)	(85–159)	(114–201)	(181–240)								
5+	12	258	44	111	160	204	232							
		(220–300)	(37–57)	(76–137)	(104–198)	(169–233)	(187–263)							
6+	10	277	50	122	181	211	231	255						
		(240–320)	(40–64)	(78–142)	(109–197)	(136–234)	(167–259)	(209–298)						
7+	15	280	47	114	166	199	222	241	259					
		(220–310)	(30–72)	(61–158)	(104–194)	(155–224)	(179–245)	(196–270)	(203–282)					
8+	2	335	47	126	190	229	255	273	299	318				
		(320–350)	(39–55)	(111–141)	(170–210)	(215–243)	(246–263)	(272–274)	(294–304)	(305–331)				
12+	1	410	48	139	179	201	223	245	259	283	314	344	374	398
simple averages			49	116	169	209	233	254	272	301	314	344	374	398
weight averages			48	115	171	208	229	248	263	306	317	344	374	398

Tab. 2. Length growth of the chub in the reservoir Kličava (in mm of the body length).
Specimens gillnetted in the year 1982; n — number of examined specimens, t — body length in the time of the capture

Age	n	t	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
2+	10	200	51	130									
		(160–230)	(36–64)	(100–163)									
3+	13	231	43	93	157								
		(200–220)	(32–55)	(63–135)	(124–187)								
4+	12	219	40	87	147	189							
		(195–295)	(30–56)	(43–142)	(103–223)	(138–261)							
5+	23	249	41	106	164	201	231						
		(200–280)	(30–54)	(61–145)	(79–203)	(116–230)	(155–256)						
6+	20	269	43	107	154	195	223	247					
		(240–290)	(30–54)	(47–143)	(103–200)	(176–226)	(198–242)	(216–267)					
7+	20	271	42	90	145	183	209	231	253				
		(230–330)	(33–62)	(52–144)	(89–188)	(107–220)	(155–240)	(169–278)	(208–295)				
8+	7	286	43	102	153	190	215	231	253	269			
		(270–310)	(32–61)	(74–139)	(115–189)	(159–212)	(188–238)	(215–261)	(235–276(	(246–290)			
9+	1	345	64	123	201	225	238	260	277	304	330		
10+	1	340	32	56	137	189	227	257	268	290	304	320	
11+	1	340	44	112	184	228	238	248	258	278	298	314	324
simple averages			44	101	160	200	226	246	262	285	311	317	324
weight averages			43	101	154	193	221	239	254	276	311	317	324

weighing 3500 g (angler Vladimír Vořechovský from Prague) (see Anonymus, 1983, 1985).

The average coefficients of condition (see Holčík, Hensel, 1972) was 1.93 (15 males) and 1.95 (32 females) in 1981 and 1.85 (26 males) and 1.99 (11 females) in 1982.

Length/weight relationship from both sexes in 1981 (51 specimens, 110—410 mm of the body length, ave. 249 mm; 24—1420 g, ave. 300 g) was calculated as log w = −4.78365 + 3.02897 log l, and in 1982 (59 specimens, 190—340 mm of the body length, ave. 252 mm; 130—760 g, ave. 299 g) as log w = −5.25342 + 3.21947 log l. The length/weight relationship (general equation log w = a + b . log l) was ascertained in the years 1967—1979 (see Hanel, 1980) in this locality, and only in one equation (average equation for the years 1969—1972) the coefficient "b" was higher than 3. When we compare the average length growth in the Kličava reservoir in the years 1967—1980 and in the years 1981—1982, it is evident that in the latter two years the growth is relatively worse, nevertheless, it is better than in the flowing waters of Czechoslovakia (Hanel, 1982).

SUMMARY

The growth of 135 specimens of the chub from the Kličava reservoir in the years 1981—1982 is presented. The average length growth in 1981—1982 is worse in comparison with the average values of the years 1967—1980. The theoretically attainable body length ($L\infty$) determined in this locality from the values of the years 1967—1982 was 439 mm. This length is in full correspondence with the average value calculated from 6 other reservoirs in Czechoslovakia (Hanel, in print). The length growth of females is more rapid than in males from the 4th year of their age on average. This fact is typical of most localities in Czechoslovakia (see Hanel, in print). The average length growth calculated for the years 1967—1982 is l_1 — 54, l_2 — 123, l_3 — 179, l_4 — 214, l_5 — 241, l_6 — 263, l_7 — 281, l_8 — 303, l_9 — 320, l_{10} — 346, l_{11} — 362, l_{12} — 388, l_{13} — 383 mm of the body length.

Acknowledgements

Thanks are due to Dr. K. Pivnička for offering kindly all scales for study, and to Dr. O. Oliva, Sen. Lecturer in Vertebrate Zoology, Charles University, Prague, for the critical reading of the typescript.

LITERATURE

Anonymus, 1983: Vyhodnocení soutěže o rekordní úlovek roku 1982. *Rybářství*, 7: 156—161.

Anonymus, 1985: Vyhodnocení soutěže o rekordní úlovek roku 1984. *Rybářství*, 5: 104—108.

Hanel, L., 1980: Odhady základních ekologických parametrů jelce tlouště v Klíčavské údolní nádrži v letech 1967—1979. M. Sc. thesis, unpublished (in Czech), 1—74.

Hanel, L., 1982: Note on the length growth of the chub (Leuciscus cephalus, Pisces, Cyprinidae) in the reservoir Klíčava and the river Berounka. *Věst. čs. Společ. zool.*, 46: 211—256.

Hanel, L., 1984: Notes on the age and growth of the chub (Leuciscus cephalus), dace (L. leuciscus) and orfe (L. idus) (Pisces), Cyprinidae in the rivulet Bystřice (Northeastern Bohemia). *Věst. čs. Společ. zool.*, 48: 81—89.

Hanel, L., (in print): Růstové možnosti jelce tlouště (Leuciscus cephalus L.) v československých vodách s poznámkou k novému indexu na porovnávání délkového růstu ryb. *Acta mus. Reginaehradecensis.*

Holčík, J., 1965: Dynamika rybích populácií vo vodárenskej údolnej nádrži Klíčava. Ph. D. thesis (unpublished, in Czech), 1—269.
Holčík, J., Hensel, K., 1972: Ichtyologická príručka. Obzor, Bratislava, 1—217.
Pecl, K., 1969: Jelec tloušť (Leuciscus cephalus, Linnaeus, 1758) v Klíčavské údolní nádrži. M. Sc. thesis, unpublished (in Czech), 1—92.
Ricker, W. E., 1975: Computation and interpretation of biological statistics of fish populations. Bull. 191 of Fish Res. Board Canada, Ottawa, 1—382.

Author's address: RNDr. Lubomír Hanel, Kladruby 30, 257 62, Č.S.S.R.

Věst. čs. Společ. zool., **51**: 125—128, 1987
ISSN 0042—6595

Department of Zoology, National Museum, Praha

ON SUPERNUMERARY ROOTS IN THE PERMANENT TEETH OF CARNIVORA

Ivan HERÁŇ

Received May 19, 1986

A b s t r a c t. Findings of supernumerary roots in the permanent teeth (P^3, P_4, M^1) of three species of Canidae (*Canis lupus, Vulpes vulpes* and *Chrysocyon brachyurus*) are reported. The size and shape of supernumerary roots as well as the frequency of their occurrence in the respective species are discussed and confronted with previous data. Attention is called to a high probability of genetic nature of the respective anomaly.

INTRODUCTION

Notes on supernumerary roots (SR), and on deviations in root number in general, are not very frequent in papers dealing with the teeth anomalies in mammals. As for Carnivora, only several publications are known to the author in which the occurrence of SR or some other abnormities in root number and /or shape are referred to (see the following text). That is why findings of SR in teeth of three species of Canidae (*Canis lupus, Vulpes vulpes* and *Chrysocyon brachyurus*) are described in the present communication.

MATERIAL

The occurrence of SR was found in Carnivora during systematic examinations of their skulls deposited in anatomical collections of the National Museum of Prague as well as of those which were occasionally loaned to the author by several other institutions. Five skulls among the total of 904 specimens (217 Mustelidae, 19 Procyonidae, 5 Ailuridae, 70 Ursidae, 10 Viverridae, 7 Hyaenidae, 391 Canidae and 185 Felidae), have shown developed SR in one tooth at least (for standard skull measurements see Tab. 1). This number represents 1.3 % of the family Canidae and 0.6 % of all the skulls under study. However, only external view of jaws was examined in the respective material so that contingent hidden (ntraalveolar) deviations of the roots are not registered.

REVIEW OF THE FINDINGS

Canis lupus Linné, 1758

Deviations in the shape and number of roots in two upper and two lower premolars (P^3 and P_4, left and right) were found in a single skull out of altogether 32 specimens (frequency F = 3.1 %).

(1) Coll. No NM 10980. Adult specimen, sex and other data unknown. Acquired from the collection of the ceased firm of V. Frič, Praha.
(a) Sizable SR is localized in the middle of lingual margin in the both left and right P^3 (Fig. 1). Markedly altered view of the respective crown face is practically identical in the left and right tooth.

Tab. 1. Skull measurements of material examined

Species and coll. No	Cb length	Greatest skull length	Zygomatic breadth	Length of teeth row upper	lower
Canis lupus					
NM 10980	235.7	255.8	147.3	127.4	131 7
Vulpes vulpes					
NM 11865	137.7	141.6	73.9	76.9	—
NM 11868	128.8	134 8	69.3	73.1	—
Chrysocyon brachyurus					
DK 394	220.4	234.7	119.8	116.6	—
DK 450	208 6	221 6	105.8	106 0	—

NM = zoological collections of the National Museum, Praha
DK = osteological collections of the East-Bohemian Zoological Garden, Dvůr Králové n. Labem

(b) Occurrence of SR in the middle of lingual margin of P_4 and corresponding modifications of the respective crown face are more expressed in the right tooth (Fig. 2) than in the left one. In both the teeth, SR fuse with the posterior root (Fig. 3); it is well developed regarding its size, however, it contains no root canal (canalis radicis dentis, Fig. 4).

Vulpes vulpes (Linné, 1758)

Supernumerary root was found in one left and two right P^3 in two out of 151 skulls examined (F = 1.3 %).

(2) Coll. No NM 11865. Adult specimen, sex and other data unknown. Collection of V. Frič, Praha.
Sizable SR found in the middle of lingual margin in the right P^3. The external view of the respective face of the tooth crown is only very slightly altered (Fig. 5).

(3) Coll. No NM 11868. Adult specimen, sex unknown. Caucasus, Oct. 27, 1901. Collection of V. Frič, Praha.
Very minute SR occurs in the mesial third of buccal margin of the left P^3 (Fig. 6), a stronger one in the analogous position in the right P^3 (Fig. 7).

Chrysocyon brachyurus (Illiger, 1817)

The supernumerary root was found in one right and two left M^1 in two out of 12 skulls under study (F = 16.6 %).

(4) Coll. No DK 394. Adult female, age 8 years at least. Born free (Paraguay), died in ZOO Dvůr Králové in 1980. Short SR located in the middle of buccal margin in the left M^1 (Fig. 8).

(5) Coll. No DK 450. Female, 1 year old (a cub of the female DK 394). Born and kept in ZOO Dvůr Králové, 1980 to 1981. Relatively long weak SR occurs in the middle of buccal margin in the right M^1 (Fig. 9), a somewhat smaller is found in an analogous position (but wholly intraalveolar) in the left M^1.

DISCUSSION AND CONCLUSIONS

The above given review shows that SR was found in three species of Canidae only. Such a restriction to a single family, however, is probably caused

mainly by its high representation in the sample (about 43 % of all specimens examined) as deviations in the number and shape of roots are already known also in Felidae (European lynx, Kratochvíl 1963; Domestic cat, Kratochvíl 1971, Lüps 1977, Porkert pers. comm.) and Mustelidae (Weasel, Wolsan 1983; Pine marten, Wolsan et al. 1985), as well as in several non-carnivorous species, e. g. in the Domestic cattle (Kratochvíl in litt.) or in the Reindeer (Zázvorka 1940, and others). They are known in the Man, too.

The findings of SR in Foxes seem to be the most common regarding the literature data (cf. Döcke 1956, van Bree and Sinkeldam 1969, Lüps 1974), while those in *Canis lupus* and *Chrysocyon brachyurus* have not been published till now. On the contrary, no SR was found by the author among 169 specimens of the Domestic dog, although its occurrence is referred to in the paper by Stockhaus (1962).

Most SR were found in the upper teeth, viz. in P^3 and M^1 (50 % and 30 % of the all root anomalies, respectively); in the lower teeth, morphological alterations caused by SR were stated in P_4 of a single specimen only (20 % of the total number). On the contrary, most papers dealing with the root anomalies in carnivores bear upon the lower teeth; they represent 90 % of all cases (P_3 — 36.7 %, P_1 — 31.8 %, P_2 — 17.0 %, P_4 — 2.4 % and M_2 — 2.4 %) while the remaining 10 % are composed of M^1 (7.3 %) and P^3 (2.4 %). A rather different situation is described only in the paper by Wolsan et al. (l. c.) where, in addition to three finds of P^3 with SR, numerous P^3 with an altered distal root are noted in *Martes martes*.

The size of SR varies substantially in the author's material. Very strong and large SR like those found in the Fox (2) and mainly in the Wolf (1a) are not very often noted in recent publications. Short and weak SR of the Maned wolf (4) seem to occur more commonly, and not only in the carnivores; in the Reindeer, they can be frequented up to 50 % in certain populations (Kormos ex Zázvorka 1940).

Shaping up the roots of lower P_4 in the Wolf (1b) corresponds, with a high probability, to the morphotype A3 which has been described by Wolsan et al. (l. c.) as a transitive type between the three-rooted (primitive) and two-rooted (progressive) premolars. A similar type was found also in M^1 of the Lynx (Kratochvíl 1963) where, however, two regular roots were fused. This is known to a human dentistry as well. Nevertheless, with regard to the author's own findings of the minute separated SR in several specimens of his material, *it seems to be probable that the above mentioned conception does* not present the only possible way of reducing the roots number in carnivores.

The identical occurrence of SR in the female Maned wolf and in her cub (4 and 5) indicates that this anomaly might be considered as a genetical character; although the conformity mentioned is the only one which supports the respective conclusion, the localization of SR in M^1 is unusual to such a degree that its accidental developing in two related specimens seems to be extremely unprobable. Besides, a similar situation like this is described by Lüps (1974) in Foxes where, in a rather numerous sample of skulls (n = 488), an occurrence of SR was restricted to the specimens caught in a limited area and time space only. According to Döcke (1956), the dental anomalies of this kind are inherited as recessive characters. However, dental variations from the normal condition, in general, are supposed to be probably mostly

congenited in their origin in mammals (M a n v i l l e 1963) as well as in human medicine.

A c k n o w l e d g e m e n t s

Author's best thanks are due to the following persons: Dr. Ing. L. J. Dobroruka (East-Bohemian Zoological Garden, Dvůr Králové) for data on the loaned specimens of the Maned wolf; to MUDr. J. Vavrein, CSc. (1st Dentistry Clinic, Praha) for consulting the respective problems connected with human dentistry; to Prof. MUDr. L. Vyhnánek, CSc. (Radiological Clinic, Praha) for kindly providing the necessary X-ray photographs of the material studied.

