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Zoologischer Garten Praha

ZUR WEITEREN KENNTNIS DER ZENTRALASIATISCHEN CHILOPODEN

Luděk J. DOBRORUKA

Eingegangen am 16. August 1977

Abstract: The description of a new species *Monotarsobius krali* sp. n. is given. For the first time the male of *Bothropolys* (*Probothropolys*) *lutulentus* Verhoeff, 1930 was found and described. Further, notes on *Lithobius giganteus* Sseliwanoff, 1881 and *Bothriogaster signata* (Kessler, 1874) are presented.

Mein Kollege und Freund, Herr Josef Král, hat von seiner Tourist-Reise nach Zentralasien (Usbekische SSR und Kirkisische SSR) ein kleines Material von Chilopoda mitgebracht, das sich — obwohl es insgesamt nur 20 Exemplare umfasst — als höchstinteressant erwies. Sei meinem Freund mein herzlichster Dank für die Liebenswürdigkeit erwiesen!

Die Chilopoden-Fauna Zentralasiens ist haupsächlich dadurch sehr interessant, dass sie einerseits Verwandschaft mit der mediterranen, anderseits mit der nearktischen Fauna aufweist. Darauf hat schon Attems (1904) und Verhoeff (1930) aufmerksam gemacht und die neuesten Arbeiten bestätigen es eindeutig. Leider ist die Chilopoden-Fauna Zentralasiens trotz ziemlich vielen bisher veröffentlichen Arbeiten sehr wenig bekannt und deshalb ist jeder weitere Beitrag zu derer Kenntnis sehr wünschenswert, da er stets die Kenntnis der Chilopoden Zentralasiens um neue Aspekte auf die Entwicklung und Zoogeographie dieser Gruppe erweitern kann.

Monotarsobius krali sp. n.

(Abb. 1—4)

Derivatio nominis: Ich nenne diese neue Art zur Ehre meines Kollegen und Freundes, des bekannten Halticiden-Spezialisten, Josef Král, Praha.

Locus typicus: Kirgisische SSR, Ala Archa, 8. 7. 1976 Král legit.

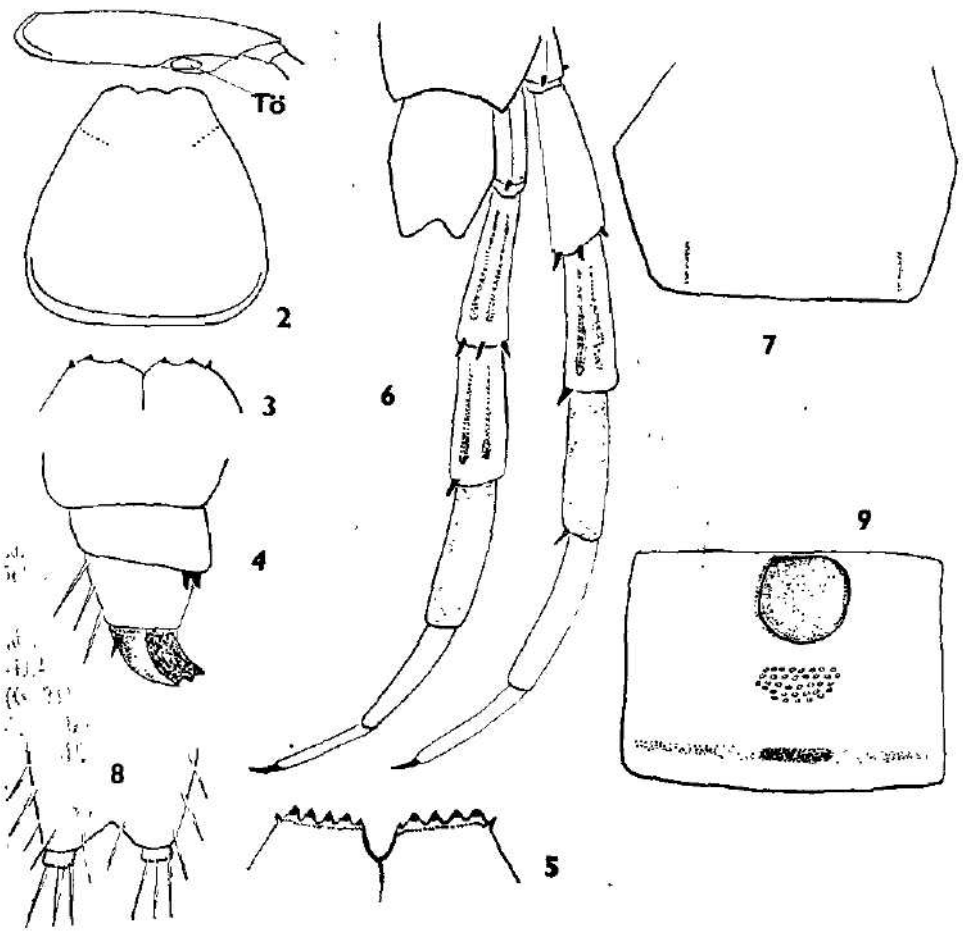
Holotypus: 1 ♂, No. 1762/III. Evert. in der Kollektion des Nationalmuseums Praha.

Paratypus: 1 ♀, No. 1763/III. Evert. in derselben Kollektion, aus der Lokalität Chimgan (Usbekische SSR), 3. 7. 1976 Král legit.

Weiters Material: 1 ♂, beschädigt, aus Chimgan (Usbekische SSR, 3. 7. 1976 Král legit.

Diagnosis: Tarsen 1—13 eingliedrig, Antennen mit 20—21 Gliedern. Ohne Ozellen. Tömösváry-Organ gross. D15 002-310 V15 01320-1, D14 10110, V14 0131-20. Klaue des 15. Beinpaares einfach. Koxalporen klein, 2, 2, 2, 2. ♀-Gonopoden mit 2 + 2 Spornen und dreispitziger Klaue.

Descriptio: Länge 8 mm (Holotypus) bis 8,5 mm (Paratypus). Farbe rostbraun. Antennen mit 20 (beide ♂♂) oder 21 (♀) Gliedern. Ozellen fehlen gänzlich. Tömösváry-Organ gross (Abb. 1) Koxosternum der Prehensoren mit 2 + 2 schwachen Zähnen, vor welchen lateral ein sehr kurzes Porodont steht (Abb. 3). Plectrotaxie: D1 00011, V1 00111; D14 10110, V14 beim Holotypus 01320, V14 beim Paratypus



Monotarsobius krali sp. n.
Abb. 1 — Kopf latral, mit Tömösváry-Organ; Abb. 2 — Kopfform, dorsal; Abb. 3 — Koxosternum der Prehensoren; Abb. 4 — ♀-Gonopoden.
Bothropolys (*Probothropolys*) *lutulentus* Verhoeff, 1930.
Abb. 5 — Koxosternum der Prehensoren; Abb. 6 — Beine des 14. und 15. Paares und das letzte Tergit; Abb. 7—11. Sternit; Abb. 8 — ♂-Gonopoden.
Bothriogaster signata (Kessler, 1874).
Abb. 9—39. Sternit mit beiden Gruben und mit Porenfeld.

01310. Der DCA zwar klein, aber deutlich ausgebildet. D15 beim Holotypus 00210, beim Paratypus 00310, V15 beim Holotypus 01320, beim Paratypus 01321. Endklaue einfach. Die Schleppfüsse des ♂ ohne jede Struktur, Femur etwas verdickt. Die Koxalporen klein, 2, 2, 2, 2. ♀-Gonopoden gedrungen, mit 2 + 2 kurzen Spornen, Klauenglied mit 3 langen Borsten. Klaue mit 3 Spitzen, dorsal mit einem starken, dunklen Dorn (Abb. 4).

Discussio: Durch die kleine Antennengliederzahl erinnert die neue Art auf drei blinde mediterrane *Monotarsobius*-Arten, *M. catacasphius* Verhoeff, 1937, *M. sphinx*

Verhoeff, 1941, und *M. hauseri* Dobroruka, 1965. Von allen diesen Arten unterscheidet sich die neue Art durch die Plectrotaxie und durch die Grösse. Aus Asien ist nur eine blinde *Monotarsobius*-Art mit 20 Antennenglieder bekannt, u. zw. *M. caecigenus* Myioshi, 1956. Bei dieser aus Japan stammenden Art, ausser der ganz anderen Kopfform, sind die ♀-Gonopoden mit nur 1 + 1 Sporn und die Gonopodenklaue ist einspitzig. Bei der neuen Art sehr interessant, dass auf dem 14. Beinpaare der DCA vorhanden ist, welcher aber auf dem 15. Beinpaare fehlt. Durch den Dorn auf der Dorsalseite der Gonopodenklaue errinert *M. krali* sp. n. auf *M. lencoranicus* Zalesskaja, 1976 oder *M. sectilis* Zalesskaja, 1976. Beide diese Arten, die aus der Aserbejdschanischen SSR (Lenkoran) stammen, sind aber nicht blind und unterscheiden sich in vielen weiteren wichtigen Merkmalen.

Bothropolys (*Probothropolys*) *lutulentus* Verhoeff, 1930

(Abb. 5–8)

Die Art wurde von Taschkent nach 2 ♀♀ beschrieben, das ♂ blieb bisher unbekannt. In unserem Material befindet sich ein topotypisches ♂ (Aktasch, Taschkent, 4. 7 1976 Král legit), so dass wir jetzt die Beschreibung dieser Art ergänzen und erweitern können.

♂, 18 mm lang, strohgelb. 20 Antennenglieder, 14 Ozellen in 3 Reihen. Koxosternum der Prehensoren mit 5 + 5 Zähnen, die inneren sind kleiner. Porodont nahe den lateralen Zähne stehend, ziemlich stark. Mediankerbe tief (Abb. 5). Die Koxalporen am 12. Beinpaar: 9 in 2 Reihen; 13. Beinpaar: 13 in 3 Reihen; 14. Beinpaar: 9 in 3 Reihen; 15. Beinpaar: 7 in 2 Reihen. Plectrotaxie: D14 10311, V14 rechts 21331, links 11331 (VCA fehlt). D15 10310, V15 21320. Auf den Koxen sind es VCA und VCM. Auf dem 14. Beinpaar Femur mit 2 Furchen, Tibia abgeplattet, auf dem 15. Beinpaar Präfemur und Femur mit 2 Furchen, Tibia abgeplattet (Abb. 6). Alle Tergite ohne Zahnfortsätze, 15. Tergit tief und scharf eingekerbt. 14. Sternit dicht und lang behaart, dieselbe Behaarung zeight auch der Kaudalrand des 13. Sternites. Die Sternite 2 bis 11 mit zwei abgekürzten Paramedianfurchen auf dem Hinterrande (Abb. 7), die schon Verhoeff in der Originalbeschreibung hervorhebt. ♂-Gonopoden kurz, knospenförmig, mit je 3 langen Borsten (Abb. 8).

In der Originalbeschreibung — ohne Kenntnis des ♂-vermutete Verhoeff (1930), dass *B. lutulentus* möglicherweise mit *B. desertorum* Lignau, 1929 identisch sein kann. Zalesskaja (1975) meint, dass *B. desertorum* ein nomen nudum ist, da Lignau niemals die Beschreibung veröffntlichte. Das ist aber ein Irrtum. Lignau (1929) veröffentlichte zwei Beiträge über zentralasiatische Chilopoden, u. zw. im Zool. Anzeiger 85. Im ersten Beitrag, S. 159—174, ist auf der S. 174 bloss der Name und Lokalität angeführt, aber in dem zweiten Beitrag, S. 204—218, ist auf den Seiten 210—211 eine Beschreibung mit Abbildungen gegeben, der Name *B. desertorum* Lignau, 1929 ist also ohne Zweifel walid. Aus der Beschreibung geht hervor, dass *B. desertorum* Lignau, 1929 eher mit *B. ghilarovi* Zalesskaja, 1975 verwand ist, als mit *B. lutulentus* Verhoeff, 1930. Beide erstgenannten Arten haben auf den Beinen des 14. und 15. Paares keine Furchen. In der Originalbeschreibung von *B. lutulentus* Verhoeff, 1930 musste ganz evident bei der Bezeichnung der ventralen Plectrotaxie der Beine zum Fehler kommen, welchen Zalesskaja (1975, S. 1323) übernommen hat. Meines Wissens besitzen ja alle Lithobiinae ventral am Trochanter mindessten des 14. und 15. Beinpaares einen Stachel (VTrM).

Lithobius giganteus Sseliwanoff, 1881

Über die Variabilität dieser interessanten Art habe ich schon früher geschrieben (Dobroruka, 1960, 1970). In dem neuen Material (8 ♂♂, 7 ♀♀), der aus Ala Archa

stammt und deshalb mit dem von Lignau (1929) untersuchten Material fast topotypisch ist, haben wir wieder eine grosse Variabilität, haptsächlich in der Zahl der Endklauen und in der Zahl der Zähne auf dem Koxosternum der Prehensoren festgestellt. 5 Exemplare haben 2 Endklauen, fünf 1 Endklaue, bei 3 Exemplaren sind einerseits 1, anderseits 2 Endklauen vorhanden (2 übrige Exemplare sind ohne Schleppfüsse). Koxosternum der Prehensoren ist meistens mit 2 + 2, doch viermal mit 4 + 4 Zähnen versehen. Diese Variabilität ist vom Geschlecht, Grösse oder Alter der Tiere nicht abhängig. Bei einem ♂, das 42 mm lang ist, wurden Antennen mit 18 Gliedern festgestellt, die übrigen Exemplare haben immer 20 Antennenglieder. Koxalporen in der Anzahl 3—4. Alle Tiere sind einfarbig dunkelbraun.

Bothriogaster signata (Kessler, 1874)

(Abb. 9)

Ein ♀, Aksaj, Alma Ata, 11. 7. 1976 Král legit. 135 mm lang, mit 111 Beinpaaren.

Die Sternitgruben sind auf den Sterniten 36. bis 46. entwickelt. Sie sind fast rund und sehr gross, ungefähr so breit wie die Porenfelder. Die Hintergruben stark entwickelt (Abb. 9).

Schon Lignau (1929, S. 163) fand die Variabilität in der Grösse und Form der Sternitgruben bei den Exemplaren aus Taschkent und Gook Tepe und bei einem Exemplar stellte er sogar solche Sternitgruben fest, die für *B. megalocycla* Attems, 1911 (Syrien, Palästina, Anti-Taurus) charakteristisch sein sollen. Das bestätigt auch unser Exemplar. Es wäre also sehr wünschenswert die beiden Arten zu vergleichen, da sie vielleicht konspezifisch sind.

SCHRIFTTUM

Attems, C., 1904: Zentral- und hochasiatische Myriapoden. *Zool. Jahrb.*, 20 : 113—130.

Attems, C., 1928: Geophilomorpha. *Das Tierreich*, 52 : 1—388.

Attems, C., 1947: Neue Geophilomorpha des Wiener Museums. *Ann. Naturhist. Mus. Wien*, 55 : 50—149.

Dobroruka, L. J., 1960: Über eine kleine Chilopoden-Ausbeute aus der Mongolei. *Acta Arachnologica*, Osaka, 17 : 15—18.

Dobroruka, L. J., 1965: Ein Beitrag zur Landtierwelt von Korfu. Chilopoda. *Sitzungsber. Österr. Akad. Wiss. Math. Naturwiss. Kl., Abt. I*, 174 : 393—402.

Dobroruka, L. J., 1970: Kurzer Beitrag zur Kenntnis der zentralasiatischen Chilopoden. *Zool Anzeiger*, 184 : 94—96.

Lignau, N., 1929: Zur Kenntnis der zentralasiatischen Myriopoden. *Zool. Anzeiger*, 85 : 159—174.

Lignau, N., 1929: Neue Myriopoden aus Zentralasien. *Zool. Anzeiger*, 85 : 204—218.

Sseliwanoff, A., 1881: Neue Lithobiiden aus Sibirien und Central-Asien. *Zool. Anzeiger*, 4 : 15—17.

Verhoeff, K. W., 1937: Chilopoden-Studien zur Kenntnis der Lithobiiden. *Arch. Naturgesch. N. F.*, 6 : 171—257.

Verhoeff, K. W., 1930: Über Myriapoden aus Turkestan. *Zool. Anzeiger*, 91 : 243—266.

Verhoeff, K. W., 1941: Zur Kenntnis mediterraner Chilopoden besonders der Insel Ischia. *Z. Morphol. Ökol. der Tiere*, 38 : 483—525.

Zalesskaja, N. T., 1975: Novye rody i vidy kostjanok (Chilopoda, Lithobiomorpha) iz srednej Azii i dalnego vostoka. *Zool. Zhurnal*, 54 : 1316—1325.

Zalesskaja, N. T., 1976: Novye vidy kostjanok roda Monotarsobius v SSSR (Chilopoda, Lithobiomorpha). *Zool. Zhurnal*, 55 : 607—612.

Anschrift des Verfasser: RNDr. Ing. Luděk J. Dobroruka, Zoologischer Garten, 171 00 Praha 7-Troja 120, ČSSR.

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THE EFFECT OF COOLING ON THE CHEMICAL BLOOD COMPOSITION OF GALLERIA MELLONELLA PUPAE (LEPIDOPTERA)

Milan MAREK

Received November 9, 1977

Abstract: Exposure of *G. mellonella* pupae to 4° C induces profound changes in respiratory metabolism and in composition of the hemolymph. Pupae kept at 30° C consumed in average 649 mm^3 O_2/g/hr. After a continuous exposure of pupae to 4° C for 26 days the oxygen consumption was 38.8 mm^3 O_2. The hemolymph volume was reduced by 2% over the first 3 days and by another 8% after the further 4 days of cooling. The osmotic pressure of the hemolymph increased by 49% during the 7 days of cooling. The protein content was 63.5 mg/ml. Cool-treatment of pupae for 7 days resulted in an increase of proteins by 32.5% and of 12 free amino acids by 76%, i.e. from 1232.6 mg% to 2170.29 mg%. The share of free amino acids in the osmotic pressure of the hemolymph of control pupae was 24.8%. During the cool-treatment their contribution to osmotic pressure rose by 18%. The content of carbohydrates decreased from 11.14 mg/ml to 1.73 mg/ml during the cooling period. The content of free fatty acids was also considerably diminished due to cooling. The glycerol content increased by 8.5% over the first half of cooling and by 21.5% over the second half. The level of uric acid increased by 100% over 3 days of cooling and by 24.5% during the next four days.

INTRODUCTION

It is known from literary data that low temperature reduces the metabolic processes in insects to minimum (Prosser and Brown, 1962). Some species are more or less able to acclimate to rather unfavourable conditions, depending on the organism's adaptibility (Lozina-Lozinsky, 1972). Adaptation to low temperature involves changes in several body constituents.

The aim of our study on cool-treated pupae of *Galleria mellonella* was to explore in detail how the cold affects the general metabolism and, in particular, the metabolism of substances which are of importance for the adaptation to coolness.

As reported in a previous paper (Marek, 1970, a temperature of 4 °C induces synthesis of a "cooling protein" in the hemocytes of *G. mellonella* pupae. Experiments described recently (Marek, 1978) showed that anorganic cations are not the main factors responsible for alterations in osmotic pressure in the hemolymph and that other metabolic substances must be involved. The results obtained in determining some of these substances are described in the present paper.

MATERIALS AND METHODS

The stock culture of *Galleria mellonella* was reared on artificial diet at 4° C and relative humidity of 60% in darkness (Balász, 1968; Sehnal, 1966). In addition to pupae kept under the same conditions we used also pupae (1—7 days old) cooled in an ice-box at 4° C and 100% relative humidity for 7 days.

Measurement of oxygen consumption

The consumption of oxygen was measured in groups of 16 pupae of both sexes using the Drastich respirometer at 30° an 4° C. Readings were taken every day at the same time for 26 days. The values of oxygen consumption obtained at 30° C and 4° C were expressed in terms of normal barometric pressure and 0° C temperature. For further particulars on respirometric methods see Drastich (1924) and Janda (1957).

Analysis of the hemolymph

Hemolymph for chemical analysis was collected from pricked pupae in siliconized eprouvettes. A small amount of phenythiourea was added to the collected hemolymph.

The amount of hemolymph per pupa was determined according to Richardson et al. (1931), using the method of weighing.

The content of carbohydrates in the hemolymph was determined with the anthron method following deproteination (Janda, 1974), and the amount of uric acid with the method described by Homolka (1969).

The content of the total proteins was determined with the biuret method according to Wannemacher et al. (1965).

The levels of individual free amino acids were estimated by column chromatography on ion exchangers (Chromex KB-52). Amino acids in eluates were detected with ninhydrin.

The osmotic pressure in the hemolymph was determmed by freezing point depression with a Knauer-semi-micro-osmometer. Value of $\Delta t°$ was calculated to doubly destilled water. The results were expressed in mmOsm $\left(\frac{\Delta t°}{1,86}\right)$.

Glycerol was estimated in 10 µl of hemolymph colorimetrically at the wave length of 410 nm using ammonia acetate and isopropanol with acetylaceton to Továrek (1974).

The lipids from the hemolymph were extracted using the chloroform-methanol mixtuer (2 : 1 vol.) according to the modification described by Folch et al. (1957). The fats rectified chloroform were further separated chromatographically on an activated thin layer of silica gel SH Spolana (5–30 µ) with 5% of plaster. The detection of the lipids was carried out by spraying the plates with a 10% solution of phospho-molybden acid in ethanol. Heating of the plates to 60° C made the lipid fractions stain blue dark (Poledne, 1968).

RESULTS

Measurements of oxygen content

The average oxygen consumption in 1 to 7 day-old pupae of *Galleria mellonella*, i.e. throughout the l-adult transformation was 649 mm³ O_2/g/hr when measured at the normal breeding temperature. When the temperature was lowered (after 1 hr) during the measuring to 4 °C, the O_2 consumption remained constant at 54.2 mm³ for 5 hours. Nearly the same consumption namely 53.5 mm³, was observed also after 12 hours of adaptation to 4 °C. After 48 hours of keeping the pupae at 4 °C the consumption dropped to 46.3 mm³ O_2. On the 7th day the consumption was 40.3 mm³ O_2. It is clear from the results that during the first 5 hours there was a decrease in O_2 consumption by 594.8 mm³. During the following days the consumption decreased only by 14.3 mm³ O_2. The O_2 consumption estimated for 26 days of culturing at a lowered temperature was 38.3 mm³ O_2/hr (Fig. 1).

Changes in the composition of hemolymph

The volume of hemolymph. The volume of pupal hemolymph decreased during the first 3 days of cooling from 15.1 mg to 14.8 mg, i.e. only by 2%. After another 4 days, the volume decreased by 1.2 mg, i.e. 8 %. Thus, during the 7 days of cool treatment the volume of hemolymph was, in total, lowered by 1.5 mg, i.e. by 10% (convered to 100 mg fresh weight, see Table 1).

Osmotic pressure. The osmotic pressure of pupal hemolymph increased from 497.8 to 744.9 mOsm, i.e. by 49.5%, over the 7 days of 4 °C treatment, the increase

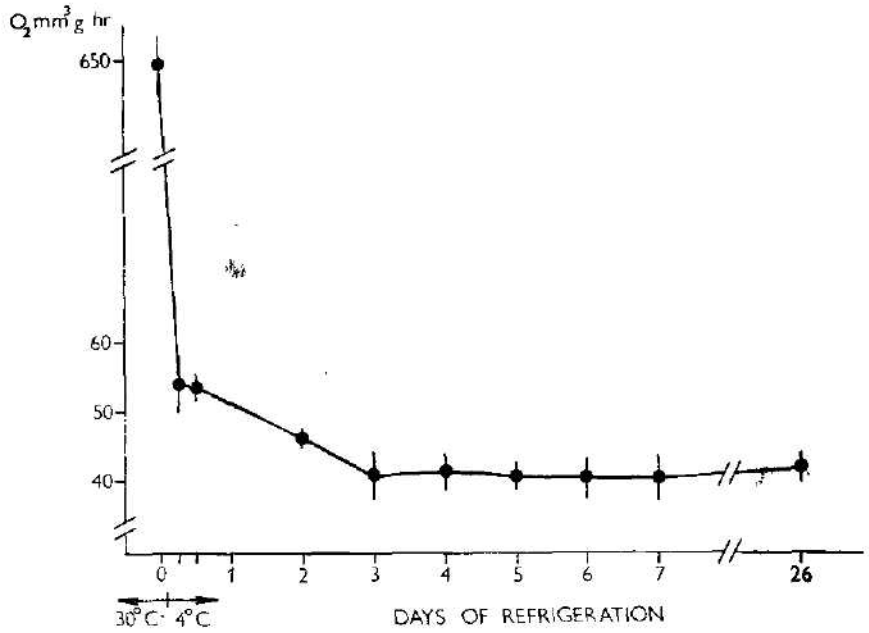

Fig. 1. Oxygen consumption in cold treated (at 4° C) and noncooled (at 30° C) pupae.

over the first half of cooling being 205.8 mOsm, i.e. 41%, and that over the second half 41.3 mOsm, i.e. 8%.