REFERENCES

B r e e, P. J. H van, S i n k e l d a m, E. J., 1969: Anomalies in the dentition of the Fox, Vulpes vulpes (Linnaeus, 1758), from continental Western Europe. *Bijdragen tot de Dierkunde*, 39: 3—5

D ö c k e, F., 1956: Zahn-und Bissanomalien beim Wild- und Farmfuchs. Berlin (Dissert., Typoscript).

K r a t o c h v í l, Z., 1963: Ein Beitrag zur Kenntnis der Variabilität, des Vorkommens und der Form von M¹ beim Luchs (Lynx lynx L.) *Zoolog. listy*, 12 (4): 352—354. (in Czech with the German summary).

K r a t o c h v í l, Z., 1971: Oligodonty and polyodonty in the Domestic cat (Felis silvestris f. catus L.) and the Wild cat (Felis silvestris silvestris Schreber). *Acta vet. Brno*, 40: 33—40.

L u p s, P., 1974: Dreiwurzlige Praemolaren bei Rotfüchsen. *Ztsch. f. Jagdwissenschaft*, 20 (3): 163—165.

L ü p s, P., 1977: Gebiss- und Zahnvariationen an einer Serie von 257 Hauskatzen (Felis silvestris f. catus L., 1758). *Zool. Abhandl., Staatl. Mus. Tierkd. Dresden*, 34 (11): 155—165.

M a n v i l l e, R. H., 1963: Dental anomalies in North American Lynx. *Ztsch. f. Saugetierkd.*, 28: 166—169.

S t o c k h a u s, K., 1962: Zur Formenmannigfaltigkeit von Haushundschädeln. *Ztsch. Tierzücht. Züchtungsbiol.*, 77: 223—228.

W o l s a n, M., 1983: Ancestral characters in the dentition of the Weasel Mustela nivalis L. (Carnivora, Mustelidae). *Ann. Zool. Fennici*, 20: 47—51.

W o l s a n, M., R u p r e c h t, A. L., B u c h a l c z y k, T., 1985: Variation and asymmetry in the dentition of the Pine and Stone martens (Martes martes and Martes foina) from Poland. *Acta theriol.*, 30 (3): 79—114.

Z á z v o r k a, V., 1940: Rangifer arcticus Richards of Bohemian pleistocen. *Čas. Nár. muzea v Praze, odd. přír.*, 114: 96—98. (in Czech)

The figures 1 — 9 will be found at the end of this issue.

Author's address: **Dr. Ivan Heráň, National Museum (Nat. History), 115 79 Praha 1,** Czechoslovakia.

Věst. čs. Společ. zool., **51**: 129—135, 1987
ISSN 0042—6595

Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice

REVIEW OF CAPILLARIID NEMATODES (CAPILLARIINAE) PARASITIC IN AMPHIBIANS AND REPTILES. PART 4. GENUS PSEUDOCAPILLAROIDES, SPECIES INQUIRENDAE, LIST OF SPECIES BY HOST FAMILIES

František MORAVEC

Received September 10, 1985

Abstract The revision of capillarids from cold-blooded vertebrates has confirmed that *Pseudocapillaroides* Moravec et Cosgrove, 1982 is a monotypic genus containing a single species, *C. xenopi* Moravec et Cosgrove, 1982; *Capillaria xenopodis* Wade, 1962 is considered its junior synonym. Three capillarid species described from amphibians, *Trichosoma bombinatoris* Linstow, 1892, *Capillaria fujianensis* Wang, 1982 and *C. ranae* Wang, 1982, cannot be assigned, for the time being, to any of the presently valid genera and these are considered *species inquirendae*. The name *Trichosoma crotali* Rudolphi, 1819 reported from snakes is considered *nomen nudum*. A list of capillarid species according to the families of host amphibians and reptiles has been provided.

This paper, representing the last part of a revision of capillariids from amphibians and reptiles, is a continuation of the author's previous papers dealing with this topic (see Moravec, 1986a, b, c).

IV. Genus *Pseudocapillaroides* Moravec et Cosgrove, 1982

Diagnosis: Length of female twice to four times that of male, diameter approximately double; stichosome composed of single row of stichocytes; lateral caudal alae in male absent; posterior end of male rounded, provided with two small, round dorsolateral lobes, each of them bearing minute papilla; dorsal cuticular membrane absent; spicule well sclerotized, with smooth surface; spicular sheath nonspiny; vulvar appendage absent; mature eggs in uterus larvated; parasitic in skin of amphibians.

Type- and the only species: *P. xenopi* Moravec et Cosgrove, 1982

1. *Pseudocapillaroides xenopi* Moravec et Cosgrove, 1982 (Fig. 1)

Syn.: *Capillaria xenopodis* Wade, 1962.

Description (after Moravec et Cosgrove, 1982): Very small, slender, thread-like nematodes 1—5 long; length of gravid female twice to four times that of male. Head end somewhat narrowed, rounded, with indistinct oral papillae; a very small stylet appearing to be present. Cuticle of head end with very fine, dense transverse striation starting a short distance from anterior extremity. Two fairly wide lateral bacillary bands present, extending practically along whole body length; bacillary bands appearing to be composed of numerous hypodermal round formations (cells), each containing a small central, highly refractile papilla. Stichosome consisting of a single row of

mostly short stichocytes provided with conspicuously large cell nuclei; some stichocytes, mostly those at posterior part of stichosome, subdivided into several transverse annuli. Nerve ring encircling muscular oesophagus slightly in front of its mid-length. Oesophagus opening into intestine through well developed valves; two large, oval cells present at junction of oesophagus and intestine.

Male (3 specimens): Length of body 1.17—1.77, maximum width 0.030—0.042. Maximum width of bacillary bands in mid-body 0.012. Length of entire oesophagus 0.579—0.775 (42—49 % of body length). Length of muscular oesophagus 0.108—0.147, distance of nerve ring from anterior extremity 0.045—0.054. Length of stichosome 0.471—0.661, stichocytes 24—26 in number. Spicule well sclerotized, colourless, 0.177—0.210 long; its proximal end somewhat expanded (width 0.009), distal end narrowed (width 0.003), spicule width at its middle part being 0.003—0.006; spicular surface smooth, distal tip of spicule rounded. Spicular sheath nonspiny; evaginated spicular sheath densely serrated at both sides; length of evaginated sheath 0.315, its width 0.012. Posterior end of body rounded, provided with two small, round dorsolateral lobes, each containing one small papilla. Cloacal opening subterminal, length of tail being 0.003—0.006.

Female (7 specimens): Body length of gravid females 3.29—5.13, maximum width 0.060—0.078; embryonated eggs present in uteri of females with body length 3.65—5.13, while uterus of one female 3.29 long contained only non-embryonated eggs. Maximum width of lateral bacillary bands 0.030. Length of entire oesophagus 0.938—1.360 (25—28 % of body length). Length of muscular oesophagus 0.117—0.201, distance of nerve ring from anterior extremity 0.054—0.069. Length of stichosome 0.821—1.211, stichocytes 27—31 in number. Posterior end of body rounded, anal pore almost terminal, length of tail being only 0.005—0.006. Rectum relatively short, in one specimen measuring 0.102. Ovary reaching posteriorly to mid-length of rectum. Vulva situated a short distance (0.024—0.045) below stichosome end level, in smallest female at its level. Vulvar lips not elevating. Uterus occupying most space of postoesophageal part of body and containing numerous, anteriorly gradually developing eggs; eggs arranged in one row near vulva region, more distant eggs in several rows. Fully mature eggs in uterus containing already formed larva, this being coiled inside egg shells. Mature, embryonated eggs elongate-oval in shape, with protruding polar plugs. Egg wall colourless, two-layered, 0.0015—0.0020 thick, inner layer hyaline, highly refractile; outer layer very thin, slightly thicker near egg poles only, with very fine, almost indistinct superficial sculpture. Width of polar plugs 0.005, their total hight 0.005, hight of their protruding part 0.002—0.003. Size of mature (larvated) eggs including polar plugs 0.060—0.070 × 0.027—0.033. Fully developed eggs more elongate in shape than those less developed.

Localization: in tunnels in the epidermis of skin.

Host: South African clawed frog, **Xenopus laevis* (fam. Pipidae).

Distribution: Apparently, the natural distribution of *P. xenopi* is in South Africa; so far this species has been recorded from the laboratory breedings of *X. laevis* in the USA (Oak Ridge, Tennessee) (Cosgrove and Jared, 1974, 1977, Moravec and Cosgrove, 1982) and in the wild *X. laevis* imported to the USA (Ithaca, New York) from South Africa (Wade 1982).

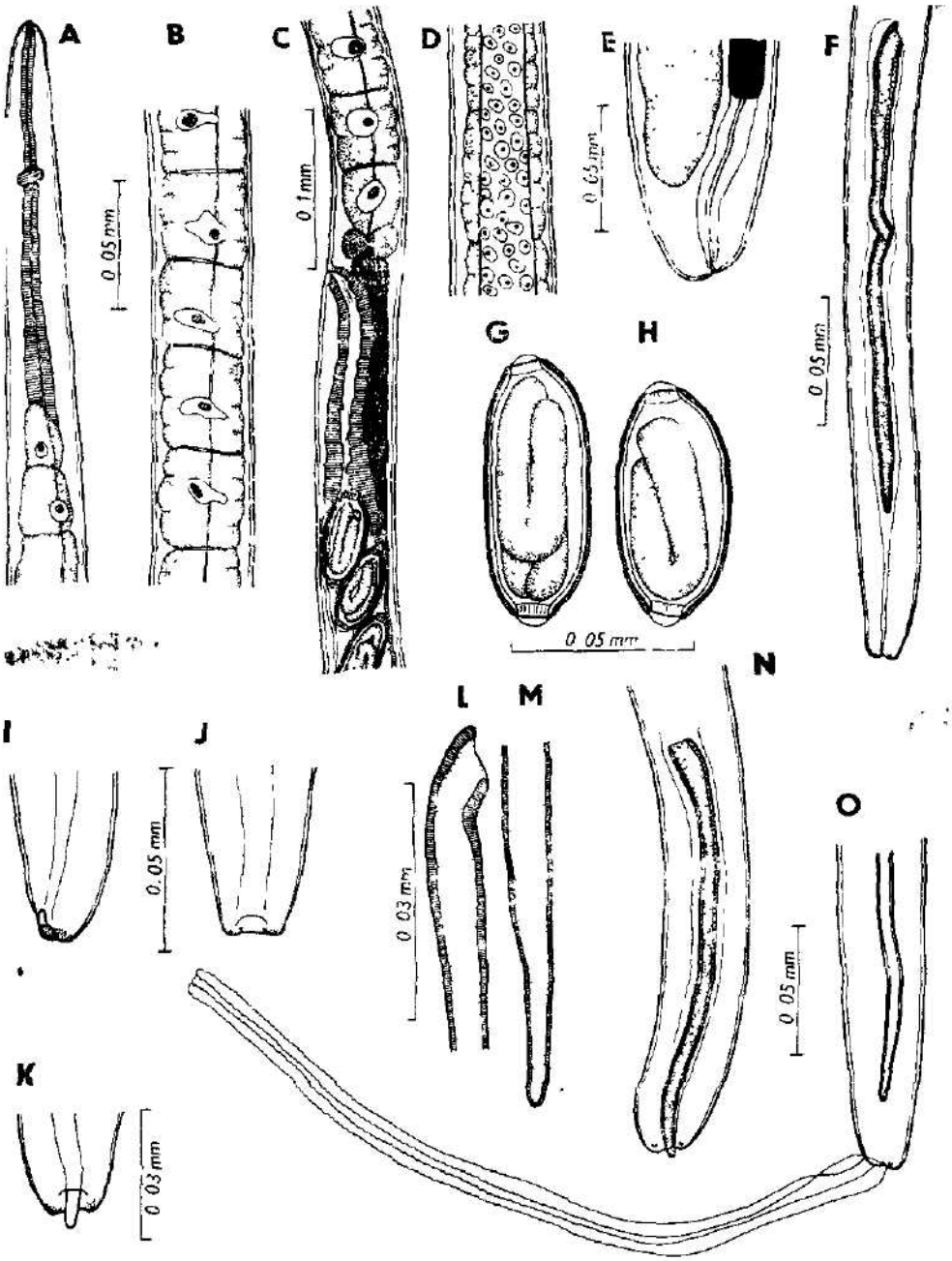


Fig. 1. *Pseudocapillaroides xenopi* Moravec et Cosgrove, 1982 from skin of *Xenopus laevis*. A — head end; B — stichosome region; C — vulva region; D — stichosome region with marked lateral bacillary band; E — tail of female; F — posterior end of male; G, H — mature egg from female uterus; J—K — tail of male. lateral and ventral views; L. M — proximal and distal ends of spicule, N. O — posterior end of male (After Moravec and Cosgrove, 1982.)

Specimens: Institute of Parasitology, Czechoslovak Academy of Sciences, České Budějovice — holotype, allotype and paratypes; Musée Royal de l'Afrique Centrale Tervuren — paratypes.

Comments: In 1982, independently on each other, Moravec and Cosgrove (1982) and Wade (1982) described this species as *Pseudocapillaroides xenopi* and *Capillaria xenopodis*, respectively. Since the paper of the first authors appeared on 31 March, while the second paper only on 15 April, the valid name of this parasite, in accordance with international rules, is *P. xenopi*, whereas *C. xenopodis* is its junior synonym. Cosgrove and Jared (1974, 1977) were the first to discover these interesting nematodes in the laboratory-bred *Xenopus laevis* in the USA, where they had caused extensive damage to the skin of the host frogs; the affected frogs had decreased activity and ability to feed and died after several months.

It has been shown by Moravec and Cosgrove (1982) that *P. xenopi* is noted for some features (the presence of larvated eggs in the uterus, marked differences in the body length between males and females, the localization in the host's skin) indicating its affinities with some members of the family Trichosomoididae, namely to the genera *Anatrichosoma* and *Paratrichosoma* (the latter genus is now considered to belong to the Capillariinae, fam. Trichuridae). On the basis of a considerable difference of *P. xenopi* from other capillariid species, Moravec and Cosgrove (1982) erected an independent genus *Pseudocapillaroides* to accomodate it, this being accepted in this paper too.

According to experimental studies by Wade (1981), the development of this parasite is direct, without an intermediate host; the parasite's eggs, containing first-stage larvae, are the only source of infection for the definitive host.

V. Species of amphibian capillariids considered as *species inquirendae*

1. *"Trichosoma" bombinatoris* Linstow, 1892

Description (adapted from Linstow, 1892): Body length of larval nematode 1.2, its width 0.026. Anlagen of genital organs lacking. Cuticle relatively thick, representing some $^1/_9$ of body width. Oesophagus very long, making $^9/_{11}$ of whole body length, formed by thin tube overlapped by cells with nuclei. Nuclei sometimes surrounded by glandular layer. Anus terminal.
Localization: intestine.
Host: Frog, *Bombina bombina* (fam. Bombinidae).
Distribution: Europe — Germany (Linstow 1892).

Specimens: The type specimen of *T. bombinatoris* was not reexamined.

Comments: This species was established on the basis of a single larva. Although it is probable that this larva belonged to a member of the subfamily Capillariinae, neither its specific nor generic identification is possible. Therefore, it is necessary to consider *T. bombinatoris* as *species inquirenda*.