Free amino acids. Under the influence of cooling, the content of free amino acids in the hemolymph increased from 1232.6 mg% to 2170.29 mg%, i.e. by 76% (Table 1). Quantitative changes were investigated in 16 free amino acids. In normal pupae the

Table 1. Changes in body weight, oxygen consumption and hemolymph consumption induced by cold treatment.

	Control pupae	Cooled pupae at 4°C for 3 days	Cooled pupae at 4°C for 7 days	Balance
Cotal weight of pupae in mg	100	97.3	95.1	−4.9
Tonsumption of oxygen at mm³/G/hr	649	40.7	40.0	−608.6
Proteins at mg/ml of hemolymph	63.5	47.5	44	−19.5
Free amino acids at mg% of hemolymph	1232.6	—	2170.3	+937.7
Uric acids at μg/ml of hemolymph	132	264	296	+164
Carbohydrates at mg/ml of hemolymph	11.1	8.2	1.7	−9.4
Content of hemolymph at % of weight body	15.1	14.8	13.6	−1.5
Glycerol at mg% of hemolymph	64	69.5	83	+19

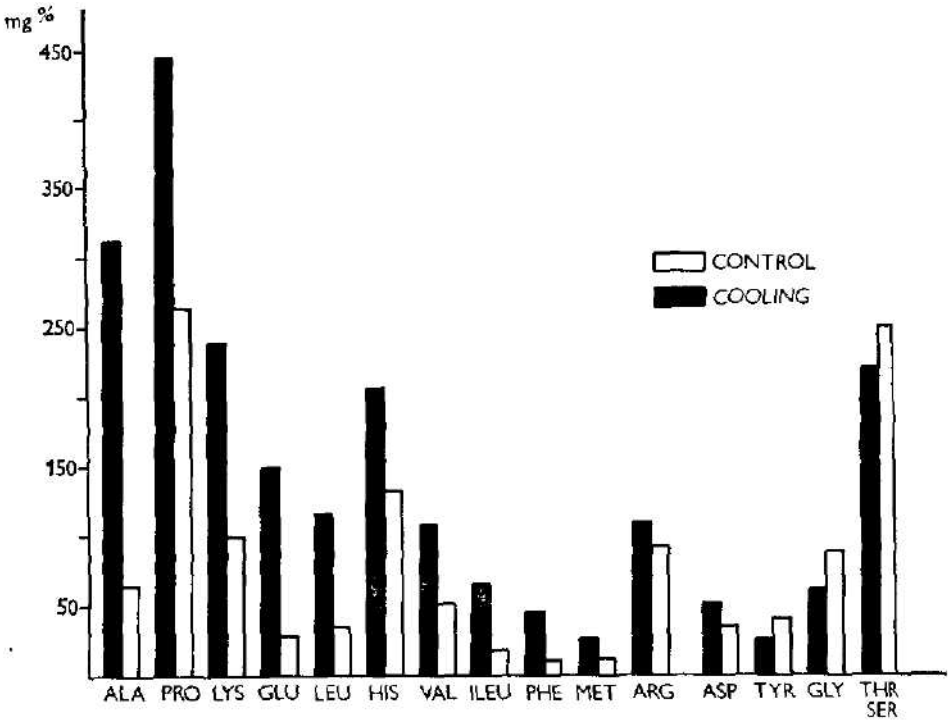

Fig. 2. Comparison of the concentration of free amino acids in the hemolymph of control pupae and in pupae kept for 7 days at 4° C.

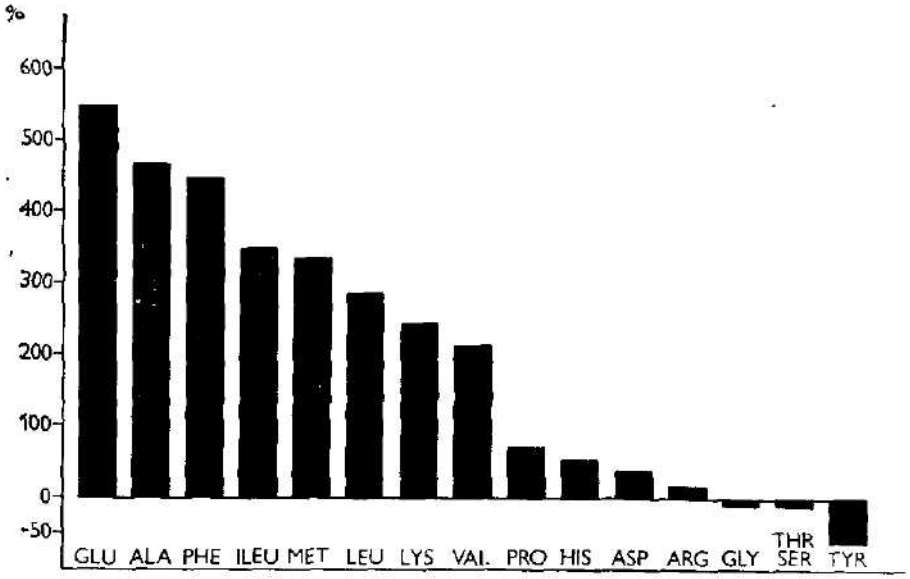

Fig. 3. Changes (%) in the content of free amino acids in the hemolymph caused by exposure of pupae to 4° C for 7 days.

highest concentration was found in proline (263 mg%). Second was serine with threonine (254 mg% each), whose chromatographic separation was poor. Histidine took the third place with 136 mg%. Next in order were lysine (98 mg%), arginine and glycine (90 mg%) and alanine with valine averaging 59 mg%.

The 7-day cooling treatment brought about an increase in the content of 12 free amino acids in the hemolymph. The highest increase was found in alanine (the concentration rose by 244 mg%), proline (179 mg% increase), lysine (139 mg% increase) and glutamine (119 mg% increase). Due to cooling the content of tyrosine decreased by 14 mg%, that of glycine by 28 mg% and that of threonine with serine by 33 mg% (Fig. 2, 3).

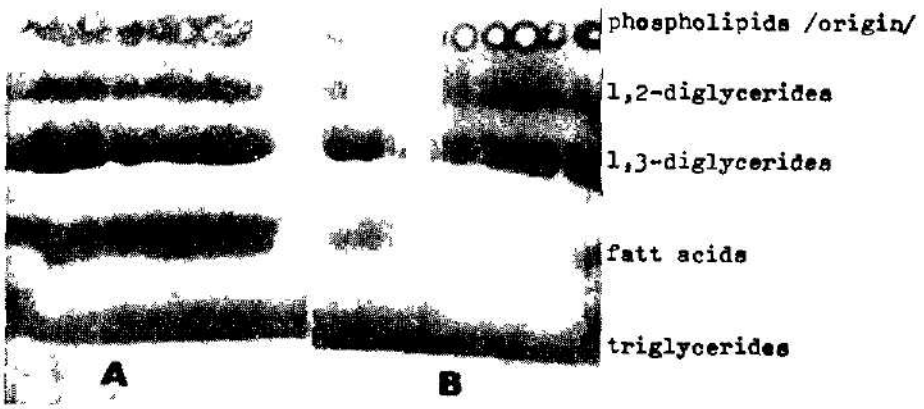

Fig. 4. Chromatogram of hemolymph lipids in pupae kept at 30° C (A) and in pupae cooled at 4° C for 7 days (B).

The overal share of free amino acids in osmotic pressure represented 24.8%. After the cooling, the increase in the amino acids content by 76% brought about a proportional rise in their participation in the overall increase of osmotic pressure in the hemolymph, i.e. by 43.6%.

Proteins. The protein concentration in the hemolymph in normally cultured pupae was 63.5 mg/ml of hemolymph. During 3 days of cooling the concentration was reduced to 47.5 mg/ml, i.e. by 25%, and on the 7th day of cool treatment it dropped to 44.0 mg/ml, i.e. by 7.5% (Table 1).

Uric acid. The level of uric acid in the hemolymph of control pupae amounted to 132 µl/ml. On the 3rd day of cooling the hemolymph contained 264 µg/ml of uric, and on the 7 day 296 µg/ml. This indicates that uric acid content increased by 100% increase during the first half of the cooling period and by another 24.5% over the second half of the cooling period (3th—7th day) — see Table 1.

Carbohydrates. The concentration of carbohydrates in the hemolymph decreased from 11.14 mg/ml to 1.73 mg/ml over the cooling period. A slowly proceeding decrease in carbohydrates by 2.97 mg/ml, i.e. by 26.8% took place during the first 3 days, and somewhat greater decrease 6.44 mg/ml, i.e. 57.8% during the next four days (Table. 1).

Glycerol. The content of glycerol in non-colled pupae was 64 mg in 100 ml of hemolymph. During the initial 3 days of cooling the level of glycerol rose very

slightly to 69.5 mg%, i.e. by 8.5%. On the 7th day of cooling a value indicating an increased synthesis or release of glycerol was determined; the estimation was 83 mg% of glycerol in the hemolymph, which corresponds to a 30% increase in glycerol over the 7-day cooling period (Table 1).

Total lipid. Using chromatography on a thin layer of silica gel and plaster, we succeeded in separating the fats present in the hemolymph into several fractions among which the greatest changes due to cooling were found in free fatty acids. As seen from Fig. 4, these fatty acids considerably decreased owing to the cool treatment. The other fractions (phospholipids, 1,2-diglycerides, 1,3-diglycerides and triglycerides) remaind almost unchanged (Fig. 4).

DISCUSSION

As a result of the absence of thermoregulation, invertebrates greatly depend on the temperature of their environment. A reduction of the intensity of physiological processes in insect tissues takes place quite lawfully under conditions of lowered temperature. As a rule, however, this reduction of biological activities does not occur simultaneously in all tissues, because not all the cells of the organism are equally sensitive to alterations in environmental temperature (Baldwin, 1949).

Evaluation of oxygen consumption is a very important indicator of the university of physiological processes and thereby an indicator of the adaptation of the organism to low temperature. Koshantchikow, 1935 and Lozina-Lozinsky, 1943 and 1955 state that adaptation is achieved when the respiratory metabolism ceases to fall and remains more or less at the same level in spite in the prolonged exposure to low temperature.

Similary, in our experiments with pupae of *G. mellonella* a sharp decline of oxygen consumption occured during the first three days of cooling being followed by a steady level lasting until the 26th day (i.e. the last day we measured respiration). It follows from the present results that within 3 days the pupae became adapted to the temperature of 4° C.

Our determinations of organic substances in the hemolymph are on the whole in agreement with the data given by Baldwin, 1949. This author concluded that the content of these substances changes under the influence of environmental temperatures.

In insects a reduction of water content in tissues is a common preventive protection to coolness. Prior to diapause, insects lose up to 10—17% of water (Bodine, 1921, 1923 and Payne, 1928, 1930).

Glycerol present in the hemolymph of diapausing pupae is one of the substances which are of importance for their increased resistance to cold and frost. Wigglesworth (1965) reported that the glycerol content was increased by 200% in *Hyalophora cecropia* during the diapause. Also in our experiments the content of glycerol in the blood of *G. mellonella* pupae increased by 30% as a result of cooling. The glycerol of the hemolymph is derivead above all from the carbohydrates, primarily from threhalose (Asahina, 1966; Lozina-Lozinsky, 1972 and Němec, 1973). Lozina-Lozinsky, 1972 states that glycerol is synthesized in the hemolymph of *Monema flaviscens* prepupae if the environmental temperature falls to 20° C. According to this author, the optimal temperature for synthesis stimulation is 10° C. At 0° C only a minimum of glycerol is synthesized in diapausing pupae. Wilhelm et al., 1961 report that the accumulation of glycerol in the hemolymph occurs also in pupae kept under anaerobic conditions. This conclusion is in agreement with

observation of Wyatt, 1961 who, experimenting upon lesion in *Hyalophora cecropia* pupae, determined a decrease in the glycerol content and an increase in oxygen consumption.

In our present experiments we confirmed that chilling of *G. mellonella* pupae causes a rise of the blood osmotic pressure (Marek, 1978). Marcuzzi, 1956 suggested that maintenance of appropriate values of the osmotic pressure depends to a great deal on the content of carbohydrates in the hemolymph and that carbohydrates can be replaced by free amino acids. These findings may to some extent help us to understand the mechanism of aminoacidemy.

According to Usherwood, 1969, a high acidemy is characteristic property of insect hemolymph, in particular of the hemolymph of endopterygotes. The content of free amino acids is as much as 50 times higher than that found in vertebrate serum (Wigglesworth, 1965; Wyatt, 1961: Gilbert and Schneiderman 1961 and L'Helias, 1970). For the most part, 16 to 20 amino acids take their share in this high concentration. The physiological significance of free amino acids has not yet been fully reconciled though both quantiative and qualitative investigations have already been carried out during various phases of insect development (Florkin, 1944; 1959). Florkin, 1959; Chen, 1966 and Corrigan, 1970, established that the concentrations of free amino acids do not change enough to be related to developmental changes in the organism.

In our experiments we started from the assumption that free amino acids might be of great importance for the resistance of insects to cooling (Ushatinskaya, 1957), and this assumption was proved right. The quantity of free amino acids in the hemolymph exceeds after the 7 days of cooling by 76% that found in normal pupae. It seems that the adaptation of non-diapausing *G. mellonella* pupae to cool conditions is accompanied first of all by an increase in the content of free amino acids. It is possibly the hydrolysis of hemolymph proteins that gives rise to these amino acids, as suggested by the great decrease of hemolymph proteins during the period of cooling. This is also connected with the increased content of uric acid, which is a product of protein metabolism and secondarily enhances the adaptation of the insect organism to coolness by increasing the osmotic pressure, as reported also by Ushatinskaya, 1957 (Table 1).

However, not all free amino acids are of equal importance for the adaptation of the organism. Cooling caused a decrease in the contents of glycine, tyrosine and of the threonine + serine fraction. It appears that increased contents of alanine (Somme, 1967), proline, lysine and glutamine are essential for the adaptation to coolness.

The increase of alanine content in the hemolymph may be related to the decline of the general metabolism in cooltreated pupae, a phenomenon observed by Hodková and Kubišta, 1972 in isolated muscles of *Periplaneta americana* which were kept under anaerobic condition with carbohydratic substances reduced.

The lowered content of non-esterified fatty acids in the hemolymph of cooled pupae suggests that these may be metabolized into carbohydrates or glycerin (Ipatowa, 1971), the latter being necessary for the adaptation to the cold.

REFERENCES

Asahina, E., 1966: Freezing and frost resistance in insects. In: Cryobiology. Ed. H. T. Meryman, London – New York, 451 – 486.

Balazs, A., 1958: Nutritional and nervous factors in the adaptation of Galleria mellonella to artifitial diet. *Biol. Acad. Scient. Hungaricae*, 9 : 47 – 69.

Baldwin, E., 1949: An introduction to comparative biochemistry. IAN SSSR, Moscow (In Russian).

Bodine, J. H., 1921: Factors influencing the water content and the rate of metabolism of certain Orthoptera. *J. Exp. Zool.*, 32 : 137—164.

Bodine, J. H., 1923: Hibernation in Orthoptera, *J. Exp. Zool.*, 37 : 457—476.

Chen, P. S., 1966: Amino acids protein metabolism in insect development. In: Advances in insect. Ed. Beament, J. W., Treherne, J. E. and Wigglesworth, V. B., vol. 3 : 53—132.

Corrigan, J. J., 1970: Nitrogen metabolism in insect. In: Comparative Biochem. of Nitrogen Metabolism. The Invertebrates. Ed. Cambell, J. W., vol. 1 : 387—488. Academic Press, London.

Drastich, L., 1924: Mikrorespirometr v nové úpravě. *Biol. listy*, 10 : 1—20 (In Czech).

Florkin, M., 1944: L'evolution biochemique. Masson, Paris.

Florkin, M., 1959: The free amino acids of insect hemolymph. *Fourth Int. Cong. Biochem.*, 12 : 63—73.

Folch, J. M., Lees, M. and Sloane-Stanley, G. H. S., 1957: A simple method for the isolation and purifikation of total lipids from animal tissues. *J. Biol. Chem.*, 226 : 497—509.

Gilbert, L. I., Schneiderman, H. A., 1961: Some biochemical aspects of insect metamorphosis. *Am. Zoologist*, 1 : 11—51.

L'Hélias, C., 1970: Chemical aspect of growth and development in insects. In: Chemical Zoology. Ed. Florkin, M. and Scheer, B. T., vol. 5: Academic Press, New York, London.

Hodková, M., Kubišta, V., 1972: Anaerobic formation of alanine in the metathoracic musculature of Periplaneta americana. *Insect Biochem.*, 1 : 461—466.

Homolka, J., 1969: Klinické biochemické vyšetřovací metody s použitím mikro- a ultramikroanalysy. SZN, Praha. (In Czech.)

Ipatowa, T. N., 1971: Nekotorije fisiologo-biochemitscheskije mechanismy podgotowki wrednej tscherepaschki k zimowke. In: Cholodostojkost nasekomych i kleschtschej. Mat. simp., Tartu 31—33. (In Russian.)

Janda, V. jr., 1957: Modifikace Drastichova mikrorespirometru ke stanovení respiračního kvocientu. *Spisy Přír. fak. Mas. univ. Brno*, 385 : 1—10. (In Czech.)

Janda, V. jr., 1974: Aufbau und Verwärtung der Kohlenhydraten Reserven bei den Larven von Galleria mellonella L. im Zusammenhang mit Wachstum und Metamorphose. *Zool. Jb. Physiol.*, 78 : 129—137.

Koshantschikow, I. V., 1935: Dychanije nasekomych pri temperaturach nishe 0°. *DAN SSSR*, 3 : 369—371.

Lozina-Lozinsky, L. K., 1943: Kolebanija intesiwnosti dychanija u nasekomych v svjazi s temperaturoj i rozwitijem. *Izw. AN SSSR*, 3 : 125—134. (In Russian.)

Lozina-Lozinsky, L. K., 1955: Shiznesposobnost anabios pri nizkich temperaturach skiwotnych. In: Anabios. Ed. Schmidt, P. Ju., 381—433. IAN SSSR, Moskau, Leningr svjazi Russian.)

Lozina-Lozinsky, L. K., 1972: Studies on cryobiology. Nauka, Leningrad. (In Russian.)

Marcuzzi, G., 1956: *R.C. Acad. Lincei*, 20 : 492—504 (cit. Wigglesworth, V. B., 1965).

Marek, M., 1970: Effect of actinomycin D on synthesis of "cooling protein" in hemolymph of pupae of Galleria mellonella L. *Comp. Biochem. Physiol.*, 34 : 221—227.

Marek, M., 1978: Effect of cooling on osmotic pressure, cation contents, and protein synthesis in the blood of Galleria mellonella prepupae and pupae. *Věst. Čs. spol. zool.*, 62 : 128—138.

Němec, V., 1973: Hormonální regulace sacharidového metabolismu u hmyzu. Kand. disert. práce EÚ ČSAV, Praha. (In Czech.)

Payne, N. S., 1928: Cold hardiness in japanese beetle Popillia japonica. *Biol. Bull.*, 55 : 163—179.

Payne, N. S., 1930: Some effect of low temperature on internal structure and function in animals. *Ecology*, 2 : 500—504.

Poledne, R., 1968: Experimentální modely pro studium synthesy a esterifikaci mastných kyselin v játrech. Kand. disert. práce. Praha. (In Czech.)

Prosser, C. L., Brown, F. A. jr., 1962: Comparative animal physiology. Saunders, Philadelphia, London.

Richardson, C. H., Burdette, R. C. and Eagleson, C. W., 1931: The determination of the blood volume of insect larvae. *Ann. Ent. Soc. Amer.*, 24 : 503—507.

Sehnal, F., 1966: Kritische Studium der Bionomie und Biometrik der in verschiedenen Lebensbedingungen gezüchteten Wachsmotte, Galleria mellonella L. (Lepidoptera). *Z. Wiss. Zool.*, 174 : 53—82.

Sømme, L., 1967: The effect of temperature and anoxia on hemolymph composition and supercooling in three overwintering insects. *J. Insect Physiol.*, 13 : 805—814.

Továrek, J., 1971: Colorimetric determination of the triglycerides in the human serum and plasma. *Sigma Techn. Bull.*, 405.

Uschatinskaja, R. S., 1957: Osnowy cholodostojkosti nasekomych. IAN SSSR, Moskau. (In Russian.)
Usherwood, P. N. R., 1969: Electrochemistry of insect muscle. In Advances in insect physiology. Ed. Beament, J. W. L., Treherne, J. E. and Wigglesworth, V. B., vol. 6 : 214—222. Academic Press. London and New York.
Wannemacher, R. W., Banks, W. L. and Wunner, W. H., 1965: Use of a single tissue extract to determine cellular protein and nucleic acid concentration and rate of amino acid incorporation. *Analyt. Biochem.*, 11 : 256—265.
Wigglesworth, V. B., 1965: The principles of insect physiology. Methuen, London.
Wilhelm, R. C., Schneiderman, H. A. and Daniel, L. J., 1961: The effect of anaerobiosis on the giant silkworm Hyalophora cecropia and Samia cynthia special reference to the accumulation of glycerol and lactic acid. *J. Insect Physiol.*, 7 : 273—288.
Wyatt, G. R., 1961: The biochemistry of insect hemolymph. *Ann. Rev. Ent.*, 6 : 75—102.

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OCCURRENCE OF THE ENDOPARASITIC HELMINTHS IN PIKE (ESOX LUCIUS L.) FROM THE MÁCHA LAKE FISHPOND SYSTEM

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Abstract: A survey of the endoparasitic helminths (5 species of Digenea, 2 Cestoidea, 2 Acanthocephala, 4 Nematoda) found in 225 pike (*Esox lucius* L.) from the Mácha Lake fishpond system, N. Bohemia, is presented. In addition to data concerning the incidence and intensity of infection and the occurrence of these helminths in other fishes of this locality, for most parasites also the seasonal changes in the abundance and maturation, and the preference to the various size groups of this host are described. These questions are discussed in the connection with the helminth life cycles and ecological conditions in the locality.

The Mácha Lake fishpond system, as understood in this paper, consists of two large ponds near Doksy, northern Bohemia, founded in the fourteenth century. The larger pond (350 ha) called Mácha Lake is a well-known recreation site noted for a shallow, well-heated water the summer temperatures of which are keeping up to some 25° C; similar conditions are in the smaller fishpond Břehyně (270 ha) which serves as the natural reserve. Both the fishponds lying in the height of 270 m are established on the Břehyně Brook (the Elbe basin) flowing first through the fishpond Břehyně, connecting it with Mácha Lake by its 2 km long section; fishes get into this „canal" from both the fishpond Břehyně and Mácha Lake. The ichthyofauna is represented mainly by carp, bream, tench, eel, pikeperch, perch and pike; some other unimportant cyprinids (e.g. rudd, roach and others) are present too. Both the ponds are being fished out in the intervals of 7—8 years (Mácha Lake last in autumn 1976, fishpond Břehyně in spring 1977), but they cannot be emptied completely.

MATERIALS

Most fishes were collected using the electric fishing machine in the "canal" between the fishpond Břehyně and Mácha Lake (Fig. 1), only a small number of them was obtained from fishermen during fishing out of Mácha Lake. In 1976, regular monthly samples of 10—17 specimens of pike were examined and this material was completed by dissections of pike in the various seasons in 1966, 1975 and 1977; a total of 225 pike was examined. At the same time also other fish species of this locality were examined for helminths; these will be surveyed in another paper. During dissections of pike, attention was paid to endoparasitic worms only, although some ectoparasites were present as well: *Tetraonchus monenteron* (Wagener, 1857), *Piscicola geometra* (Linnaeus, 1761), *Ergasilus sieboldi* Nordmann, 1832, *Argulus foliaceus* (Linnaeus, 1758) and *Anodonta* sp. glochidium.