2. *"Capillaria" fujianensis* Wang, 1982

Description (adapted from Wang, 1982):
Male: Length of body 5.80—6.36, maximum width 0.040—0.043. Length of entire oesophagus 3.08—3.40; number of stichocytes 30. Length ratio of anterior oesophageal part of body and posterior part of body 1 : 0.9. Length of spicule 0.62—0.64.

Female: Length of body 8.40—10.56, maximum width 0.064—0.076. Length of entire oesophagus 3.2—3.6, number of stichocytes 30—32. Length ratio of anterior oesophageal part of body and posterior part of body 1 : 1.6. Vulva provided with linguiform appendage. Size of eggs 0.054—0.060 × 0.026—0.030.
Localization: intestine.
Host: The toad *Bufo melanostictus* (fam. Bufonidae).
Distribution: China (Fuzhou, Prov. Fujian) (Wang, 1982).

Specimens: I did not succeed in obtaining the type specimens of C. *ranae* for study.

Comments: The original description of "C." *fujianensis* is very incomplete and the drawings too schematic; consequently, it is impossible to assign this species to a genus. Some features (e. g. the length of the spicule, that of the oesophagus, the size of the body, the host type) show that "C." *fujianensis* is similar to, or perhaps identical with *Amphibiocapillaria bufonis* or *A. costa-cruzi* (considering the presence of a vulvar appendage, more probably with the second species); however, in contrast to these species, "C." *fujianensis* allegedly does not possess a spiny spicular sheath, the sheath being comparatively long in this species, and the stichosome is referred to be composed of only 30—32 stichocytes; the male tail is poorly described. Since these data cannot be verified without study of the type or topotypic materials, it is necessary to consider this species as *species inquirenda*.

3. *"Capillaria" ranae* Wang, 1982

Description (adapted from Wang, 1982): Bacillary bands present.
Male: Length of body 4.19—4.56, maximum width 0.076—0.086. Length of entire oesophagus 2.1—2.4, number of stichocytes 26—28; length ratio of anterior oesophageal part of body and posterior part of body 1 : 0.96. Length of spicule 0.288—0.315.
Female: Length of body 5.28, maximum width 0.108. Length of entire oesophagus 2.08, number of stichocytes 26. Length ratio of anterior oesophageal part of body and posterior part of body 1 : 1.5.
Localization: intestine.
Host: Frog, *Rana guentheri* (fam. Ranidae).
Distribution: China (Fuzhou, Prov. Fujian) (Wang, 1982).
Specimens: I did not succeed in obtaining the type specimens of C. *ranae* for study.

Comments: Like in the foregoing species, also the original description of "C." *ranae* is very incomplete and its drawings too schematic, making it impossible to assign this species to a genus at the present time. According to some features (a terminal anus in the female, the length of the spicule), this species resembles *Amphibiocapillaria tritonispunctati* or young specimens of *A. bufonis*. However, in contrast to these species, "C." *ranae* possesses allegedly a nonspiny spicular sheath and its maximum number of stichocytes is 28. Regarding its inadequate description and an inavailability of the type or topotypic materials, at present it is necessary to consider this species as *species inquirenda*.

A LIST OF CAPILLARIID SPECIES ACCORDING TO FAMILIES OF THE HOST AMPHIBIANS AND REPTILES*)

*) Capillariids without specific name have not been included in the list.

Class Amphibia

Caudata

Fam. Hynobiidae:
Amphibiocapillaria tritonispunctati
Fam. Salamandridae:
Amphibiocapillaria tritonispunctati
Amphibiocapillaria tritoniscristati
Amphibiocapillaria bufonis (?)
Fam. Plethodontidae:
Amphibiocapillaria tritonispunctati
Fam. Amblystomidae:
Amphibiocapillaria tritonispunctati

Anura

Fam. Bombinidae:
"Trichosoma" bombinatoris (larva)
Fam. Bufonidae:
Amphibiocapillaria bufonis
Aonchotheca buccalis
"Capillaria" fujianensis
Fam. Leptodactylidae:
Capillaria recondita
Fam. Pipidae:
Pseudocapillaroides xenopi
Fam. Microhylidae:
Pseudocapillaria spratti
Fam. Ranidae:
Amphibiocapillaria constacruzi
Amphibiocapillaria bufonis
Amphibiocapillaria tritonispunctati (?)
Aonchotheca buccalis
"Capillaria" ranae

Class Reptilia

Testudinata

Fam. Chelydridae:
Amphibiocapillaria serpentina
Fam. Emydidae:
Amphibiocapillaria serpentina
Fam. Kinosternidae:
Amphibiocapillaria serpentina

Sauria

Fam. Iguanidae:
Amphibiocapillaria freitaslenti

Ophidia

Fam. Colubridae:
Paracapillaria cesarpintoi
Paracapillaria congolensis
Paracapillaria kuntzi
Paracapillaria madagascariensis

Paracapillaria sonsinoi

Fam. Viperidae:

Paracapillaria sonsinoi

Fam. Crotalidae:

Paracapillaria modiglianii

Fam. Boidae:

Paracapillaria longispicula

Paracapillaria murinae

Crocodylia

Fam. Crocodylidae:

Paratrichosoma crocodylus

Paratrichosoma recurvum

REFERENCES

Cosgrove, G. E., Jared, D. W., 1974: Diseases and parasites of Xenopus, the clawed toad. In: Gulf Coast Regional Symposium on Diseases of Aquatic Animals (Ed. R. L. Ambroski, M. A Hood, R. R. Miller), Center for Wetlands Research, Louisiana State University, Baton Rouge, pp. 225—242.

Cosgrove, G. E., Jared, D. W, 1977: Treatment of skin-invading capillariid nematode in a colony of South African clawed frogs (Xenopus laevis). *Laboratory Animal Science*, 27: 526—527.

Linstow, O., 1892: Beobachtungen an Helminthenlarven. *Arch. Mikr. Anat.*, 39: 325—343.

Moravec, F, 1986a: Review of capillariid nematodes (Capillariinae) parasitic in amphibians and reptiles. Part 1. General introduction, genera Capillaria. Aonchotheca and Paratrichosoma. *Věst. čs. Společ. zool.*, 50. 120—131 + 3 Plts

Moravec, F., 1986b: Review of capillariid nematodes (Capillariinae) parasitic in amphibians and reptiles. Part 2. Genus Amphibiocapillaria. *Věst. čs. Společ. Zool.*, 50: 217—230 + 6 Plts.

Moravec, F., 1986c: Review of capillariid nematodes (Capillariinae) parasitic in amphibians and reptiles Part 3. Genus Paracapillaria. *Věst. čs. Společ. zool.*, 50: 273—289 + 8 Plts.

Moravec, F., Cosgrove, G. E., 1982: Pseudocapillaroides xenopi gen. et sp. nov. from the skin of the South African clawed frog, Xenopus laevis Daud. (Nematoda: Capillariidae). *Rev. Zool. afr.*, 96: 129—137.

Wade, S. E., 1981: The parasites of Xenopus laevis Daudin (South African clawed frog) with special reference to the bionomics and pathogenicity of Capillaria xenopodis sp. n. (Trichuroidea: Trichuridae). *Dissertation Abstract Inter.* 42: 1345—1346—B.

Wade, S. E., 1982: Capillaria xenopodis sp. n. (Nematoda: Trichuroidea) from the epidermis of the South African frog (Xenopus laevis Daudin). *Proc. Helm. Soc. Wash.*, 49: 86—92.

Wang, P. Q., 1982· (Studies on nematodes of the family Capillariidae from Fujian.) *Acta Zootaxonom. Sinica*, 7: 117—126 (in Chinese, Engl. summary).

Author's address: Dr. F. Moravec, Institute of Parasitology, Czechoslovak Academy of Sciences, Branišovská 31, 370 05 České Budějovice, Czechoslovakia.

ADDENDUM

Since this series reviewing amphibian and reptilian capillariids was accepted for publication, two additional papers concerning these parasites have appeared Moravec and Sey (1985) redescribed *Aonchotheca buccalis* on specimens from *Rana rugulosa* from Viet-Nam and the same authors (Moravec and Sey 1986) described a new species. *Pseudocapillaria spratti*, from the microhylid frog *Phrynomantis stictogaster* from Papua New Guinea. These finds have been incorporated in the list of capillariids provided in the present paper.

Moravec F, Sey O., 1985: Some nematode parasites of frogs (Rana spp.) from North Viet Nam. *Parasit. hung.*, 18: 63—77.

Moravec, F, Sey O, 1986: Three new nematode species from Phrynomantis spp (Amphibia: Microhylidae) from Papua New Guinea. *Folia parasitol.*, 34: 343—351.

Věst. čs. Společ. zool., 51: 136—139, 1987
ISSN 0042—6686

Institute of Soil Biology, Czechoslovak Academy of Science, České Budějovice

MESAPHORURA RUDOLFI SP. N. FROM CZECHOSLOVAKIA (COLLEMBOLA: TULLBERGIINAE)

Josef RUSEK

Received April 30, 1986

A b s t r a c t. *Mesaphorura rudolfi* sp. n. from South Bohemia (Czechoslovakia) is described.

During synecological studies on the impact of herbicides on soil Collembola a new *Mesaphorura*-species related to *M. italica* (Rusek, 1971) was discovered in an apple orchard in South Bohemia. The new species is described in this contribution.

Mesaphorura rudolfi sp. n.

(Figs. 1—2)

D i a g n o s i s : Body 500 μm long, white. Lateral sensilla s on mesonotum and metanotum slightly thickened. Sensilla p_3 on abdominal tergite V spindle-like. Formula of pseudocelli 11/011/10011. Pseudocelli on mesonotum laterally between p_5 and m_5. Antennal segment IV with sensillae a—e. Postantennal organ with simple vesicles. Metanotum without chaeta a_2. On abdominal tergite IV m_4 and m_5 present and p_1 is microchaeta and p_2 macrochaeta. Abdominal tergite V with 3 + 3 anterior microchaetae between a_4 macrochaetae. Anal spines 7 μm long. Anal lobes without chaeta l_2'. Only females known.

D e s c r i p t i o n : Body elongated, 500 μm long and 95 μm wide (Figs. 1 A, B). White. Granulation on whole body fine, on lateral parts and medial strip of nota and tergites slightly coarser. Dorsum of head and abdominal tergite V with very fine granulation, granules about 0.5—0.75 μm in diameter here. Most coarse granulation occurs on last abdominal tergite. Chaetae differentiated into microchaetae and macrochaetae (Figs. 1 A, B). Longest chaetae on last abdominal tergite (19 μm). Dorsal chaetotaxy as in following formula (Figs. 1 A, B)

	I	II	III	I	II	III	IV	V
a	–	10	8[1]	10	10	10	10	10[4]
m	8	8	8	2	2	2	4[2]	–
p	–	8	8	10	10	10	10[3]	8[5]
pl	2	3	3	4	3	3	4	

[1]) a_2 missing, [2]) m_4 and m_5 present, [3]) p_1 microchaeta, p_2 macrochaeta, [4]) a_2 microchaeta present, [5]) p_3 spindle-like, 8 μm long sensilla (Fig. 2 E)

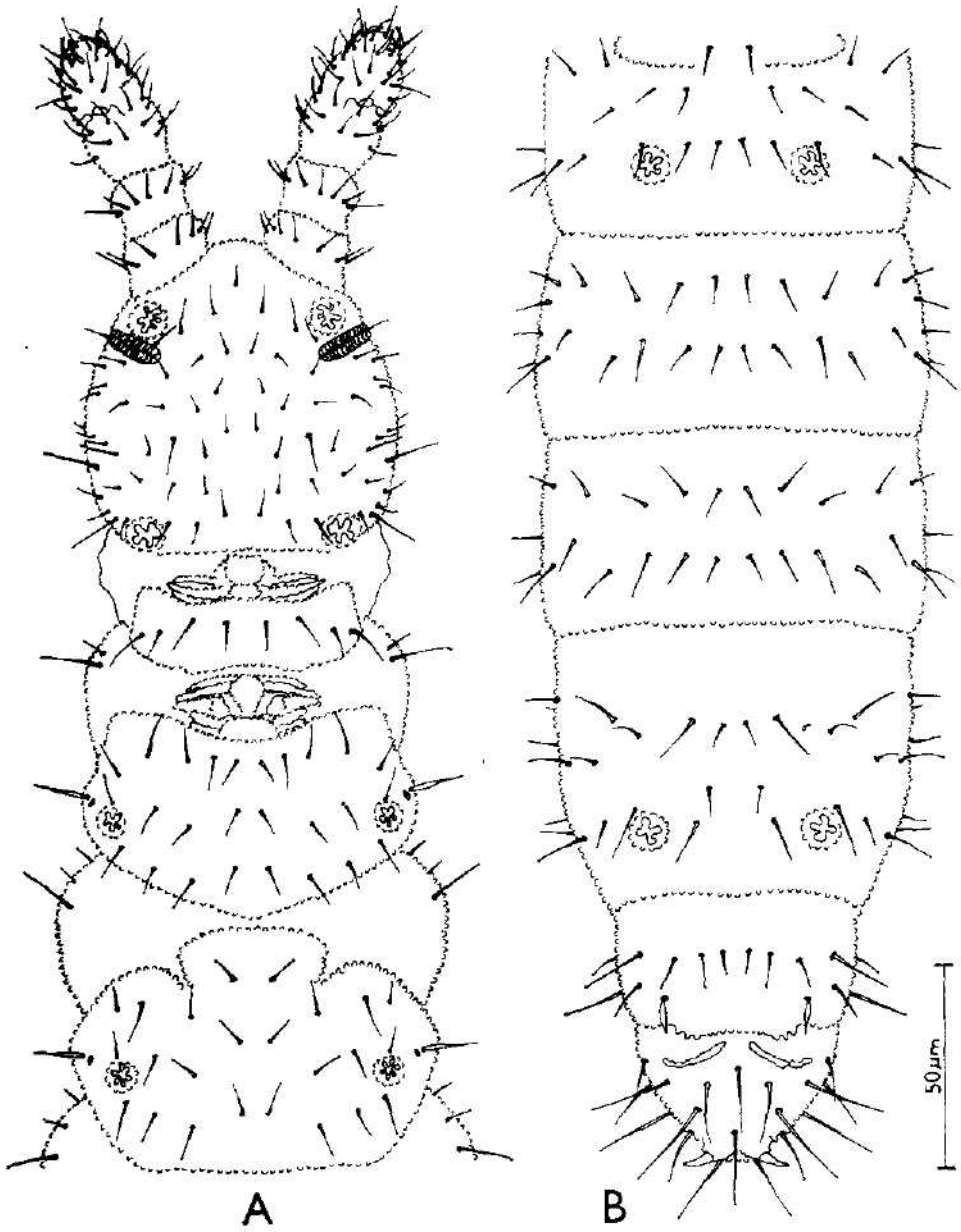


Fig. 1. *Mesaphorura rudolfi* sp. n.: A — dorsal chaetotaxy of head and nota; B — dorsal chaetotaxy of abdominal segments I—VI. Scale: Figs A, B: 50 µm.

Lateral sensilla s on mesonotum and metanotum 13 µm long, slightly thickened (Fig. 2C). Sensory rod s' on mesonotum and metanotum 1.5 µm long, in shallow pit (Fig. 2C). Anal lobes without chaeta l_2.

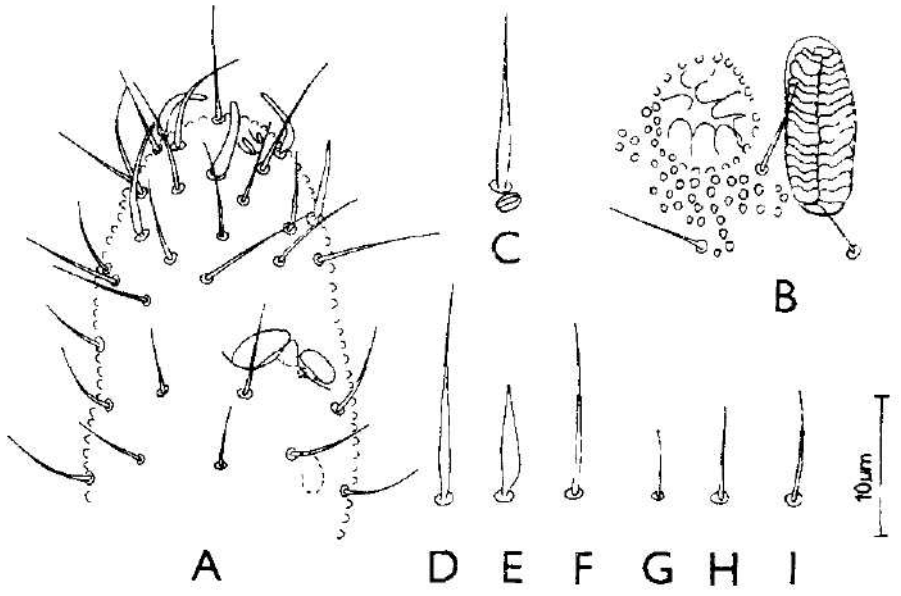


Fig 2. *Mesaphorura rudolfi* sp. n.: A — dorsal side of antennal segments III and IV; B — postantennal organ with pseudocellus; C — lateral sensilla s and sensory rod on mesonotum; D — p_5 from abdominal tergite V; E — sensilla p_3 from abdominal tergite V; F — p_2 from abdominal tergite V; G — a_1 from abdominal tergite V; H — a_2 from abdominal tergite V; I — a_3 from abdominal tergite V. Scale: Figs A—I: 10 µm.

Pseudocelli circular, 8 µm in diameter, with stellate centre (Fig. 2B). Number and arrangement of pseudocelli (Fig. 1 A, B): 11 011 10011. Pseudocelli on mesonotum and metanotum lateral, between chaetae m_5 and p_5 (Fig. 1A).

Antennae shorter than head, as 60 : 80 µm. Antennal segments I : II : III : IV as 13 : 13 : 15 : 20 µm. Antennal segment IV (Fig. 2A) with five thickened sensillae a—e, two small sensory rods f and g and with very small apical papilla. Sensillae a—e without basal heel (Fig. 2A). Antennal organ III (Fig. 2D) consists of two small sensory rods concealed behind integumental fold and two thick sensory clubs bent toward each other. Thick sensory club present on ventral side of antennal segment III.

Postantennal organ (Fig. 2B) 13 µm long and 5 µm wide. It consists of 30 simple vesicles lying in two parallel rows.

Legs short without clavate tibiotarsal hairs. Claw without teeth, 11 µm long. Empodial appendage rudimentary, 2 µm long.

Abdominal tergite IV without transversal groove. Abdominal tergite V with spindle-like , 8 µm long sensilla p_1 (Fig. 2E). Abdominal tergite VI with two crescentic ridges anteriorly and two 7 µm long anal spines on low papillae (Fig. 1B).

Ventral tube with 6 + 6 chaetae. Abdominal sternite V without thickened chaetae. Only females known.

Affinities: The new species is related to *Mesaphorura italica* (Rusek 1971) and *M. spelaea* (Nosek et Neuherz, 1976) and differs from them clearly

by the missing a_2 chaetae on metanotum. All three species are easily separated using the following key:

1. Metanotum without chaeta a_2. On abdominal tergite IV. chaeta p_1 shorter than p_2 . . . . . *M. rudolfi* sp n.
— Chaeta a_2 present on metanotum 2
2. On abdominal tergite IV chaeta p_1 shorter than p_2 . *M. italica* (Rusek, 1971)
— On abdominal tergite IV chaeta p_1 longer than p_2 *M. spelaea* (Nosek et Neuherz, 1976)

Holotype No. 28. V. 1981 / A-508 and 5 paratypes in author's collection in the Institute of Soil Biology, Czechoslovak Academy of Sciences, České Budějovice.

Locus typicus: Czechoslovakia. Bohemia meridionalis. Bavorov near Vodňany, old apple orchard on the left from the road Bavorov — Vodňany, about 500 m from last buildings in Bavorov, in samples of brown grassland soil. 28. V. 1981 six specimens leg. J. Rusek.

Derivatio nominis: The new species is dedicated to my late father Rudolf Rusek.

REFERENCES

Nosek, J., and Neuherz, H., 1976: Tullbergia (Mesaphorura) spelaea sp n. a new species of Collembola. *Věst. čs. Společ. zool.*, 40: 104—106

Rusek, J., 1971: Zur Taxonomie der Tullbergia (Mesaphorura) krausberi (Börner) und ihrer Verwandten (Collembola). *Acta ent. bohemoslov.*, 68: 199—206.

Author's address: Dr. J. Rusek, CSc., **Ústav půdní biologie ČSAV, Na sádkách 7,** 370 05 České Budějovice, Czechoslovakia.

Věst. čs. Společ. zool., 51: 140—151, 1987
ISSN 0042—8595

Department of Hydrobiology, Charles University, Praha

COHORT ANALYSIS AND PRODUCTION ESTIMATE OF CHIRONOMUS LARVAE (DIPTERA, CHIRONOMIDAE) IN A CARP POND IN SOUTHWEST BOHEMIA

Jana RŮŽIČKOVÁ

Received March 26, 1986

Abstract. In the carp pond Velký Pálenec, a cohort analysis and an estimate of the production of *Chironomus* larvae were made. Studies were conducted in the years 1983 and 1984 in unprotected and protected parts of the bottom of two different sampling areas. In the course of one year, the development of two cohorts of *Chironomus* larvae was recorded in the central area and three cohorts of larvae in the inshore area. The production of larvae was estimated by means of four methods, the removal-summation, the instantaneous growth, Winberg and Hamilton methods. The average annual production of larvae in both areas (the mean of all the methods), the average cohort and annual turnover ratios amount to 124 $g.m^{-2}$, 2.7 and 6.5 in unprotected parts, and to 297 $g.m^{-2}$, 2.4 and 6.0 in protected parts of the bottom.

INTRODUCTION

Production studies have occupied an important place in ecology since the twenties of this century. At the present time, the question of production conditions in waters command an ever increasing attention.

The importance of estimating the size of the secondary production of *Chironomus* larvae in carp ponds follows from their big share in the total benthos biomass and from their significant position in the trophic chain as a component of the natural food of fish (Lellák 1957b, 1961, 1966, 1974, Matěna 1978, Kitzberger 1985, Sokolova et al. 1983 etc.).

Various methods are available for the estimate of benthos production; some of them were applied in the present work. The resultant values of the production of *Chironomus* larvae are not only affected by abiotic factors such as, e. g., temperature and oxygen conditions, but also by biotic ones such as, e. g., trophic conditions or the character and quantity of the fish stock (Sokolova et al. 1983).

MATERIAL AND METHODICS

The production of *Chironomus* larvae was studied in Velký Pálenec, a pond near the town of Blatná in southwest Bohemia. Water area — 31.8 ha, maximum depth — 3.2 m, average depth — 1.4 m. In the years 1983 and 1984, a two-year economic cycle proceeded in the pond. The main fish introduced was carp K_2, the total weight amounting to 5400 kg (170 $kg.ha^{-1}$). In the carp yield the weight was roughly tenfold.

The material was sampled in the central part of the pond (depth 2.5 m, bottom covered with a 25 cm layer of fine sediment) and in the inshore zone (depth 1.5 m, sandy bottom with 5—10 cm of sediment). In both the sampling areas, wire cages of 2×2 m dimensions were installed to protect the bottom from fish predation (Lellák 1957a). Benthos samples were taken concurrently in the cages as well as outside them in the period from May 1983 until October 1984 when the pond was emplied and

Tab. 1. Fundamental data on the developments of *Chironomus* larvae cohorts in the different parts of carp pond Velký Pálenec

Part of the bottom		Central unprotected		Central protected		Inshore unprotected			Inshore protected		
Cohort		1	2	1	2	1	2	3	1	2	3
Time duration	83/84	V–IX	IX–VI	V–IX	VIII VI	V–VII	VIII–IX	IX–V	VI–VII	VIII–IX	IX–VI
	84	VI–X	–	VI–X	–	VI–X	–	–	VI–X	–	–
Max. abundance (ind. . m^{-2})	83/84	3100 VI	4000 X	3240 VI	1900 X	800 VI	1460 VIII	1980 X	2560 VII	4120 IX	5180 X
	84	740 VIII	–	2680 VIII	–	480 VII	–	–	3780 VIII	–	–
Max. biomass ($g.m^{-2}$)	83/84	29 VII	77 XII	85 VII	56 XII	3 VI	11 IX	18 X	26 VII	75 IX	169 XII
	84	15 VIII	–	51 VIII	–	3 VIII	–	–	66 VIII	–	–
Mean weight in the final cohort's phase (mg . $ind.^{-1}$)	83/84	57 IX	61 VI	49 IX	58 VI	33 VII	37 IX	21 V	30 VII	41 IX	46 VI
	84	25 IX	–	21 IX	–	12 IX	–	–	26 IX	–	–

fished. The sampling intervals were three weeks, in the winter season longer. For sampling, Lelláks modification of the benthic bottom grab on a bar was used; area capacity — 250 cm^2, height capacity — 35 cm. The obtained material was washed on a sieve of 0.5 mm mesh, and preserved in a 4% formaldehyde solution. In the laboratory, the larvae were measured and weighed on an analytical balance.

On the basis of the length-frequency analysis of *Chironomus* larvae, the production of the individual cohorts was estimated by the methods that work with the changes of the parameters between individual sampling. The removal-summation method (Waters and Crawford 1973) calculates the production as a total sum of the eliminated biomass of larvae. The instantaneous growth method (Waters and Crawford 1973) works with the product of the growth rate of larvae and their average biomass, the growth rate being defined as a natural logarithm of the portion between the mean weights of larvae in the subsequent and preceding sampling. Another method to be applied was that from the book Edmonson and Winberg (1971) and referred to as Winberg's method. Here, the production estimate is made on the basis of the product of the average number of larvae between sampling and the difference in the mean weights in the subsequent and preceding sampling. If the cohorts cannot be distinguished, Hamilton's method is applied (Hynes and Coleman 1968, modified by Hamilton 1969). The production is calculated on the basis of the eliminated biomass between the size groups of larvae. This method was applied to calculating the annual larval production, and in case there were enough size groups, it was experimentally used also to estimating the production of the cohorts already known.

RESULTS

Length-weight relationship of larvae

From the data on the length and weight of individual size groups of *Chironomus* larvae we obtained a relation that expresses the dependence of these quantities. The form of the established equation of the straight line is as follows:

$$\lg y = -2.225 + 2.867 \lg x,$$

where x is the length of larvae (mm), y is their weight (mg). From this equation it ensues that the weight of larvae grows approximately with the third power of their length. The correlation coefficient being 0.997.

Development of cohorts in the areas under study

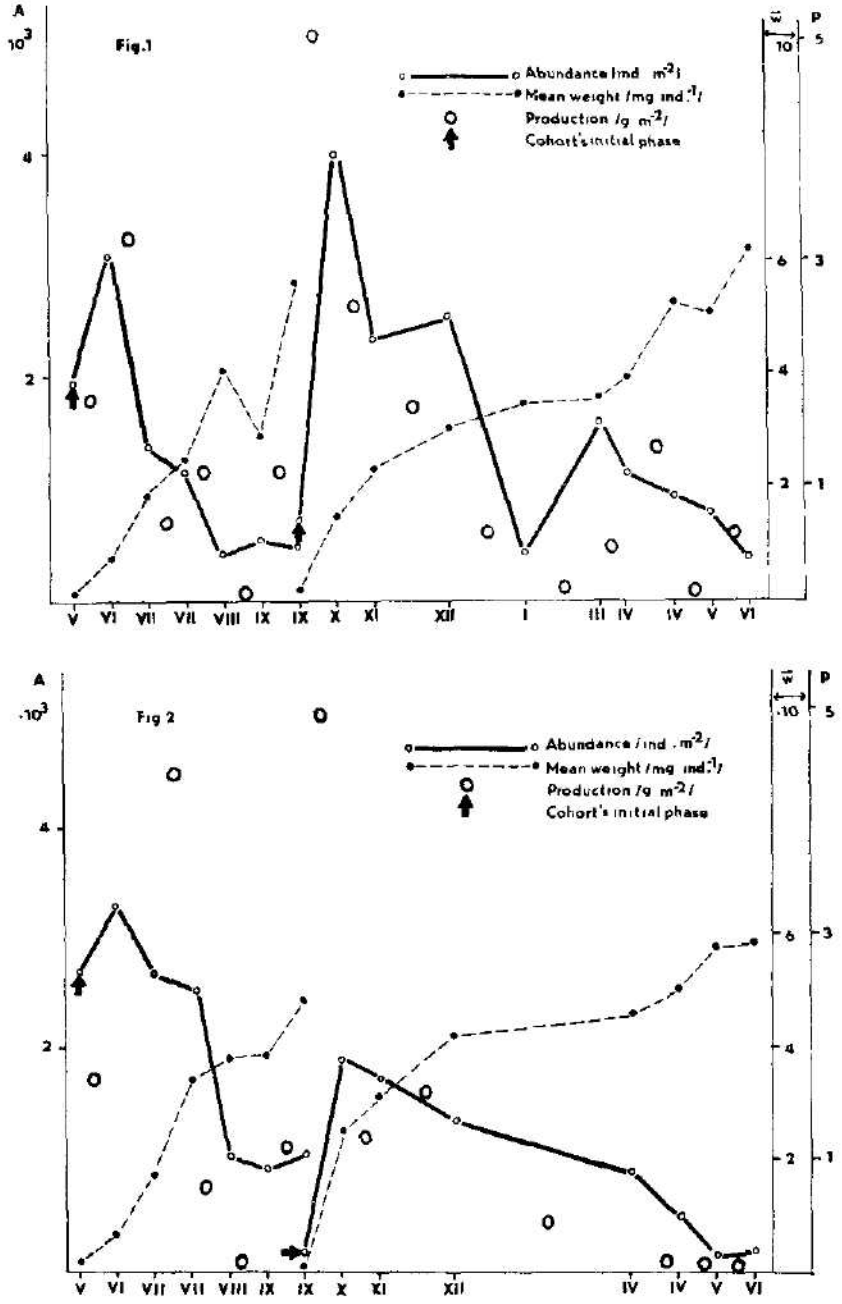
In the period from May 1983 until June next year, two larval generations (summer and winter) developed in both the protected and unprotected stands in the central part of the pond, in the inshore zone three generations (two summer generations and one winter generation) were observed. The fundamental data on the development of the cohorts are contained in Tab. 1.