SURVEY OF ENDOPARASITIC HELMINTHS OF PIKE

Digenea

1. *Azygia lucii* (Müller, 1776)

This typical stomach parasite of pike is frequent in the locality; its overall incidence in *E. lucius* was 40% (intensity of infection 1—19), while in individual

monthly samples it ranged from 13 to 89%. Fig. 3A shows that in 1976 the incidence distinctly increased in April and then again in September—December. It appears, however, that this fluctuation is irregular and independent of the season; it is suggested by the fact that in April of the following year the incidence was only 13%. The fluctuation of incidence is apparently caused mainly by changes in the food composition of pike, i.e. by the choice and availability of the forage fishes which are the main source of *A. lucii* infection. Analysis of the state of maturity of trematodes from individual months did not indicate any significant seasonal changes in pike of the size examined, but the mature trematodes containing eggs as well as young specimens still without eggs occurred in pike throughout the year.

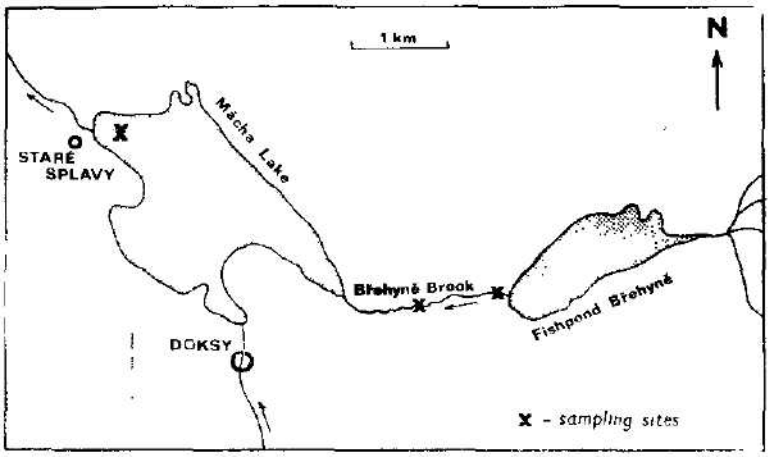

Fig. 1. Map of the Mácha Lake fishpond system showing sampling sites.

According to Odening (1976b) it is necessary to distinguish between the primary infection of *A. lucii* via freely swimming cercariae (possible only in pike at most 3 cm long) and the secondary infection acquired from forage fishes including pike (paradefinitive or postcyclic host): with increasing age, pike are more and more exposed to secondary infections. While primary infections are subjected to seasonal changes, new secondary infections are acquired in the course of the whole year and, accordingly, no cyclical changes in the incidence or maturation of this trematode can be expected. It has been confirmed by Odening's studies (1976b) and by our observations.

It is obvious from Fig. 4A that the values of incidence and mean intensity of infection increased with size of pike to reach their maximum in fish longer than 50 cm; it is due to the fact that as pike grows, its consumption of forage fishes increases which results in the gradual concentration of these trematodes. Similar results were obtained by Gorbunova (1936) studying the infestation with *A. lucii* of the various age groups of pike from Lake Konchezero in the Karelian SSR.

In this locality, three species of fishes were found to be the subsidiary hosts of *Azygia lucii*: occasional juvenile specimens (without eggs) were recorded in *Perca fluviatilis* (incidence 8.4%, intensity 1) and *Anguilla anguilla* (incidence 5.2%, intensity 1) and two young trematodes containing a small number of eggs in the

uterus were found in 1 out of 2 *Stizostedion lucioperca* examined. Considering the secondary infections in pike, these fishes, particularly perch, are along with smal pike an important source of infection with *A. lucii*.

Intermediate hosts of *Azygia lucii* are various species of water snails of the families *Planorbidae, Lymnaeidae, Physidae* and *Valvatidae* (Odening, 1976a).

2. *Phyllodistomum folium* (Olfers, 1816)

According to Pigulevskij (1953), *Ph. folium* is a specific parasite of fishes of the fam. *Esocidae*, whereas the trematodes reported under this name from cyprinids (e.g. Ergens et al., 1975) represent an independent species, *Ph. dogieli* Pigulevsky, 1953; however, Bychovskaja-Pavlovskaja et al. (1962) consider both the species identical. We found *Ph. folium* in pike only, while it was lacking in cyprinids. Since any reliable comparison of these two forms has never been done, for the time being we feel inclined to the opinion of Pigulevskij; also Yamaguti (1971) listed both these species as independent.

In the locality *Ph. folium* is a common parasite of pike, being found mainly in the urinary bladder, less often (mostly young forms) in ureters and mesonephros Overall incidence was 28.5%, intensity 1—369 (average 44) specimens per fish Monthly values of incidence exhibited certain fluctuation; the curve of incidence (Fig. 3C) shows two distinct drops — in spring time (April—June) and lesser one

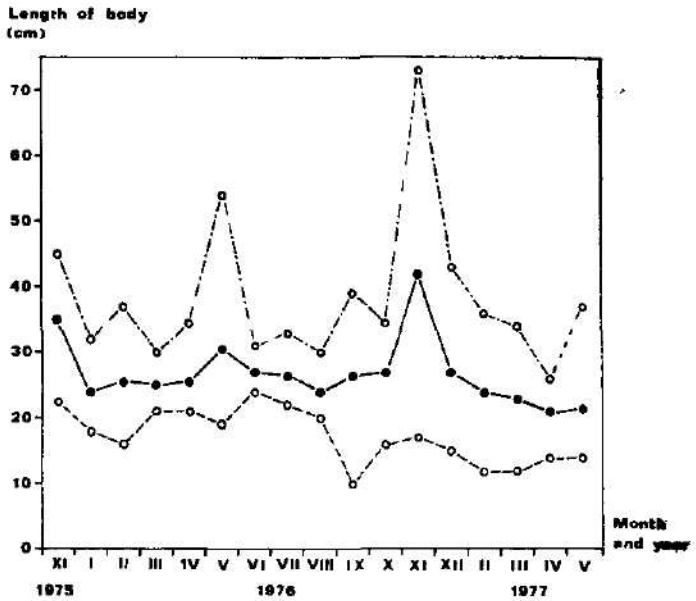

Fig. 2. Range of sizes of pike in samples from 1975—1977; maximum length of body (-.-.-.-), minimum length (-------), average length (———).

in autumn (September—November). These variations of the incidence may be associated with the seasonal changes in the availability of the invasive larvae of *Ph. folium*. The state of maturity in the individual monthly samples of trematodes did not reveal differences indicating any seasonal changes in maturation; throughout

the year occurred the worms 0.6—1.3 mm long containing only a small number of eggs in the uterus, as well as the fully gravid specimens 1.2—3.8 mm long. It suggests that recruitment of *Ph. folium* in the fish host occurs all the year round.

Distribution of *Ph. folium* in pike population (Fig. 4C) indicates the preference of this parasite to the fish with body not exceeding 40 cm; in pike 40 to 50 cm long a marked decline of the incidence was recorded while the mean intensity remained approximately equal to those in the preceding size groups; in pike longer than 50 cm this parasite was not recorded at all. It may be associated with the life cycle of this trematode and the way of infection of the definitive host: so far it is not known. According to Pigulevskij (1953) this parasite develops in bivalves. It is probable that, as in several congeners, fishes acquire infection by feeding on the freely flowing sporocysts containing encysted metacercariae or, if any, on the second intermediate hosts (arthropods) which may be included in the life cycle; an unequable distribution of *Ph. folium* infections in pike population suggests the first way. Great differences in the intensity of infection are even among pike of the same size group; while a great number of fish are without infection, the worm load of infected specimens is usually very high, representing often up to several hundreds of parasites.

3. *Bunodera luciopercae* (Müller, 1776)

Pike is only the secondary, transitive host of *B. luciopercae* acquiring infection with these trematodes while feeding on their obligate definitive host — perch; apparently the worms can survive for some time in the pike intestine. *B. luciopercae* was recorded in pike with length of 20—32 cm; overall incidence was only 5.7%, intensity 1—20 (average 4) specimens. The trematodes containing eggs were found only in the period from December to April, one juvenile specimen was recorded in July. Accordingly, the incidence of *B. luciopercae* reflects the seasonal changes in the occurrence and maturation of this parasite in the obligate definitive hosts, such as described e.g. by Ljajman (1940) and Cannon (1972); according to Ljajman (1940), in pikeperch of Lake Seliger in the USSR new infections occur at the end of July and in August, during the winter months eggs develop in the trematodes, and after oviposition in March—May the worms are passed out from the host. Cannon (1972) believes the increased water temperature is the principal factor responsible for liberation of the host from infection in summer months.

The obligate host of *B. luciopercae* in the locality is *Perca fluviatilis* and possibly also *Stizostedion lucioperca*; in perch examined (body length 6—33 cm) the incidence was 6.2%, intensity 1—4 trematodes per fish.

The life cycle of *B. luciopercae* involves two intermediate hosts: the first intermediate hosts are some small species of bivalves (*Sphaerium, Pisidium*), as the second intermediate host serve various plankton crustaceans (Wiśniewski, 1958; Moravec, 1969a, Cannon, 1971)

4. *Tylodelphys clavata* (Nordmann, 1832) — metacercariae

Specific identification of diplostomulid metacercariae is very difficult and problematic; precise identification of species can only be made as a result of experimental studies, but no such feeding experiments have hitherto been performed with metacercariae from fishes of this locality. Regarding the papers of Vojtek (1974), Kennedy (1975) and others, we consider all the metacercariae found in the humour of the eye to be *T. clavata* and those parasitic in the lens as *D. spathaceum*; however, it cannot be excluded that the material also involved other species.

Metacercariae of *T. clavata* are frequent parasites of pike in this locality; the comparison of samples from the individual months showed no substantial changes in the infestation of pike with this parasite in the course of the year. The overall incidence in *E. lucius* was 25.7%, intensity 1—150 (average 8) specimens. Clear differences are, however, in the infestation of the individual size groups of pike; the incidence and intensity of infection reach maximum values in pike longer than 40 cm, while in the fish less than 20 cm in length both the values are very low (Fig. 4D).

The first intermediate host of *T. clavata* is the snail *Lymnaea ovata* (Niewiadomska, 1960): as second intermediate hosts serve various species of fishes, in Czechoslovakia largely those of the fam. *Percidae* and *Cyprinidae* (Vojtek, 1974). In the locality the metacercariae of *T. clavata* were recorded in addition to pike also in *Perca fluviatilis* (incidence 41.6%, intensity 1—50), *Rutilus rutilus* (incidence 23.5%, intensity 4—200), *Scardinius erythrophthalmus* (incidence 11.9%, intensity 1—12), and *Leuciscus cephalus* (in 1 examined fish 63 specimens were found). Definitive hosts are the grebes, mainly *Podiceps cristatus*, and some other waterbirds.

5. *Diplostomum spathaceum* (Rudolphi, 1819) — metacercariae

The metacercariae of *D. spathaceum* located in the lens of the eye were only recorded in one case in pike 50 cm long (incidence 0.4%, intensity 12 specimens). As the main hosts of these metacercariae in the locality were found various cyprinids: *Abramis brama* (incidence 80.4%, intensity 2—54), *Rutilus rutilus* (incidence 50%, intensity 2—42), *Leuciscus cephalus* (1 specimen found in 1 fish examined), *Tinca tinca* (incidence 7.8%, intensity 1), *Cyprinus carpio* (incidence 50%, intensity 1—19), and *Gobio gobio* (incidence 87.5%, intensity 2—30).

As first intermediate hosts of *D. spathaceum* are reported snails of the genus *Lymnaea*, dominant definitive hosts in Czechoslovakia are the gulls (*Larus ridibundus* (see Vojtek, 1974).

Cestoidea

6. *Triaenophorus nodulosus* (Pallas, 1781)

Although there are records of *T. nodulosus* from several other predatory fishes in the literature, pike was the only definitive host of this tapeworm found in the locality in question. The overall incidence was 51.5%, intensity 1—54 (average 7) specimens; incidence in individual months ranged from 20 to 100%. Fig. 3D shows that in spite of considerable fluctuation of the values of incidence and intensity, the rate of infection was highest in the period from the late spring until December with a conspicuously high intensity of infection in August; this increased infection during the summer and autumn is largely due to newly established parasites, as suggested by a great share of plerocercoids in the intestines of pike in these months. Also Ergens (1966) found distinct cyclical seasonal changes in the intensity of *T. nodulosus* infection in pike of the Lipno reservoir (ČSSR) when it attained its maximum always in the period from the end of spring until the half of summer.