In the year 1984, the summer larval generation exhibited some differences compared with the year 1983. In the central as well as the inshore part of the pond, only one larval generation developed, its initial phase was not recorded until June, maximum abundance was reached as late as August, in September the mean weight of larvae was still low, the cohort remainders still occurred in the orientation sampling early in October performed in the emptied out pond. Due to the latter two facts, the production of that cohort was not estimated. The retarded development of larvae and the development of only one generation in the inshore zone may be the consequence of lower temperatures as compared with the year 1983 (e. g. in April, May, June and July the mud temperature was 4° C lower on the average).

An important regulation factor of the population density in a cohort is elimination (metamorphosis of larvae, emergence of adult, fish predation, diseases,

Tab. 2. Estimates of production and turnover ratios in *Chironomus* larvae of pond Velký Pálenec (production – $g.m^{-2}$)

Part of the bottom	Central unprotected		Central protected		Inshore unprotected			Inshore protected		
Cohort	**1**	**2**	**1**	**2**	**1**	**2**	**3**	**1**	**2**	**3**
Removal-summation										
P	77.2	135.5	120.7	89.8	7.5	31.9	21.1	71.3	151.6	196.9
P/B cohort	4.0	3.2	2.9	3.5	4.4	3.7	2.6	2.3	2.8	2.3
P/B annual	**5.9**		**6.4**			9.2			6.1	
Instantaneous growth										
P	68.4	141.8	110.8	111.9	1.2	22.5	4.1	32.0	93.1	**232.9**
P/B cohort	3.5	3.4	2.7	4.3	0.7	2.6	0.5	1.8	1.7	**2.7**
P/B annual	5.8		6.8			4.2			5.2	
Winberg										
P	80.6	105.0	105.8	63.2	3.5	25.6	4.8	30.7	64.4	124.7
P/B cohort	4.1	2.5	2.5	2.4	2.1	3.0	0.6	1.0	1.2	1.4
P/B annual	5.1		5.2			5.1			3.2	
Hamilton										
P	62.2	96.6	132.1	53.0	–	–	29.1	–	–	198.8
P annual	185.7		203.1			74.6			570.6	
P/B cohort	3.2	2.3	3.2	2.0	–	–	3.5	–	–	**2.3**
P/B annual	5.1		6.2			11.3			8.3	



Figs. 1 and 2. Seasonal changes in the production of *Chironomus* larvae related to the abundance and mean weight of larvae in individual cohorts in the central unprotected (Fig. 1) and protected (Fig. 2) parts of the bottom.

etc.). Apart from this decrease in the abundance of larvae, also losses in the weight of individuals were found. Such a situation occurred at the time of the collapse of strong water bloom made up of blue-green alga *Aphanisomenon* (August 1983). The oxygen content in water decreased, which obviously resulted in a slow to negative growth rate of larvae, particularly in the deeper central part. Negative values or retardation of the growth rate was also recorded in the winter cohorts in both stands, especially in the period from December until March. The likely factors responsible for these facts are lower temperature and worse oxygen and trophic conditions, also manifest in the longer persistence of the winter cohort as opposed to the summer cohort.

Production estimate

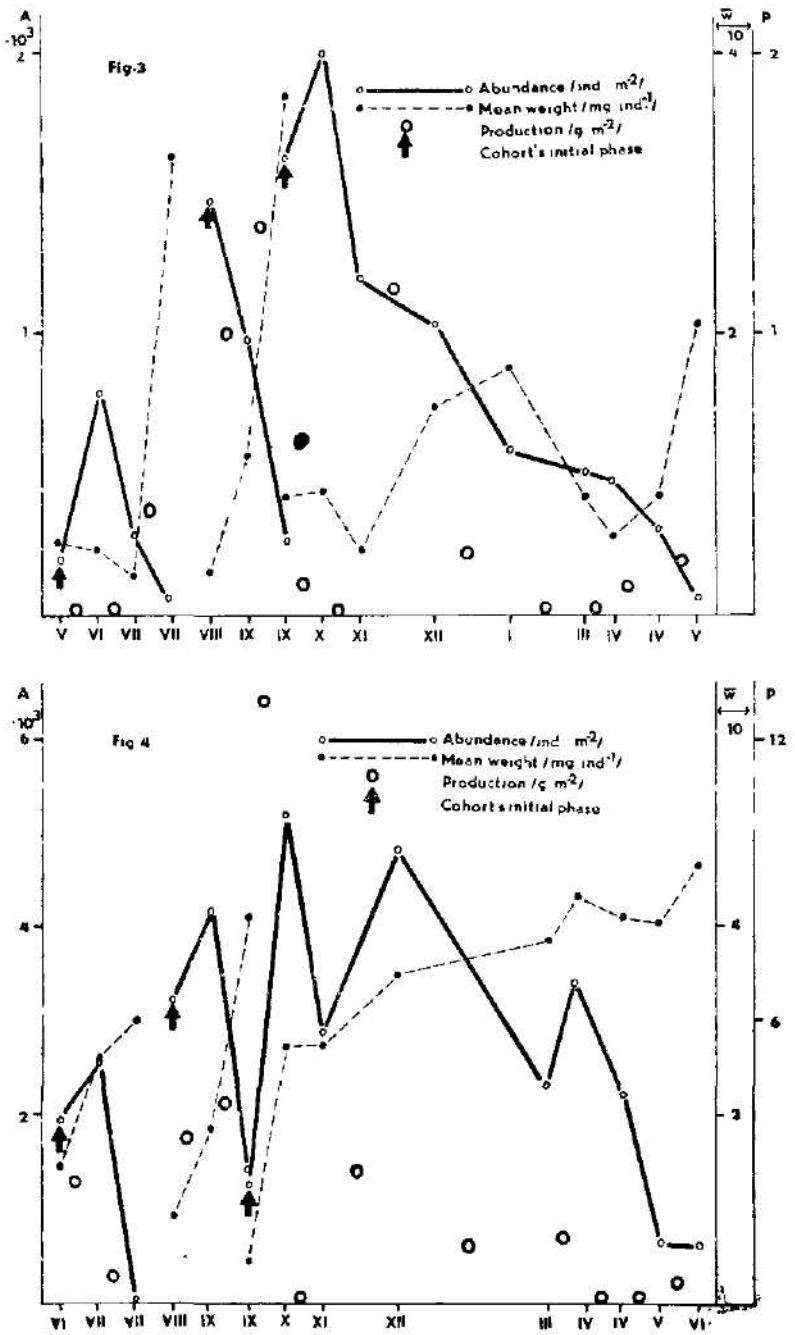
The production of *Chironomus* larvae was estimated by means of four methods (removal-summation, instantaneous growth, Winberg, Hamilton), in the protected and unprotected parts of both areas. The results of the production estimates obtained by the above methods are presented in Tab. 2. For both the unprotected parts of the bottom the mean annual production (Ø of all the methods) amounts to 124 $g \cdot m^{-2}$ (1240 $kg \cdot ha^{-1}$), and for both the protected parts 297 $g \cdot m^{-2}$ (2970 $kg \cdot ha^{-1}$). The distinctions of the removal-summation, instantaneous growth, Winberg, and Hamilton methods from the mean are 1.1 : 1.0 : 0.9 : 1.1 for the unprotected parts, and 1.1 : 1.0 : 0.7 : 1.3 for the protected ones.

The difference in the production of protected and unprotected areas is probably caused mainly by fish predation. However, the effect of some other factors, which will be discussed further, cannot be ruled out, either. Predation is most intensive in the inshore part of the pond, where the sediment layer does not attain such a thickness as in the central part, which makes the escape of larvae more difficult. Intensive fish predation is obviously also the reason for a much higher production in the protected inshore area than in the unprotected one (Tab. 2). The difference in the production in the protected and unprotected areas in the central part of the pond is less pronounced (lower predation intensity), and moreover, the production of the second larval cohort decreased in the protected area so that the annual production is almost the same in both areas.

Seasonal changes in the production of larvae in relation to the abundance and the mean weight of the larvae in individual cohorts in the protected as well as unprotected parts of both areas were taken into account in the production estimates (Figs. 1—4). Here, the production is the mean of two methods that estimate the production directly between individual sampling data (Winberg and instantaneous growth methods). Figures 1—4 show the production to be high when there is a large quantity of larvae with a low mean weight (i. e. in the initial phase of a cohort), and on the contrary, the production is low when the mean weight of individuals is great (i. e. in the final phase of a cohort).

Turnover ratio estimate

The mean cohort turnover ratio makes 2.7 in the unprotected area and 2.4 in the protected one. To estimate the turnover ratios, we used the production values calculated by the removal-summation, instantaneous growth and Winberg's methods. Further, also the mean annual turnover ratio was



Figs. 3 and 4. Seasonal changes in the production of *Chironomus* larvae related to the abundance and mean weight of larvae in individual cohorts in the inshore unprotected (Fig. 3) and protected (Fig. 4) parts of the bottom.

determined, which equals 6.5 in the unprotected area and 6.0 in the protected one. For the determination we applied the production obtained using all the four methods.

DISCUSSION

In the general length-weight relationship, $y = k \cdot x^n$, of *Chironomus* larvae in pond Velký Pálenec, coefficient k equalled 0.006. For pond Velký Bezděkovský (the same pond district), Matěna (1978) gives k = 0.004 as a mean of all size groups of *Chironomus* larvae (extremal values 0.0036—0.0047).

The number of larval generations and the time of their development are influenced by temperature, nutrition and oxygen conditions in the reservoir. The first year of observations was characterized by relatively high temperatures, an appreciable development of the water bloom of blue-green alga *Aphanisomenon*, and during its collapse by drops in the oxygen concentration (August). In the deeper central stand, one summer larval cohort developed, and in the shallower inshore stand, where we can expect more favourable temperature and oxygen conditions for larval development, two summer larval cohorts were recorded. The mean weight of the larvae in this shallower stand was lower than in the central part, and it is quite possible that smaller species of the genus *Chironomus* are involved. Two summer cohorts of the genus *Chironomus* were also recorded by Matěna (1978). The development of a different number of generations in deeper and shallower places is mentioned by e. g. Sokolova et al. (1983), who states that e. g. reservoirs in 56—58° n. lat. have dicyclic populations of *Chironomus* larvae in shallow water and monocyclic populations in deeper water. Another example mentioned is mountain lake Karakul (40° n. lat.), in whose deeper parts two larval generations develop a year and in the shallow water three. The second year of observations differed from the preceding one by lower temperatures and stronger *Aphanisomenon* development was not established. These factors contributed to the general retardation in the development of the summer larval generation and also to the origin of only one larval cohort in the inshore area.

The development and the August collapse of the water bloom of blue-green alga *Aphanisomenon*, and the subsequent drops in the oxygen concentration adversely affected the growth rate of larvae, particularly in the central part of the pond. The growth of the winter cohort larvae was adversely affected by a whole complex of factors (temperature, oxygen, food). In laboratory experiments with *Aphanisomenon*, also Rusina (1956) ascertained a decrease in the weight of *Chironomus larvae*. At first the growth rate was rapid but as the alga was slowly dying down the weight of larvae decreased. Jónasson and Kristiansen (1967) observed a decrease in the weight of the *Chironomus* larvae of deep Lake Esrom in the summer period, which in their opinion may have been caused by the decomposition of food or by a low oxygen concentration in the hypolimnion (blue-green algae *Anabaena* and *Microcystic* had their share in the summer peak of the phytoplankton, too). The larval growth rate in pond Velký Pálenec is likely to have been negatively affected not only by the lack of oxygen due to the collapse of the blue-green alga, but also by some toxic products. A decrease in weight or a halt of growth of winter larvae was observed by e. g. Schlott (1978) or Jónasson (1975).

Velký Pálenec belongs to carp ponds with intensive economy. The production of *Chironomus* larvae amounted to 124 g . m^{-2} . $year^{-1}$ in the unprotected areas and in the protected ones to 297 g . m^{-2} . $year^{-1}$ (the presented values are a mean of all the applied methods of the production estimate). Table 3 contains a comparison of the ascertained production with the results obtained by some authors. Ponds exhibit a relatively high production. Zelinka (1979), for instance, gives an annual average production of 45—150 g . m^{-2} of zoobenthos in pond with economy. Sokolova et al. (1983) give values in the range of 88 to 248 g . m^{-2} . $year^{-1}$ for the production of *Chironomus* larvae in ponds. In assessing the differences of the methods applied to the production estimate we found relatively small deviations. There were some variations in the estimate of the production in the inshore part of the pond, where it was the consequence of a rapid larval development between individual sampling. A comparison of some methods of the production estimate was made by e. g. Waters and Crawford (1973) in their study of stream mayfly *Ephemerella subvaria*. The authors concluded that the removal-summation, instantaneous growth, and Allen's methods yielded analogous results, and that Hamilton's method overrated by 15—26 %. Cushman et al. (1978) investigated the sensitivity of individual methods of the production estimate (removal-summation, instantaneous growth and Hamilton) in a hypothetic insect population to various growth types of larvae and to the number of sampling. A computer performed analysis showed the removal-summation method to be least dependent on the larval growth and on the sampling regime, and the instantaneous growth method to be suitable in the case of a sufficient number of sampling and an exponential larval growth.

The difference in the production in protected and unprotected areas is probably due to a number of factors. In an unprotected area, the intensity of fish predation is likely to make a great contribution (Lellák 1957a, 1965, 1974, Sokolova et al. 1983, etc.). Neither can the effect of larval migration between protected and unprotected areas be precluded (Hruška 1961). Due to the formation of mat communities and to mud stratification, more favourable food conditions are created in an enclosure; on the other hand, the light conditions deteriorate, which may be the reason for the immigration of larvae into the enclosure. However, also larval migration in the opposite direction can be supposed as a result of deteriorated oxygen conditions or as a protection against unduly overcrowding by larvae. That is why the estimate of the larval production consumed by fish may be partly distorted. Undesirable changes, especially due to a prolonged use of enclosures and to long intervals between sampling are pointed out by e. g. Kajak (1972). Also Hruška (1961) gives reasons for which he considers the practice of enclosures unsuitable for an estimate of the consumed fauna. As opposed to it, e. g. Lellák (1965, 1974) found during experiments with cages in the mud and sandy parts of a carp pond that the average annual biomass of *Chironomus* larvae was analogous in cages with carp stock to that in an unprotected area.

The difference in the production between an unprotected area and a protected one makes 1730 kg of larvae per 1 ha a year. Under the presumption of about 20 % ecological efficiency of energy transfer, it is possible to estimate the portion of larvae to be at least $^1/_3$ in the increment of fish stock (1574 kg . ha^{-1}). In order to obtain more exact information, however, we have to know the share of migration in the difference between areas, the predation intensity in

Tab. 3. Comparison of estimates of the production and turnover ratios in *Chironomus* larvae with some data in literature (production in $g.m^{-2}.year^{-1}$)

	Lokality	Method	P	P/B cohort	P/B annual	Author
Chironomus	Velký Pálenec	Removal-summation	137	3.6	**7.6**	Růžičková (1986)
		Instantaneous growth	119	2.1	5.0	
		Winberg	110	2.5	5.1	
		Hamilton	130	–	8.2	
		mean	124	2.7	**6.5**	
Ch. plumosus	–	–	0.4–248	–	3–28	Sokolova and kol. (1983)
Ch. anthracinus	Lake Esrom	Allen	25*	–	4.0*	Jónasson (1975)
Ch. cingulatus	Piburger See	Boysen-Jenson	12*	–	3.4*	Schlott (1978)
Ch. decorus	Lake Norman	Hamilton	0.2–7	–	50–70	Wilda (1984)
Chironomidae	–	–	–	3.5	–	Menzie (1978) in Wilda (1984)
Zoobenthos	ponds	–	45–150	–	–	Zelinka (1979)
Zoobenthos	–	–	–	4–6	–	Waters (1979) in Beattie (1982)
Zoobenthos	–	–	–	–	10	Waters (1974) in Wilda (1984)
Ephemerella subvaria	Luxemburg Creek	Removal-summation	29	4.6	6.3	Waters (1973)
		Instantaneous growth	27	4.2	5.8	
		Allen	26	4.2	5.7	
		Hamilton	33	–	7.2	

Note: mean values of several years are denoted by *

the period the larval production was not observed, which could have been rather different due to changed conditions (e. g. temperature effect and other factors). Lellák (1957a, 1961) calculates that in the Blatná region. 600—1000 kg of bottom animals are consumed by fish from 1 ha per year, $^1/_3$—$^1/_2$ of the annual natural increment being covered by consumption from the bottom. The author also points out more intensive predation in the littoral zones of ponds compared with the deeper zones with a thick mud layer providing escape possibilities to more animals, and further to preferable consumption of *Chironomus* larvae to Oligochaetes, which are able to penetrate into mud more quickly.In view of the fact that consumption of other benthic animals by fish was not observed in pond Velký Pálenec, the benthos share in the increment of fish stock may be fairly significant.

SUMMARY

1. In the period from May 1983 until October 1984, a cohort analysis and a production estimate were made in the dominant benthos component, the *Chironomus* larvae, of carp pond Velký Pálenec.

2. The length-weight relationship of the larval bodies is expressed by the following equation of the straight line:

$$\lg y = -2.225 + 2.867 \lg x.$$

the correlation coefficient being 0.997.

3. From May 1983 until June next year, one summer cohort and one winter cohort of larvae developed in the central (protected and unprotected) sampling area; in the inshore area (protected and unprotected), two summer cohorts and one winter cohort were recorded. In the summer period of 1984, only one cohort developed in either area and it was retarded in comparison with the previous year.

4. In summer 1983, a negative effect of the development and collapse of sizable water bloom formed by blue-green alga Aphanisomenon was manifest in the growth rate of larvae, particularly in the central part of the pond (slow to negative growth rate). A retarded growth or even losses in weight were also established in the winter larval cohorts of both sampling areas.

5. The production in both the protected and unprotected parts of the bottom was estimated by means of four methods (removal-summation, instantaneous growth, Winberg, and Hamilton). The average annual production (the mean of all the methods) was 124 g . m^{-2} in both unprotected parts, and 297 g . m^{-2} in both protected parts. The distinction of the methods from the mean of all the methods was determined and found to be 1.1 : 1.0 : 0.9 : 1.1 for unprotected parts, and 1.1 : 1.0 : 0.7 : 1.3 for protected parts of the bottom.

6. The average cohort turnover ratios in unprotected and protected parts are 2.7 and 2.4, respectively, the average annual turnover ratios 6.5 and 6.0, respectively.

Acknowledgements

The author wishes to thank doc. RNDr. J. Lellák, CSc. for his stimulating comments on the present work, and J. Kitzberger for the help rendered in sampling and preparing the material.

REFERENCES

Beattie, D. M., 1982: Distribution and production of the larval Chironomid population in Tjeukemeer. *Hydrobiologia*, 95: 287—306.

Cushman, R. M., Shugart, H. H., Jr., Hildebrand, S. G., Elwood, J. W., 1978: The effect of growth curve and sampling regime on instantaneous growth, removal-summation, and Hynes/Hamilton estimates of aquatic insect production: A computer simulation. *Limnol. Oceanogr.*, 23: 184—189.

Edmonson, W. T., Winberg, G. G., 1971: A Manual on Methods for the Assessment of Secondary Productivity in Fresh Waters. IBP Handbook, 17: 358 pp.

Hamilton, A. L., 1969: On estimating annual production. *Limnol. Oceanogr.* 14: 771—782.

Hruška, V., 1961: An attempt at a direct investigation of the influence of the carp stock on the bottom fauna of two ponds. *Verh. Internat. Verein. Limnol.*, 14: 732—736.

Hynes, H. B. N., Coleman, M. J., 1968: A simple method of assessing the annual production of stream benthos. *Limnol. Oceanogr.*, 13: 569—573.

Jónasson, P. M., 1975: Population ecology and production of benthic detritivores. *Verh. Internat. Verein. Limnol.*, 19: 1066—1072.

Jónasson, P. M., Kristiansen, J., 1967: Primary and Secondary Production in Lake Esrom. Growth of Chironomus anthracinus in Relation to the Seasonal Cycles of Phytoplankton and Dissolved Oxygen. *Int. Rev. ges. Hydrobiol.*, 52(2): 163—217.

Kajak, Z., 1972: Analysis of the influence of fish on benthos by the method of enclosures. Product. probl. of freshw., 111—127.

Kitzberger, J., 1985: Srovnání populační dynamiky benhtosu okrsků dna chráněných před rybami a nechráněného dna kaprového rybníka Velký Pálenec. Dipl. práce, přír. fak. UK Praha: 118 pp.

Lellák, J., 1957a: Der Einfluß der Freßtätigkeit des Fischbestandes auf die Bodenfauna der Fischteiche. *Z. Fisch. N. F.*, 6: 621—633.

Lellák, J., 1957b: Kvantitativní studie zoobenthosu tří blatenských rybníků. Kandid. disert. práce, Praha: 212 pp.

Lellák, J., 1961: Zur Benthosproduction und ihrer Dynamik in drei böhmischen Teichen. *Verh. Internat. Verein. Limnol.*, 14: 213—219.

Lellák, J., 1965: The food supply as a factor regulating the population dynamics of bottom animals. *Mitt. Internat. Verein. Limnol.*, 13: 128—138.

Lellák, J., 1966: Zákonitosti populační dynamiky benthosu a jeho úloha v ekosystému vodních nádrží rybničního charakteru. Habilitační práce, Praha: 181 pp.

Lellák, J., 1974: The intensity of fish predation upon the bottom fauna in carp ponds. (Abstract.) *Ent. Tidskr.*, 95, suppl. 156.

Matěna, J., 1978: Saisondynamik und Production der Chironomus larvae in einem Karpfenteich. *Acta Univ. Carol. — Biologica:* 133—139.

Rusina, O. N., 1956: Usvojenije otmerších vodoroslej i dafnij ličinkami Chironomus dorsalis. *Vopr. ichtiol.*, 6: 165—173.

Schlott, G., 1978: The production of Chironomus cingulatus Meig. in the Piburger See (Tirol, Austria). *Acta Univ. Carol. — Biologica:* 227—233.

Sokolova, N. Ju., i kol., 1983: Motyl'Chironomus plumosus L. (Diptera, Chironomidae). Sistematika, morfologija, ekologija, produkcija. Izd. Nauka Moskva: 309 pp.

Waters, T. F., Crawford, G. W., 1973: Annual production of stream mayfly population: a comparison of methods. *Limnol. Oceanogr.*, 18: 286—295.

Wilda, T. J., 1984: The production of five genera of Chironomidae (Diptera) in Lake Norman, a North Carolina reservoir. *Hydrobiol.*, 108: 145—152.

Zelinka, M., 1979: Základy aplikované hydrobiologie. SPN Praha (Scriptum): 234 pp.

Author's address: RNDr. Jana Růžičková, Katedra parazitologie a hydrobiologie, přírodovědecká fakulta UK, Viničná 7, 128 44 Praha 2, ČSSR.

Věst. čs. Společ. zool., **51**: 152—159, 1987
ISSN 0042—6599

Department of Systematic Zoology, Faculty of Science, Charles University, Praha

BIOMETRICAL EVALUATION OF GREEN RANID FROGS (AMPHIBIA, RANIDAE) FROM THE SURROUNDINGS OF PLZEŇ (WESTERN BOHEMIA)

Lubomír ŠKODA

Received February 24, 1986

A b s t r a c t. 190 specimens of green ranids from the surroundings of Plzeň (Western Bohemia) were evaluated biometrically and specified as *Rana esculenta* Linnaeus, 1758 and *Rana lessonae* Camerano, 1883. There are significant morfological differences between the two forms, sexual dimorphism is much less distinct.

INTRODUCTION

Three morphologically different forms of green ranids are found in central Europe. These are *Rana ridibunda* Pallas, 1771, *Rana esculenta* Linnaeus, 1758 and *Rana lessonae* Camerano, 1883. According to the latest research (B e r g e r 1975, 1977) the forms *Rana ridibunda* and *Rana lessonae* can be considered as species, while the form *Rana esculenta* is the hybrid of both species, in which retaining of constant fenotypes occurs in regressive cross during the hybridogenesis and therefore no more transient forms come into being.

The aim of this paper is to find out which of the three known forms of green ranids occur in two close localities in the surroundings of Plzeň and evaluate statistically their morphological characteristics.

MATERIAL AND METHODS

190 adults (91 males, 99 females), the minimum body length of which was 40.0 mm, were evaluated.

138 specimens were aught in 13 pools in the area of abandoned china-clay quarry situated 2 km from the village of Ledce at Plzeň in the south-eastern direction, on the north-eastern slope of the hill Krkavec (district Plzeň-North). The place is situated 430—460 m above sea level. Estimations of numerosity of green ranids populations, using the method of marking and recatching in more steps according to S c h n a b e l, in 3 chosen pools of the area, acknowledged abundant occurrence of this species (Š k o d a, 1982) and eliminated the negative impact on populations by exercised catches.

52 specimens were caught at 2 Kokot ponds situated 2.5 km from the village of Klabava (district Rokycany) in northern direction. The place is situated 440—450 m above sea level.

Both places, the distance between which is 15 km, are situated near the town of Plzeň (western Bohemia). The mean annual temperature of this area is 8° C, the mean annual precipitation is 600 mm. Collection of material was carried out in 1979—82.

Material preserved in 4 % formalin for several months was measured by the sliding gauge with the accurancy of 0.05 mm. The measurements were taken according to the scheme and indication of L á c (in: O l i v a, H r a b ě, L á c, 1968). The shape of Callus internus was determined according to the characteristics of this sign for different forms of green ranids according to B e r g e r 1977, L á c 1968 and

Table 1 — D.p./C.i.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	2.15	1.69 — 2 96	0.2318	0.0297	10.78	61
♀♀	E	2.19	1.77 — 2 84	0.2239	0.0252	10.22	79
♂♂	L	1.71	1.28 — 2 29	0.1853	0.0338	10.84	30
♀♀	L	1.66	1.36 — 1 93	0.1483	0.0332	8.93	20
	E	2.17	1.69 — 2 96	0.2274	0.0192	10.84	140
	L	1.69	1.28 — 2 29	0.1713	0.0242	10.14	50

Table 2 — T./C.i.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	7.90	6.14 — 10 47	0.7747	0.0992	9.81	61
♀♀	E	8.09	6.05 — 10 58	0.7546	0.0849	0.0849	79
♂♂	L	6.26	5.06 — 7 29	0.5106	0.0932	8.16	30
♀♀	L	6.02	5.27 — 6 70	0.3599	0.0805	5.98	20
	E	8.01	6.05 — 10.58	0.7661	0.0647	9.56	140
	L	6.17	5.06 — 7.29	0.4678	0.0662	7.58	50

Table 3 — L./T.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	2.08	1.86 — 2.34	0.0785	0.0101	3.77	61
♀♀	E	2.08	1.90 — 2.39	0.0998	0.0112	4.80	79
♂♂	L	2.26	1.99 — 2.55	0.1035	0.0189	4.58	30
♀♀	L	2.31	2.20 — 2.43	0.0871	0.0195	3.77	20
	E	2.08	1.86 — 2.39	0.0909	0.0077	4.37	140
	L	2.28	1.99 — 2.55	0.1005	0.0142	4.41	50

Table 4 — L./P.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	1.90	1.76 — 2.09	0.0665	0.0085	3.50	61
♀♀	E	1.92	1.75 — 2.16	0.0832	0.0094	4.33	79
♂♂	L	1.91	1.69 — 2.05	0.0839	0.0153	4.39	30
♀♀	L	1.98	1.84 — 2.16	0.1034	0.0231	5.22	20
	E	1.91	1.75 — 2.16	0.0767	0.0075	4.02	140
	L	1.94	1.69 — 2.16	0.0974	0.0138	5.02	50

Table 5 — T./P.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	0.91	0.82—1.01	0.0338	0.0043	3.71	61
♀♀	E	0.93	0.81—1.06	0.0395	0.0044	4.25	79
♂♂	L	0.85	0.80—0.89	0.0252	0.0046	2.96	30
♀♀	L	0.86	0.79—0.96	0.0380	0.0085	4.42	20
	E	0.92	0.81—1.06	0.0376	0.0032	4.09	140
	L	0.85	0.79—0.96	0.0309	0.0044	3.64	50

Table 6 — F./T.

Set		$\bar{x}$	Variability	s	$s_{\bar{x}}$	v	n
♂♂	E	1.01	0.92—1.07	0.0304	0.0039	3.01	61
♀♀	E	1.00	0.93—1.05	0.0299	0.0034	2.99	79
♂♂	L	1.05	0.97—1.11	0.0285	0.0052	2.71	30
♀♀	L	1.05	0.99—1.10	0.0324	0.0072	3.09	20
	E	1.00	0/92—1.07	0.0301	0.0025	3.01	140
	L	1.05	0.97—1.11	0.0299	0.0042	2.85	50

Table 7 — D.p./C.i.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	1.03	0.09
♂♂ L × ♀♀ L	1.01	0.15
♂♂ E × ♂♂ L	9.06	1.05
♀♀ E × ♀♀ L	10.03	1.42
E × L	13.60	1.20

Table 8 — T./C.i.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	1.46	0.12
♂♂ L × ♀♀ L	1.82	0.28
♂♂ E × ♂♂ L	10.51	1.28
♀♀ E × ♀♀ L	11.90	1.86
E × L	15.94	1.49

Table 9 — L./T.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	0	0
♂♂ L × ♀♀ L	1.78	0.26
♂♂ E × ♂♂ L	9.24	0.99
♀♀ E × ♀♀ L	9.42	1.23
E × L	12.99	1.04

Table 10 — L./P.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	1.54	0.13
♂♂ L × ♀♀ L	2.63	0.37
♂♂ E × ♂♂ L	0.62	0.04
♀♀ E × ♀♀ L	2.74	0.32
E × L	2.20	0.17

Table 11 — T./P.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	3.16	0.27
♂♂ L × ♀♀ L	1.12	0.16
♂♂ E × ♂♂ L	8.60	1.02
♀♀ E × ♀♀ L	7.14	0.90
E × L	11.81	1.02

Table 12 — F./T.

Sets	t-test	C.D.
♂♂ E × ♀♀ E	1.95	0.17
♂♂ L × ♀♀ L	0	0
♂♂ E × ♂♂ L	6.03	0.68
♀♀ E × ♀♀ L	6.57	0.80
E × L	10.10	0.83

Table 13 — D.p./C.i.