It is obvious from Fig. 4B that in this locality the infestation of pike with *T. nodulosus* increased with the body size of the fish. It is associated with the local conditions and then mainly with the choice and availability of forage fishes; these relationships may be quite different in other localities as found, for example, by Chubb (1963) in Lake Llyn Tegid in Great Britain.

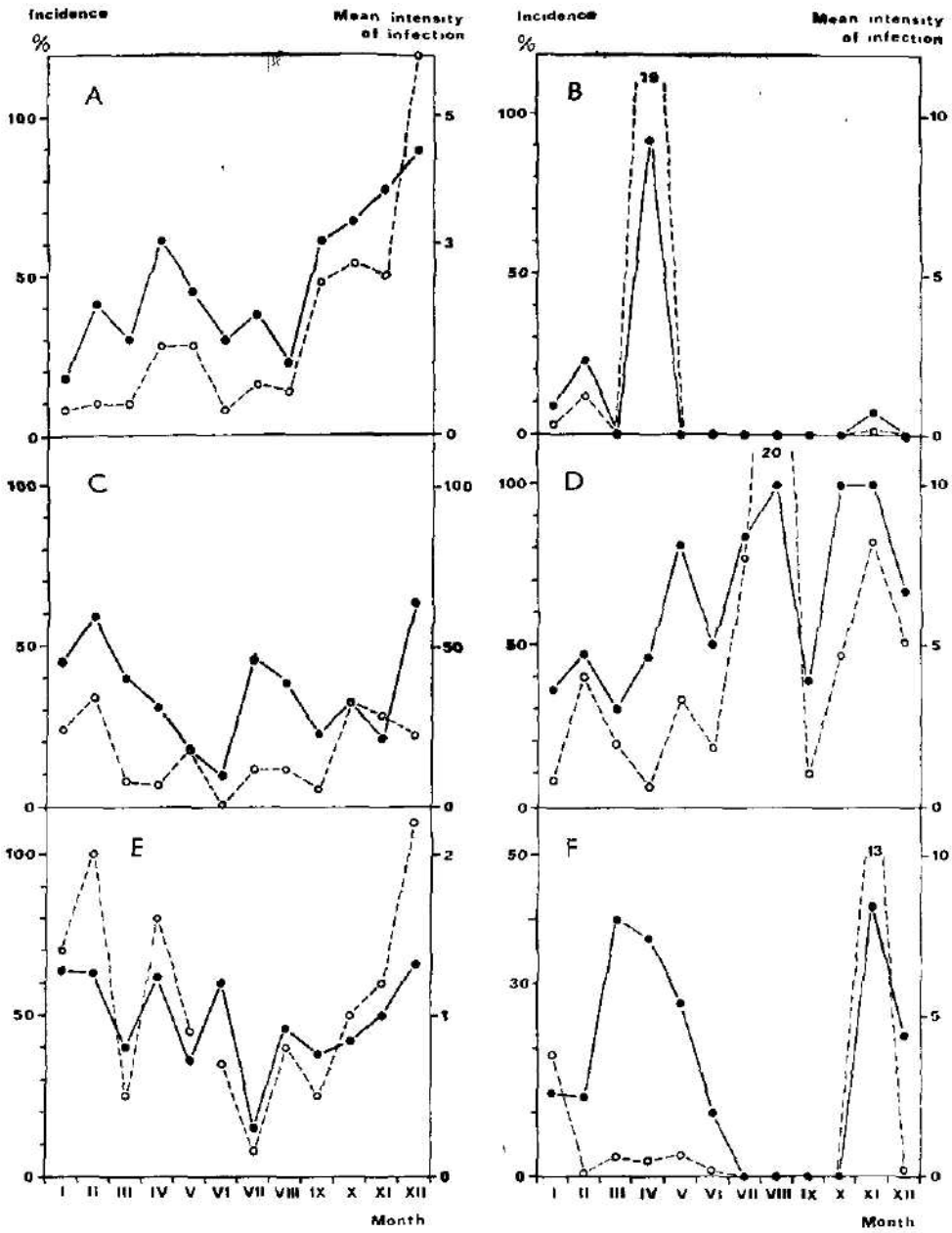

Fig. 3. Variation of incidence (———) and mean intensity of infection (-------) of six species of helminths in pike in 1976: A — *Azygia lucii*, B — *Proteocephalus percae*, C — *Phyllodistomum folium*, D — *Triaenophorus nodulosus*, E — *Camallanus lacustris*, F — *Raphidascaris acus*.

Any detailed analysis of the worm samples from individual months was not performed, only the shares of the tapeworms containing eggs and those still without

eggs were followed; this comparison indicated that the mature worms containing eggs were present in the locality only from October to April, while the juvenile forms and mature tapeworms lacking eggs occurred throughout the year. It confirms the observations of several earlier authors (e.g. Scheuring, 1929; Miller, 1943a; Chubb, 1963; and others) on the seasonal maturation of this serious parasite of pike. According to Scheuring (1929) new infections occur in pike in May—June, according to Izjumova (1960) from May to August; we observed, however, that although the plerocercoids are present in the intestines of pike mainly during summer, they occur less frequently as well in winter. Also Chubb (1963) observed that new infections in pike occur throughout the year; since, however, according to this author, the number of worms in pike is approximately constant at all times of the year, he suggests that there is a dynamic equilibrium between gain and loss of the worms. Scheuring (1929) presupposed the existence of the so called superinfection immunity limiting the number of maturing *T. nodulosus* specimens in the intestine of pike.

Two intermediate hosts are required for the development of *T. nodulosus*: the first one are various copepods (Miller, 1943b) in which the larva attains the stage of procercoid, the second one are some fishes (largely perch) in which the plerocercoid develops, being located mainly in liver. In the given locality the plerocercoids of *T. nodulosus* were found in all seasons exclusively in the liver of *Perca fluviatilis* (body length 8—33 cm), the incidence being 25% and intensity 2—35 plerocercoids per fish; it confirms the data of Chubb (1964) that there is no seasonal periodicity in the occurrence of these plerocercoids in perch.

7. *Proteocephalus percae* (Müller, 1780)

The obligate hosts of *P. percae* are perch and some other members of the fam *Percidae*. Pike acquires infection of this parasite while feeding on perch and, accordingly, serves as only a transitive host. In the Mácha Lake system this parasite was recorded in 13.3% of pike with the intensity 1—96 specimens. Fig. 3B shows that it was found only in the period November—April; the values of the incidence and mean intensity of infection varied greatly in the individual months, reaching their maximum in April. Specimens containing eggs in the uteri were recorded in April only. It is obvious that infections of this parasite in pike follow its seasonal occurrence and development in the obligate host — perch. Seasonal changes in the occurrence and maturation have been reported for many *Proteocephalus* species (e.g. Wagner, 1917; Hopkins, 1959; Molnár, 1966; Kennedy and Hine, 1969) in which the egg-production occurs always in spring and early summer and new infection by the next generation either overlaps the old one or there is a gap, sometimes as much as several months, between the loss of adult worms and the appearance of the new generation (Kennedy and Hine, 1969).

The only recorded obligate host of *P. percae* in this locality was *Perca fluviatilis* in which this tapeworm was found in the period from October till April with the overall incidence 35.4% and intensity 1—8 specimens per fish. It may occur as well in *Stizostedion lucioperca*. The development of *Proteocephalus* spp. requires one intermediate host — a copepod, in which the larva attains the stage of plerocercoid.

Acanthocephala

8. *Acanthocephalus lucii* (Müller, 1776)

This acanthocephalan is a frequent intestinal parasite of pike of this locality, overall incidence in *E. lucius* was 63.5%, intensity 1—53 (average 6) specimens per

fish; the incidence in individual months ranged from 46 to 100%. The maximum infestation was found in April—May; in June it began to diminish and the lowest values of the incidence and mean intensity of infection were reached in summer months July and August; during autumn both the values again gradually increased (Fig. 5). It is obvious from Fig. 7 that the mature females of *A. lucii* containing eggs were present in pike almost throughout the year (not recorded only in December), but their share suddenly increased in spring (May—June) and then again in

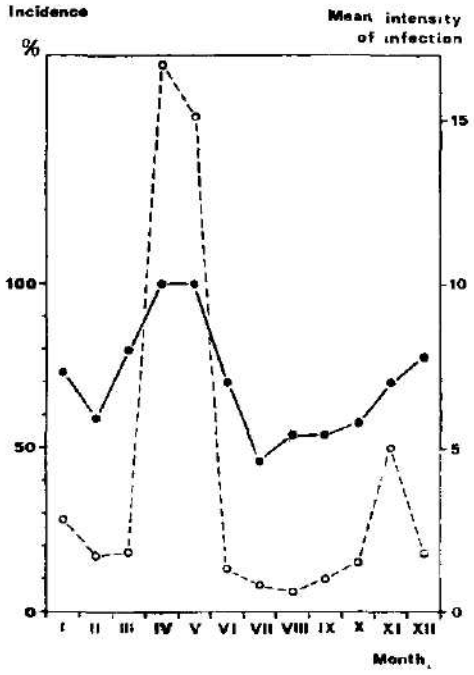

Fig. 4. Variation of incidence (———) and mean intensity of infection (-------) of *Acanthocephalus lucii* in pike in 1976.

autumn (September—October). It indicates that in this locality *A. lucii* has not two distinct generations per year but its occurrence and maturation show partial seasonal quantitative changes, these being apparently evoked by the water temperature and availability of the intermediate hosts. On the other hand, Komarova (1950) found distinct seasonal periodicity in the occurrence and maturation of *A. lucii* from perch of the River Dnieper when the worms perished after laying eggs in summer and infection with a new generation of the parasites appeared only at the end of autumn. In the Mácha Lake system the loss of adult *A. lucii* in June—July is evident from the sudden decline of the incidence and intensity of infection as also from the share of gravid females in samples; besides, dead, macerated acanthocephalans were often found in the intestines of pike examined during that period Nevertheless, the total loss of gravid females did not occur and, on the contrary, their share in samples strikingly increased in autumn and decreased again in winter. These changes can be explained so that the parasite does not exhibit

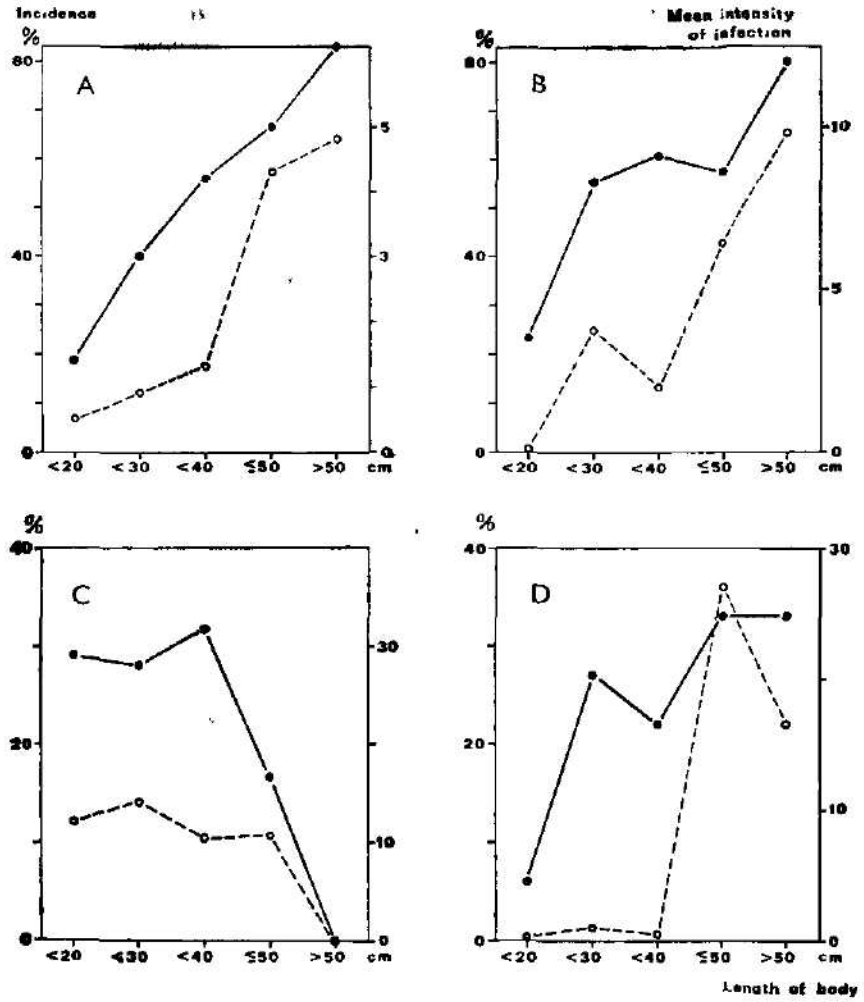

Fig. 5. Relationship of incidence (———) and mean intensity of infection (-------) to body length of pike: A — *Azygia lucii*, B — *Triaenophorus nodulosus*, C — *Phyllodistomum folium*, D — *Tylodelphys clavata*.

any distinct annual cycle in this locality but the recruitment and loss of the worms take place continuously and are between each other in a certain dynamic equilibrium. The same was observed in several other fish acanthocephalans (e.g. Chubb, 1964; Kennedy, 1967).

In addition to pike, *A. lucii* also parasitizes *Perca fluviatilis* (incidence 68.7%, intensity 1—15) and *Anguilla anguilla* (incidence 35.1%, intensity 1—17) in the locality; in both these hosts the females of *A. lucii* are able to produce eggs. In one case two juvenile *A. lucii* females were recorded in the intestine of *Cyprinus carpio* (incidence 12%). While it is possible to assume that the main source of *A. lucii* infection in perch and eel are the intermediate hosts — isopods *Asellus aquaticus*,

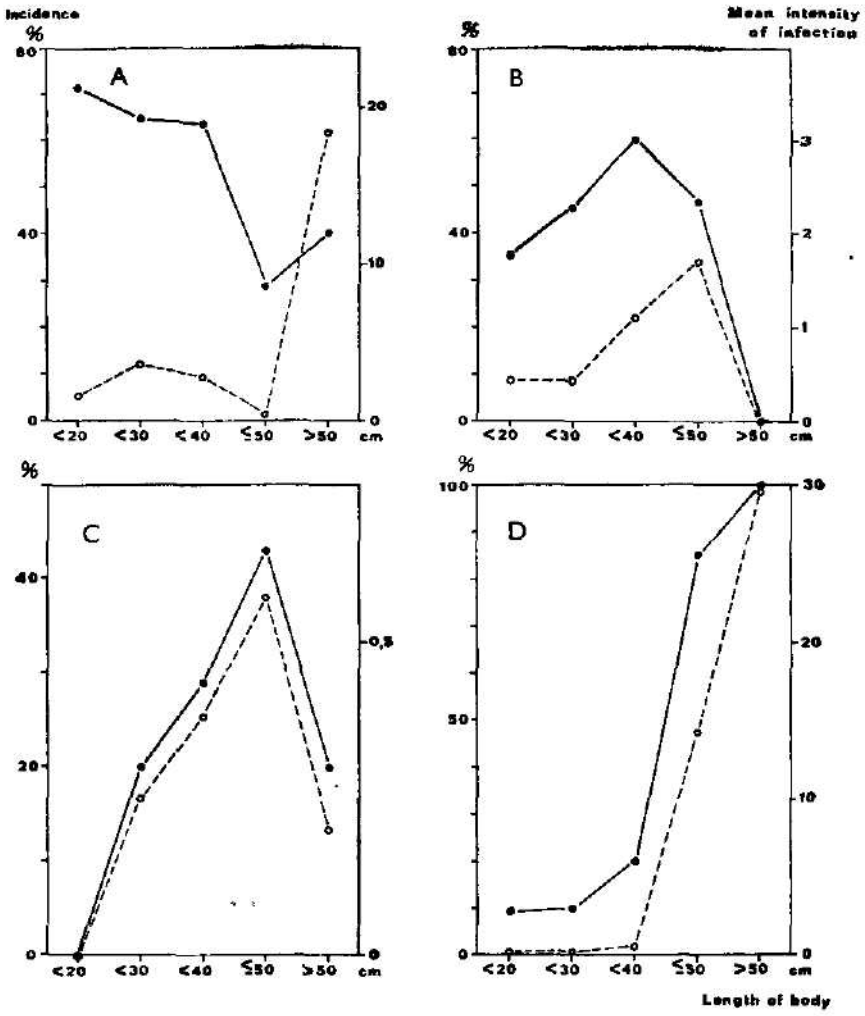

Fig. 6. Relationship of incidence (———) and mean intensity of infection (-·-·-·-) to body length of pike: A — *Acanthocephalus lucii*, B — *Camallanus lacustris*, C — *Philometra obturans*, D — *Raphidascaris acus*.

pike of the size studied serves apparently only as the secondary host of this parasite, acquiring infection by feeding on perch.

As follows from the comparison of the incidence and intensity of *A. lucii* infection of the individual size groups of pike, the maximum infestation was found in pike with body shorter than 40 cm, whereas the larger fish were less infected (Fig. 6A). It is apparently associated with the choice of food: while the smaller pike feed largely on small perch, numerous in the locality, the big pike prefer larger-sized cyprinids — mainly bream.

In the intestines of heavily infected pike, hyperparasitism of *A. lucii* was frequently observed when the specimens of this species were attached to the strobilae

of *Triaenophorus nodulosus* or *Proteocephalus percae*; in penetrating deeply with their probosces into the body segments they cause a serious damage to these tapeworms.

The intermediate hosts of *A. lucii* — water isopods *Asellus aquaticus* — are very frequent in the locality, mainly in the bottom vegetation near the shores of both the ponds. In March 1977, 46 specimens of these invertebrates from the fishpond Břehyně were examined and the acanthellae of *A. lucii* were found in 5 (10.8%) of them with the intensity 1—4 specimens per isopod. This high infestation of the intermediate hosts corresponds to the considerable degree of infection in the host fishes.

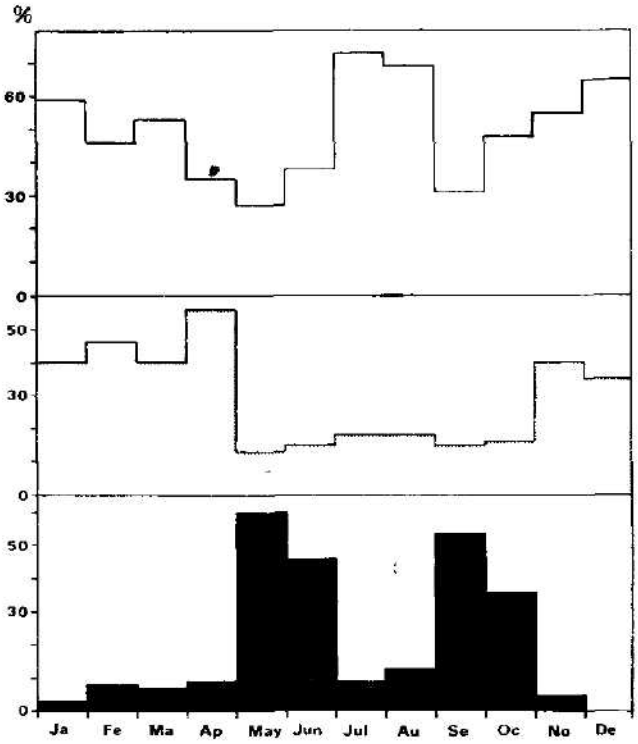

Fig. 7. Monthly changes in occurrence and state of maturity of *Acanthocephalus lucii* in pike in 1976. The data are expressed as percentages of the total number of acanthocephalans found per month: males (unsheaded), females without eggs (hatched), and females containing mature eggs (blackened).

9. *Neoechinorhynchus rutili* (Müller, 1780)

Occasional findings of not fully mature forms of this parasite of cyprinids were recorded in pike from November until April (incidence 2.2%, intensity 1). The main host in this locality is *Abramis brama* (incidence 25%, intensity 1—13), less often it occurs in *Scardinius erythrophthalmus* (incidence 2.3%, intensity 13) and perhaps also in other cyprinid fishes. Pike serves as a secondary host acquiring infection by feeding on cyprinids; young forms of *N. rutili* cannot apparently ma-

ture in this host. *N. rutili* was recorded in pike 24—60 (average 36) cm long, i.e. in rather larger specimens in which, in this locality, the share of cyprinids in food is distinctly higher than in smaller-sized pike feeding largely on small perch.

Nematoda

10. *Esocinema bohemicum* Moravec, 1977

This specific parasite of pike has been described by the author (Moravec, 1977) only recently. In this locality it seems to be rare and up to now only three specimens were found under the serosa of the airbladder of pike — one gravid and one juvenile females in January 1976 and one male in May of the same year; body length of the infected fish was 20—54 cm. It is probable that this parasite, like other members of *Skrjabillanidae*, parasitizes largely fishes of the older age groups (see Tichomirova, 1975a).

The life cycle of *E. bohemicum* is not known but may be similar to that in other members of this family (*Skrjabillanus, Molnaria*) developing in branchyurids (*Argulus* spp.) as intermediate hosts (Tichomirova, 1970, 1975b; Rudometova, 1974); during sucking of the infected branchyurid on fish the infective larvae of the nematode leave its body and penetrate actively through the skin into the organism of the fish (Tichomirova, 1975b). In this locality only the species *Argulus foliaceus* (L.) was found on various fishes and it apparently serves as the only intermediate host for all the skrjabillanid nematodes occuring there.

11. *Philometra obturans* (Prenant, 1886)

The life history and occurrence of *Ph. obturans* in this locality has been dealt with in detail in a separate paper (Moravec and Dyková, 1978) It can be concluded that gravid and subgravid females of this pathogenic parasite are found in the blood system of pike throughout the year, whereas the male and the mature female in the vitreous body of the eye were only recorded in September; the incidence of *Ph. obturans* in individual monthly samples ranged from 8 to 38% (reaching maximum values in April—July and again in October—December in 1976) and the intensity of infection was 1—4 (most often 1) nematodes per pike. Gravid females containing larvae in the uteri were present practically throughout the year, differing thus from other members of *Philometra* whose gravid females occur only within 1—2 months in the year, mostly in spring. Apparently it is due to the fact that, in addition to the intermediate host (various copepods), there are also reservoir hosts (forage fishes) involved in the life cycle of *Ph. obturans*; the latter are the main source of infection in pike, making it possible to gain new infections throughout the year.

As reservoir (transport) hosts of *Ph. obturans* larvae were found in the locality *Perca fluviatilis* and *Scardinius erythrophthalmus* in which the invasive larvae of this nematode are located in the vitreous body of the eye; in the first host the incidence was 10.4% with intensity 1—7 larvae, in the second host only 3 larvae were found in one case (incidence 2.4%)

12. *Camallanus lacustris* (Zoega, 1776)

The nematode *C. lacustris* is an intestinal parasite of perch-like and some other freshwater fishes (Moravec, 1971). Pike, being only a secondary host, becomes infected while feeding on the primary definitive hosts (e.g. perch) or the reservoir

hosts of larvae (various small fishes), but the nematodes cannot develop further in its gut; apparently the mature *C. lacustris* survive only shortly in pike, as suggested by the relatively low degree of intensity and also by the fact that no females of *C. lacustris* containing larvae were recorded from this host. Totally it was found in 45.7% of *E. lucius* examined, with the incidence in individual months ranging from 15 to 75% and intensity of infection being 1—16 (average 3) nematodes. Fig. 6E shows that in the locality only pike not exceeding 50 cm in length were infected, while in larger fish the nematodes were not recorded. It is due to the fact that small perch — the main source of *C. lacustris* infection in this host — are eaten by smaller pike, while big pike largely feed on cyprinids (bream); However, in other localities these relationships may be quite different.