Author		*R. esculenta* x_{min} — $\bar{x}$ — x_{max}			*R. lessonae* x_{min} — $\bar{x}$ — x_{max}		
1.		1.73 —		2.89	0.81 —		2.33
2.	♂♂	1.89 —	2.19 —	2.61	♂♂ 1.35 —	1.72 —	1.94
	♀♀	2.00 —	2.25 —	2.58	♀♀ 1.46 —	1.69 —	2.00
3.		—	2.07 —		—	1.56	
4.					♂♂ 1.10 —	1.76 —	2.08
	♀♀	1.62 —	2.03 —	2.50	♀♀ 1.31 —	1.69 —	1.97
5.		1.50 —	1.99 —	2.49	1.11 —	1.40 —	1.85
6.		1.69 —	2.17 —	2.96	1.28 —	1.69 —	2.29

Table 14 — T./C.i.

Author		*R. esculenta* x_{min} — $\bar{x}$ — x_{max}			*R. lessonae* x_{min} — $\bar{x}$ — x_{max}		
2.	♂♂	6.80 —	7.54 —	8.97	♂♂ 5.21 —	6.11 —	6.86
	♀♀	6.92 —	7.72 —	8.95	♀♀ 5.40 —	6.00 —	6.77
4.					♂♂ 5.25 —	6.61 —	7.21
	♀♀	6.52 —	7.91 —	9.60	♀♀ 5.16 —	6.22 —	7.62
6.		6.05 —	8.01 —	10.58	5.06 —	6.17 —	7.29

Table 15 — L./T.

Author		*R. esculenta* x_{min} — $\bar{x}$ — x_{max}			*R. lessonae* x_{min} — $\bar{x}$ — x_{max}		
2.	♂♂	1.95 —	2.09 —	2.24	♂♂ 2.07 —	2.21 —	2.36
	♀♀	2.07 —	2.17 —	2.35	♀♀ 2.08 —	2.28 —	2.39
3.		—	2.02 —		—	2.18	
4.					♂♂ 1.97 —	2.12 —	2.29
	♀♀	1.93 —	2.03 —	2.22	♀♀ 2.06 —	2.23 —	2.41
5.		1.82 —	2.02 —	2.27	1.94 —	2.17 —	2.58
6.		1.86 —	2.08 —	2.39	1.99 —	2.28 —	2.55

Table 16 — T./P.

Author		*R. esculenta* x_{min} — $\bar{x}$ — x_{max}			*R. lessonae* x_{min} — $\bar{x}$ — x_{max}		
4.					♂♂ 0.77 —	0.84 —	0.88
	♀♀	0.84 —	0.91 —	1.00	♀♀ 0.77 —	0.85 —	0.92
5.		0.81 —	0.92 —	1.06	0.79 —	0.85 —	0.96

Table 17 — F./T.

Author		*R. esculenta* x_{min} — $\bar{x}$ — x_{max}		*R. lessonae* x_{min} — $\bar{x}$ — x_{max}
4.*	♂♂		♂♂	9.29 — 9.72 — 10.00
	♀♀	9.15 — 9.60 — 10.00	♀♀	9.22 — 9.62 — 10.00
6.		0.92 — 1.00 — 1.07		0.97 — 1.05 — 1.11

* — The index value given by the author F.10/T.

Table 18 — Maximum body lenghts found

Author	♂♂ E	♀♀ E	♂♂ L	♀♀ L
3.	85.00	100.00	63.00	75.00
4.	85.00	100.0	66.00	72.00
5.	83.00	95.80	57.90	75.20
6.	78.40	95.00	71.00	71.35

was divided according to this sign (see literature) into the set of *R. esculenta* (61 males, 79 females) and *R. lessonae* (30 males, 20 females). Callus internus of the *ridibunda* type was not found. Statistical characteristics of proportional indexes D. p./C. i., T./C. i., L./T., L./P., T./P., and F./T. were studied in these sets.
D. p. — length of the first toe of the hindleg. C. i. — length of the Callus internus. T. — length of the shinbone. F. — length of the thigh. L. — length of the body. P. — length of the sole.
The difference between indexes studied in individual sets was verified by t — test on 1 % level (p = 0.01) and by C. D. koeficient (Šiler, Váchal, Vinš 1967; Holčík, Hensel 1972).

RESULTS

Statistical characteristics of the indexes observed in both forms (E = *esculenta*, L = *lessonae*) are presented in Tables 1—12. T — test (p = 0.01) and C. D. koeficient values showing significant difference are underlined.

DISCUSSION

The gained values of the statistical characteristics of the proportional indexes correspond with the data in literature presented for both forms of green ranids by other authors (see Tables 13—18: 1. — Banikov and others 1977, 2. — Berger 1966, 3. — Kux 1975, 4. — Lác 1968, 5. — Růžička 1974, 6. — author's own results).
Sexual dimorphism in studied indexes is indistinct in both forms. Statistically significant difference was found only in index T./P. of *Rana esculenta* where t (140) = 3.16. Řepa 1976 also found very small sexual dimorphism in green ranids from Tachov area (without distinction of individual forms).
Highly significant differences in both sexes and totally as well found, however, between forms *esculenta* and *lessonae*. Index L./P., in which only females show significant difference between both forms was the only exception.

This result is in keeping with the work of Kux 1975, who found a highly significant difference in indexes D. p C. i. and L. T. between forms from Czechoslovakia using a great number of measured specimens: D. p C. i. — — t (1162) = 44.3. L.,T. — t (998) = 80.

Maximum body lenghts found in both forms and sexes correspond with the results of other authors — Table 18. It can be claimed that the body length of *R. esculenta* is bigger than that of *R. lessonae*, while the male body length in both forms is smaller than that of the female body.

The fact that groups *esculenta* and *lessonae* obtained by differentiation according to the shape of Callus internus (see Material and Methods) show significant differences in studied indexes confirms that this feature is an important determination criterion for individual forms of green ranids group (Berger 1966, Lác 1968, Růžička 1974).

Common occurrence of *R. esculenta* and *R. lessonae* at both sites is in keeping with the works of Berger, who considers the occurrence and survival of the hybrid form *esculenta* possible only at places with common occurrence of *R. lessonae* and *R. ridibunda* or in the isolated population of *R. lessonae* (Berger 1977), as is the situation at both studied sites near Plzeň.

CONCLUSION

1. At two close sites of green ranids near the town of Plzeň (Western Bohemia) the forms *Rana esculenta* and *Rana lessonae* were found.

2. Statistical characteristics of studied indexes D. p. C. i., T./C. i., L./T., L./P. T./P. and F. T. correspond with literature data of other authors for both forms

3. Sexual dimorphism in studied indexes was found only in index T./P. at *Rana esculenta*.

4. Both forms show a mutual statistically significant difference in all studied indexes with the exception of index L. P. in which only females show a significant difference.

5. Chosen method for differentiation of both forms according to the shape of Callus internus is suitable and can be used especially for determination of specimens from the sites in which more forms of green ranids occur.

Acknowledgements

I am highly indebted to Doc. Dr. O. Oliva, Senior lecturer in Vertebrate Zoology, Charles University, Prague, for many constructive comments and suggestions to the manuscript.

LITERATURE

Banikov, A. G., Darevskij, I. S., Iščenko, V. G., Rustamov, A. K. Ščerbak, N. N., 1977. Opredelitel zemnovodnych i presmykajuščichsja fauny SSSR. Prosveščenie Moskva.

Berger, L., 1966: Biometrical Studies on the Population of Green Frogs from the Environs of Poznan. *Ann. Zool. PAN, Inst. Zool.*, 23: 303—324.

Berger, L., 1975: Zaba vodna, "Rana esculenta L." — mieszaniec szczególnego rodzaju. *Przeglad Zool.*, 19: 74—78.

Berger, L., 1977: Je skokan zelený Rana esculenta křížencem? *Živa*, 25: 107—109.

Holčík, J., Hensel, K., 1972: Ichtiologická příručka. Obzor Bratislava.

Kux, Z., 1975: Příspěvek k rozšíření druhů Rana lessonae Cam., Rana esculenta L. a Rana ridibunda Pall. v ČSSR s několika taxonomickými poznámkami. *Čas. mor. Mus. Scient. natur.*, 60: 161—184.

Oliva, O., Hrabě, S., Lác, J., 1968: Stavovce Slovenska I — Ryby, obojživelníky, plazy. SAV Bratislava.

Růžička, J., 1974: Proměnlivost zelených skokanů — Rana esculenta L. a Rana lessonae Camerano — na českých lokalitách. Theses, Charles University, Faculty of Sciences. Praha, unpublished
Řepa, P., 1977: Biometrische Analyse der Grünfrosche aus dem Český les Gebirge und der Tachovska brazda Senke (Südwestböhmen). *Věst. čs. Společ. zool.*, 41: 121—134.
Šiler, R., Váchal, J, Vinš, J., 1967: Matematika v chovatelské praxi. SZN Praha.
Škoda, L., 1982: Vyskyt a ekologie obojživelníků v nádržích na území opuštěných lomů. Theses, Charles University, Faculty of Sciences, Praha, unpublished.
Škoda, L., Pivnička, K., 1986: Die Bedeutung verlassener Brüche als Refugialgebiete der Amphibien. *Věst. čs. Společ. zool.*, 50. 149—157.

Author's address: RNDr. Lubomír Škoda, Pařížská 6, 301 50 Plzeň.

Bestimmung wirbelloser Tiere im Gelände. Bildtafeln für zoologische Bestimmungsübungen und Exkursionen. Herausgegeben von H. J. Müller, Jena. 147 Tafeln und 2 Abbildungen. VEB Gustav Fischer Verlag Jena 1985. Preis 20.— DM.

Das besprechende Buch stellt das Resultant einer langjahriger Praxis in den Geländepraktika und Exkursionen an der Universität Jena dar. Die Paedagogen haben für die Studenten der Biologie und zukünftige Lehrer ganz neu konzipierte Bestimmungstabellen vorbereitet auf denen die im Gebiet regelmässig vorkommenden Strudelwürmer, Weichtiere und Gliedertiere angeführt und abgebildet werden. Die Auswahl ist auf limnische und terrestrische Formen beschränkt, die mit 10facher Lupenvergrösserung bestimmt werden können. Die Autoren haben die Zahl-, Grösse- und Farbeangaben sowie auch einfache, schematisch abgebildete Merkmale benützt. Auf dieser Weise sind im Buch insgesamt mehr als 1500 Gattungen und 1600 Arten zusammengebracht. Nach der Meinung der Autoren sind die Bestimmungstabellen auch in angrenzenden mitteleuropäischen Gebieten verwendbar.

Die Arbeit mit diesem Bestimmungsbuch ist sicher leichter und schneller als mit den anderen Exkursionsfaunen. Es besteht jedoch die gleiche Gefahr, dass in den Gebieten mit reicherer *Fauna* oder mit anderer *Artdominanz* der Benützer des Buches die gefundenen Tiere etweder gar nicht oder falsch bestimmen wird. Daneben kann die Anwendung der leicht erfassbaren Merkmale besonders bei den Gruppen, wo die taxonomischen Unterschiede auf komplizierten morphologischen Kriterien beruhen, die Studenten zur Ansicht fuhren, dass die faunistische und taxonomische Arbeit methodologisch allgemein auf einer sehr niedrigen Stufe steht. Es taucht also die Frage auf, ob es nicht besser wäre, die Tabellen in mehreren Fällen unter Berücksichtigung anspruchsvoller diakritischer Merkmale nur bis zu den höheren systematischen Kategorien zu führen.

Die reichlich benützten Längeangaben sollten in einigen Fällen lieber durch andere Merkmale ersetzt werden, weil sie irrefurend sein können. Z. B. nach der Angabe in der Tafel 1 sollen die Schalen der gefundenen Muscheln länger als 1 cm sein. Weiter kommen wir aber zur Gattung *Pisidium* mit 17 Arten, von denen die meisten nicht länger als 5 mm sind. Auf derselben Tafel lesen wir, dass die in Betracht genommenen Anneliden langer als 5 cm sind, obwohl später auch die Enchytraeiden genannt werden, die meistens kaum eine Länge von 2 cm erreichen. Ebenso täuschend sind in einigen Fällen die Farb- und Farbmusterangaben. Z. B. die meisten Arten der Spinnegattung *Pirata* haben nicht einen so klar ausgeprägten dunklen Gabelstreifen auf dem Prosoma wie auf der Figur. Das gleiche gilt auch für die Unterscheidungsmerkmale von *Singa hamata* und *nitidula* auf derselben Tafel.

Das Bestreben nach den klaren, einfachen Abbildungen führt machmal zu übertriebenen Schemata wie z. B. bei den Tricladiden *Polycelis cornuta* (richtig *P. felina*), *Polycelis nigra* und *tenuis* und *Crenobia alpina*.

Sehr wünschenswert wäre auch das konsequente Benützen der neueren Nomenklatur (z. B. Turbellaria: *Dugesia* statt *Euplanaria*, Gastropoda: *Bithynia* s. *Bulinus*, Araneae: *Pardosa* s. *Lycosa*, *Alopecosa* s. *Tarentula*, Heteroptera: *Enoplops* s. *Coreus* und *Coreus* s. *Mesocerus* — hier sind auch die Abbildungen gegenseitig gewechselt). Auf den Tafeln mit den Gastropoden vermissen wir bei den Gattungs- und Artnamen die entsprechenden Ordnungen bzw. Unterordnungen. Die Klassifikation der Arthropoden auf der S. 40 ist in einigen Detailen schon veraltet.

Alle diesen Bemerkungen, die nur als Beispiele angeführt wurden, vermindern keinesfalls den bahnbrechenden Verdienst des Autorekolektivs. Die weiteren Erfahrungen und Gebrauch der Tabellen wird sicher zur Verbesserung dieses nützlichen Buches führen. Schon jetzt findet es sicher eine gute Annahme sowohl in den Kreisen der Paedagogen wie ein Nachschlagebuch bei den Exkursionen als auch bei den Studenten der Biologie und allen Naturliebhabern, die mit dieser Publikation die ersten Schritte zur Erkenntnis der Mannigfaltigkeit der Tierwelt tun können.

M. Kunst

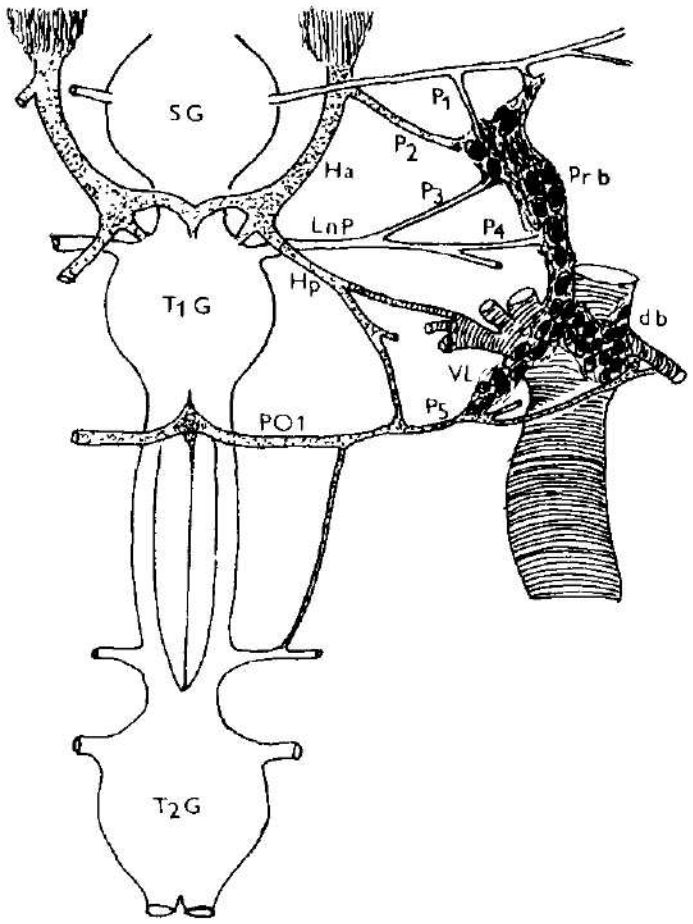


Fig. 1 Diagramatic representation of the innervation of prothoracic glands in the larvae of *G. mellonella*. db — dorsal branch od prothoracic glands, Ha — anterior arm of H-organ, Hp — posterior arm of H-organ; P 1—5 — nerves to the prothoracic glands; PO 1 — first metameric perisympathetic organ; SG — suboesophageal ganglion; T_1 G — prothoracic ganglion; vb — ventral branch of prothoracic glands.

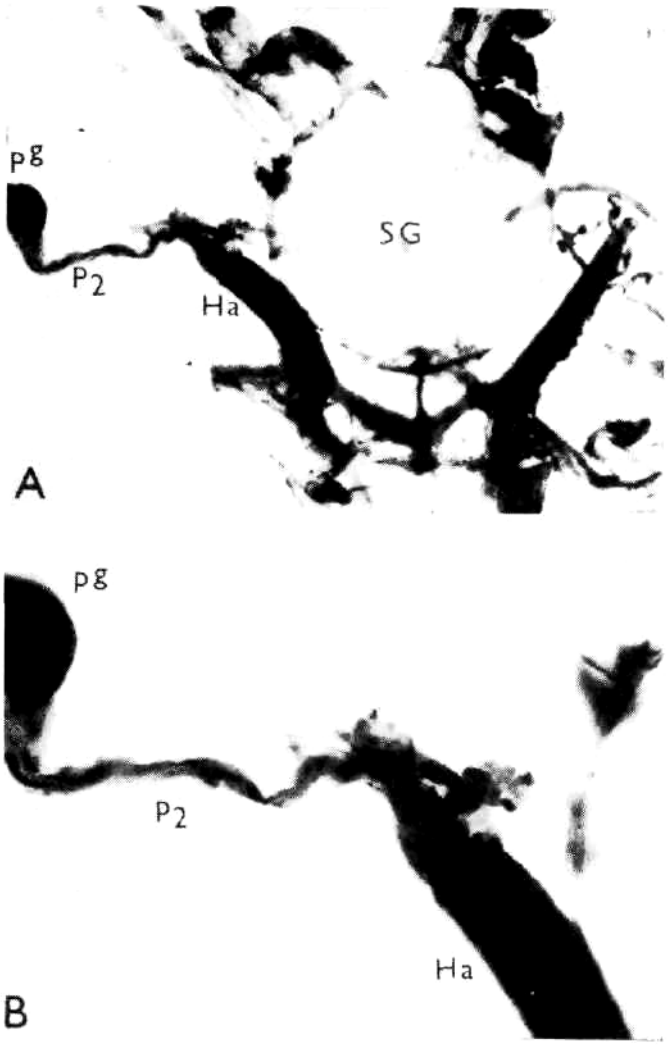


Fig. 2. A — whole mount preparation of the suboesophageal and prothoracic ganglia with H-organ (the black armed structure) innervating the prothoracic glands (methylene blue x 10). B — the same at higher magnification (x 25) to show the neurosecretory granules from P2 to the cell of prothoracic glands. Explanation see Fig. 1

Fig. 31. Ocypus fuscoaeneus — L III. Body length 18 mm.

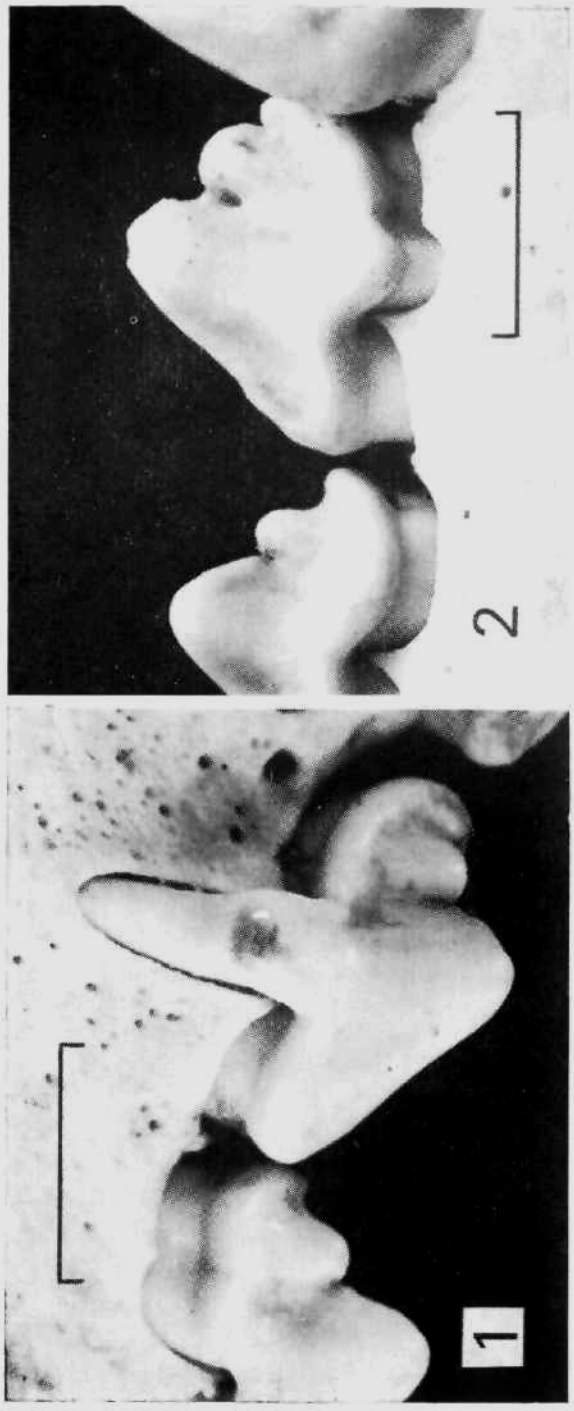
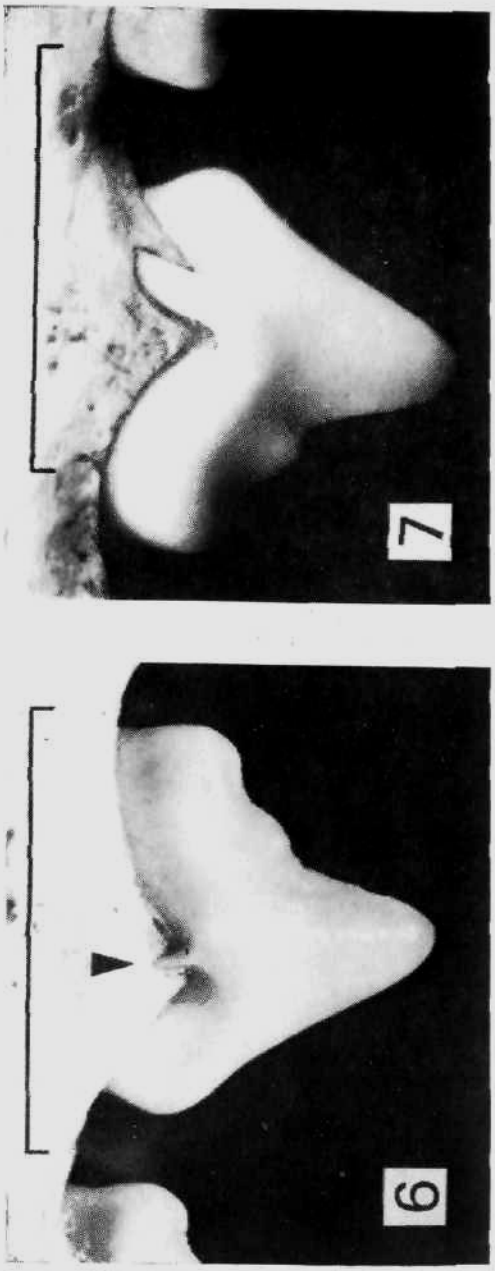
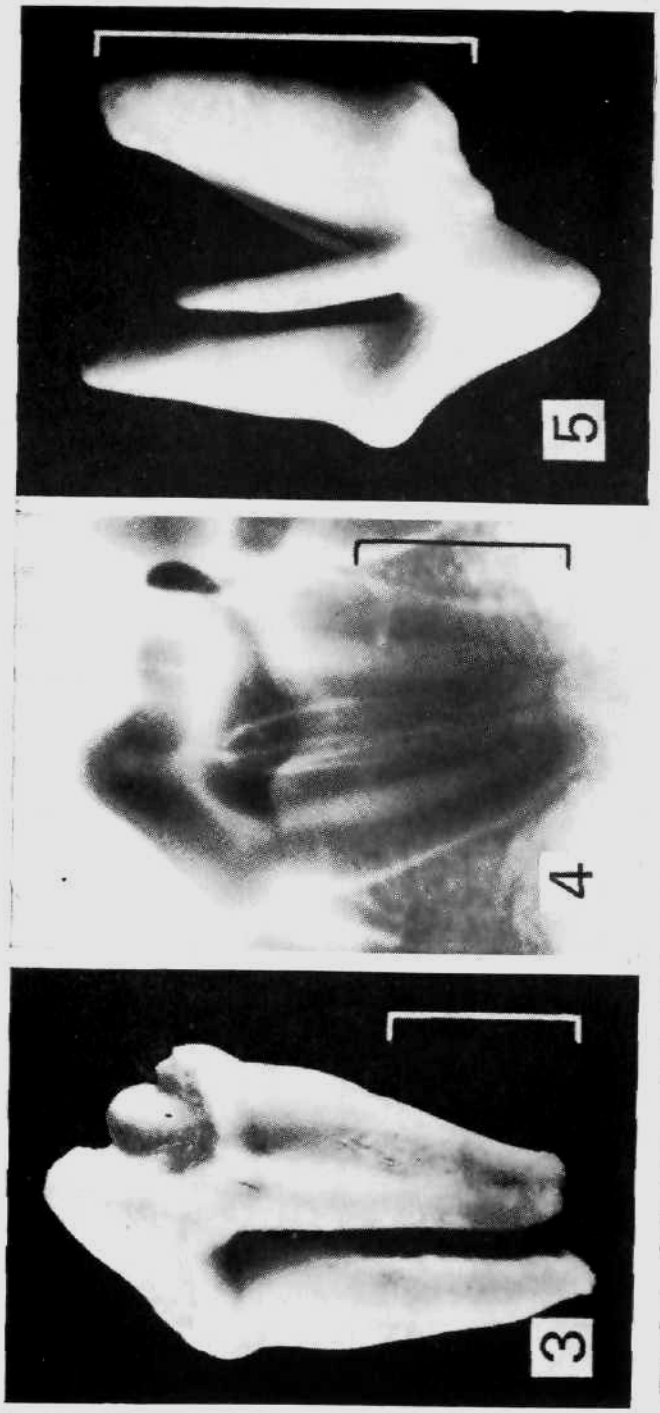


Fig 1. *Canis lupus*, coll. No NM 10980. External view of right P^3 in situ, lingual face. (Line represents length standard 10 mm in all figures.)

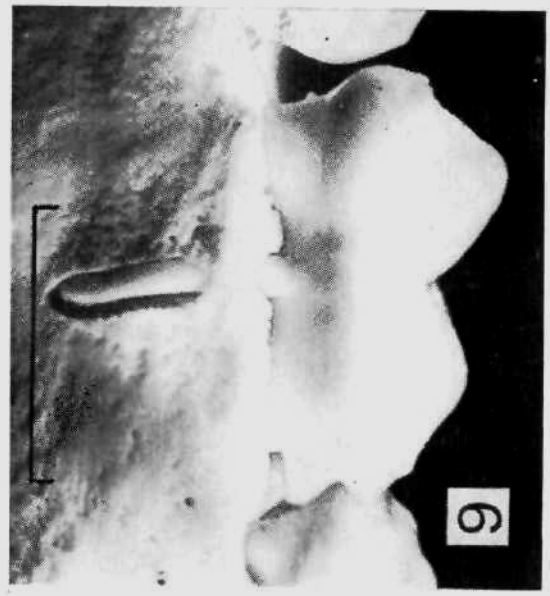
Fig. 2. *Canis lupus*, coll. No NM 10980. External view of right P_4 in situ, lingual face. Altered margin of lingual crown face well visible.



Figs. 6—7. *Vulpes vulpes*, coll. No NM 11868. Left P^3 with minute SR (indicated by black arrow, 6) and right P^3 (7): in situ, buccal faces.



Figs. 3—4. *Canis lupus*, coll. No 10980. Right P_4, lingual face. External view of extracted tooth, groove between fused medial (supernumerary) and distal roots well visible (3); X-ray photo of tooth in situ (4).
Fig. 5. *Vulpes vulpes*, coll. No NM 11865. Right P^3 extracted, lingual face.



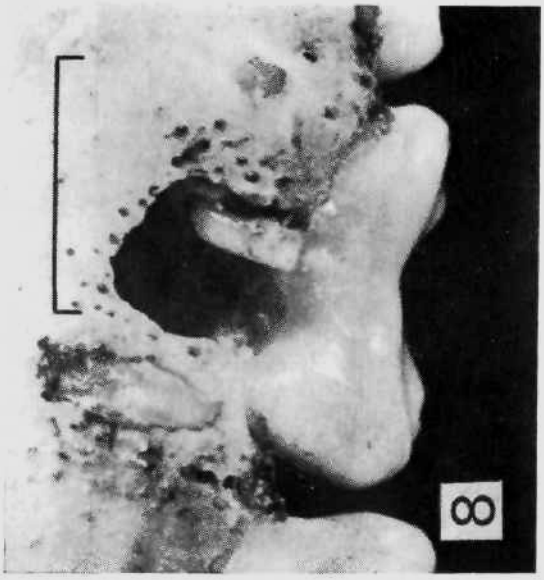


Fig. 8. *Chrysocyon brachyurus*, coll. No DK 394. Left M¹, buccal face; SR visible in cavity caused by cystogranuloma.
Fig. 9. *Chrysocyon brachyurus*, coll. No DK 450. Left M¹, buccal face; SR visible in fenestration of maxilla.
Photos I. Heráň (1—3 and 5—9) and M. Malinovský (4).

POKYNY PRO AUTORY

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

Formální úprava prací:

Rukopis (originál a 1 kopie) musí být psán na stroji s většími typy obřádek, na stránce 30 řádek, řádky po 60 úhozech, bez větších oprav. Rukopisy, které by neodpovídaly těmto formálním požadavkům, budou vráceny k přepsání.

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

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

Citace prací proveďte podle jednotného vzoru: autor, rok, název, časopis (mezinárodními bibliografickými zkratkami), ročník, sešit pouze v případě, že ročník není průběžně stránkován, stránky. U knižních titulů nakladatel a místo vydání. Např.: Hrabě, S., 1975: Second contribution to the knowledge of marine Tubificidae (Oligochaeta) from the Adriatic Sea. *Věst. čs. Společ. zool., 39: 111—119.*

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

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

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

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

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

Práce zasílejte na adresu: Doc. Dr. K. Hůrka, CSc., výkonný redaktor Věstníku čs. Společ. zool., Viničná 7, 128 44 Praha 2.

Redakční rada