According to Izjumova (1960) the highest incidence of *C. lacustris* in pike of

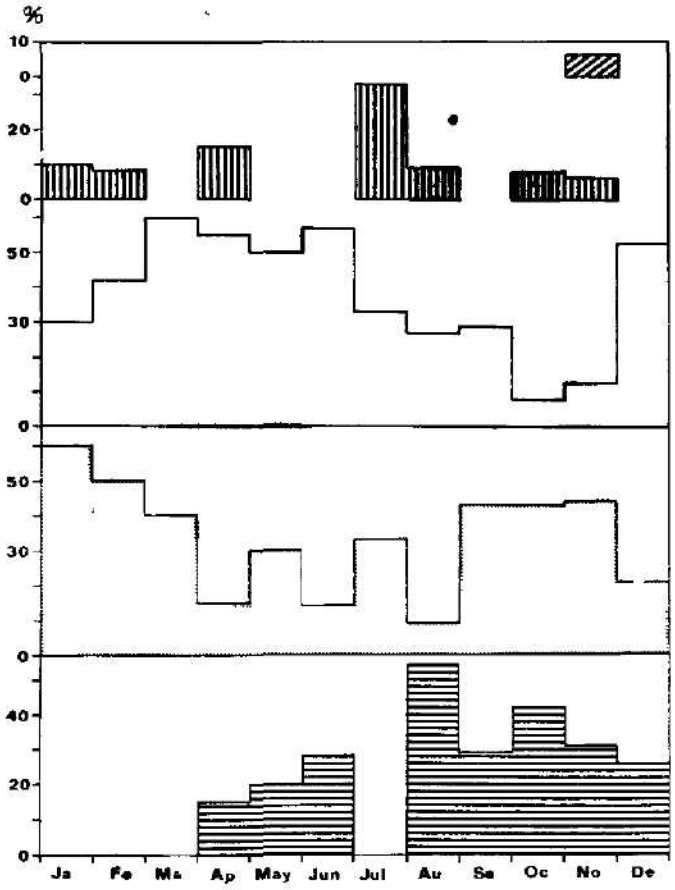

Fig. 8. Monthly changes in occurrence and state of maturity of *Camallanus lacustris* in pike in 1976. The data are expressed as percentages of the total number of nematodes found per month: third-stage larvae (obliquely hatched), fourth-stage larvae (perpendicularly hatched), males (unsheaded), juvenile females without eggs (stippled), and females containing eggs (longitudinally hatched).

the Rybinsk water reservoir in the USSR appears in spring; Ergens (1966) reported the maximum values of the incidence and intensity of infection of *C. lacustris* in the same host from the Lipno reservoir (ČSSR) to occur in the summer months. Our observations in the Mácha Lake system indicate (Fig. 3E), however, great variations of both these values during the year, showing in summer (July) the lowest degree of infestation with this parasite. According to Tornquist (1931), in Sweden *C. lacustris* exhibits a distinct seasonal maturation; new infections in fish take place in summer, during autumn and winter months the nematodes grow and become mature, and only in the late spring and summer the parasite larvae are released into the water and the mature worms perish. Similar seasonal changes in maturation have been observed in the North-American species *C. oxycephalus* (Stromberg and Crites, 1975). Our observations in pike do not confirm, however, any sharp seasonal dependence in the maturation of *C. lacustris*, although certain quantitative differences were found. Fig. 8 shows that the fourth-stage larvae were present in all seasons as well as males and young females, whereas the females containing eggs were not recorded in January-March and in July; gravid females containing larvae were not found in pike at all. In the primary hosts (perch) the gravid *C. lacustris* females containing larvae occurred practically throughout the year including the winter months. It suggests that in the locality new infections in fish take place all the year round, although the warm seasons from spring until autumn are apparently more favourable for the development of this parasite than are the winter months.

In addition to pike, *C. lacustris* was recorded in the locality also in *Perca fluviatilis* (incidence 73.8%, intensity 1—20), *Stizostedion lucioperca* (in 1 out of 2 fishes examined, intensity 17) and *Anguilla anguilla* (incidence 40.5%, intensity 1—235); the latter fish serves probably as only a secondary host for this parasite.

Intermediate hosts of *C. lacustris* are various copepod species (Leuckart, 1876; Kuprjanova, 1954; Moravec, 1969b; and others) which are, beside reservoir fishes, the main source of infection for the definitive host. It was proved experimentally (hitherto unpublished) that the invasive larvae of *C. lacustris* acquired from the intermediate host did not develop in pike.

13. *Raphidascaris acus* (Bloch, 1779)

This pathogenic parasite was found in the intestines of 16.4% pike examined with the incidence in individual months ranging from 0 to 42% and the intensity being 1—53 (average 8) specimens per fish. The distribution of infections was not equable within the pike population but was strongly influenced by the host sizes. Fig. 6D indicates a distinct increase of the degree of infestation in pike with the increasing size of the host; the conspicuous increase was recorded in pike longer than 40 cm. It is associated with feeding habits of pike in this locality; big pike prey largely on bream and other cyprinids, these being the principal source of *R. acus* infections, whilst smaller pike eat here mostly minute perch.

It is obvious from the curve of incidence and mean intensity of infection (Fig. 3F) that in 1976 this parasite was recorded in pike in all months except for July—October, with the incidence showing two peaks — in March—April and again in November. This variation is evidently associated with the development and seasonal maturation of *R. acus* in the definitive host. Engašev (1964) documented that *R. acus* occurred in pike of the River Amu-Darya delta in the Soviet Central Asia in two generations per year — a mass generation in early spring and a less numerous generation in autumn.

Also Suprjaga and Mozgovoj (1974) found in pike and perch from Krasnodar District in the USSR two generations of this parasite — the first from the end of February until the beginning of June and the second from the end of August until October. On the contrary Malachova (1961) in the Karelian SSR and Moravec (1970b) and Žitňan (1973) in Czechoslovakia recorded only one generation of *R. acus* when these nematodes in dependence on the temperature conditions of the locality became mature either from May to the half of June or as late as in mid-summer (July—August). Our observations of the occurrence of *R. acus* in pike of the Mácha Lake system confirm seasonal maturation of this nematode and show that it has only one generation here. During November only numerous larvae 2 to 8 mm long were present in pike, while in December—January some larvae have already attained the length of 10—15 mm; in February—April also young males and females were present in addition to larvae, but gravid females occurred only in May and at the beginning of June. Beside the gradually maturing specimens all the samples from November until June contained also minute larvae (2—6 mm); their presence indicates that new infections take place throughout this period. The absence of *R. acus* from pike in July—October is probably not only due to the loss of nematodes of the old generation but it might result as well from the increased water temperature, which is known to cause that some intestinal helminths leave the host (e.g. Kennedy, 1967; Cannon, 1972); it is suggested by the fact that neither the larvae of *R. acus* were recorded from pike in these months, although also in this period pike feed on cyprinids in which the invasive larvae of this parasite are present throughout the year. Of course, also the possibility should be taken into account that the degree of *R. acus* infestation in pike in July—October was very low and, therefore, was not recorded in samples. The absence of *R. acus* from the definitive host in summer (August) was also found by Moravec (1970b) who had followed the seasonal dynamics of this parasite in trout of the River Bystřice in Czechoslovakia; in spite of the completely different ecological conditions in the locality in question including the range of definitive and intermediate hosts, the seasonal changes in maturation of *R. acus* were similar to those in pike of the Mácha Lake system and also the period of *R. acus* egg-production was the same (May and the beginnig of June). According to Žitňan (1973) the oviposion of this parasite in the colder water of the Dobšiná reservoir in Slovakia takes place only in July and August.

In addition to pike, also eels (*A. anguilla*) were found to serve as the definitive hosts of *R. acus* in this locality; altogether two advanced larvae (length 10 mm) and one male were found (incidence 5.3%, intensity 1—2). It was not recorded from perch and pikeperch, which are the known definitive hosts of *R. acus* in other localities.

Pike and eels were found at the same time as the intermediate hosts of *R. acus*: in 2.2% *E. lucius* were found the larvae of *R. acus* located in small cysts in the walls of stomach and intestines (intensity 1—6 specimens), exceptionally the cyst was found on the gill arch and, in one case, an unencysted *R. acus* larva was present in ovary; in *A. anguilla* the encysted larvae of *R. acus* were recorded only once in the stomach wall (incidence 2.6%, intensity 27). More frequently the encysted and unencysted *R. acus* larvae were found in the liver, abdominal cavity and gut of cyprinid fishes: *Abramis brama* (incidence 60%, intensity 1—10), *Scardinius erythrophthalmus* (incidence 14.3%, intensity 1—2), *Tinca tinca* (incidence 5.3%, intensity 1—2) and *Cyprinus carpio* (incidence 12.5%, intensity 7).

Accordingly, the main source of *R. acus* infection for pike is bream not only

because of its high infestation with larvae of this nematode but also because in the locality bream is the dominant fish species, becoming frequently a prey of pike. Bream is according to some authors very receptive to *R. acus* infection resulting often in a considerable mortality of these fish, as found for example in several lakes in the USSR (Osmanov, 1954; Bauer and Zmerzlaja, 1972, 1973). It may cause, however, mortality in other species of the intermediate fish host too (Žitňan, 1967). The nematode *R. acus* is considerably pathogenic also to the definitive host and may be the cause of the mass mortality of the fish; such a case was described by Carrara and Grimaldi (1960) for rainbow trout in Italy and similar case was observed in brown trout in Czechoslovakia (personal communication of Prof. J. Vojtek).

Intermediate hosts of *R. acus* are mostly various species of fish while a number of invertebrates (mainly larvae of *Chironomidae* and *Oligochaeta*) serve as the reservoir hosts of the preinfective larvae (Moravec, 1970a); according to several authors (e.g. Suprjaga and Mozgovoj, 1974) also invertebrates function as intermediate hosts for *R. acus*.

CONCLUSIONS

It is apparent from the given survey that the fauna of the endoparasitic helminths of pike is relatively rich and includes 13 species; most of them (11) parasitize this host as adults and only 2 species as larvae. Analysis of the parasites indicates that these species can be roughly divided into four groups according to the degree of their host specificity: 1. strictly specific species occuring only in pike (*Phyllodistomum folium, Esocinema bohemicum* and *Philometra obturrans*), 2. species parasiting mainly pike but occuring also in other fishes (*Azygia lucii, Triaenophorus nodulosus, Raphidascaris acus*), 3. species for which pike is a subsidiary obligate host (*Tylodelphys clavata, Diplostomum spathaceum*), and 4. species developing in other fishes than pike which survive for some time in the gut of pike after the original host was swallowed and digested (*Bunodera luciopercae, Proteocephalus percae, Acanthocephalus lucii, Neoechinorhynchus rutili, Camallanus lacustris*). It follows from the comparison among the individual groups that more than one half (7) of the species found belong to the parasites for which pike is only a subsidiary or transitive host (groups 3 and 4), while only 3 species may be considered as strictly specific for pike. A relatively large number (5) of the helminths of group 4 is not surprising in this predatory fish, because facultative parasites form usually a substantial part of the parasite fauna of pike in other localities (e.g. Gorbunova, 1936; Ergens, 1966; Ergens et al., 1975; Rauckis, 1974; etc); of course, their quantitative and qualitative composition depends on the given ecological conditions, mainly on the present ichthyofauna and the share of the particular fish species in pike's diet.

Although the average lengths of pike examined in individual months do not exhibit any substantial differences (Fig. 2), there are distinct differences in the rates of infestation of the various size groups of the host with individual parasite species. However, these comparisons concern only 8 most common species, whereas it was not possible to make any comparisons in 5 remaining species (*B. luciopercae, D. spathaceum, P. percae, N. rutili* and *E. bohemicum*) due to their rare occurrence in pike. The differences in rates of infestation of the individual size groups of pike are both qualitative and quantitative: while in pike with body length of 20—50 cm all 8 parasite species were present, in pike shorter than 20 cm one species (*Ph. obturans*) was absent and in pike exceeding 50 cm were absent 2 species (*Ph. folium, C. lacustris*).

Quantitative differences concern the incidence and mean intensity of infection of these helminths and, according to relationships between these values and the body size of hosts, it is possible to distinguish three main groups of the species: a) species with the incidence and mean intensity increasing along with increasing of the host's length (*Azygia lucii*, *T clavata*, *T nodulosus*, *R acus*), b) species in which both the values decrease with increasing of the host's length (*Ph folium*, partly *Acanthocephalus lucii*), and c) species in which both the values first increase until a certain size of pike is attained and then go again down (*Ph obturans*, *C lacustris*) All these growth changes in the helminth fauna are associated with the way of development of each parasite and the source of infection for pike Such changes found in some species seem to be possibly of a more general validity, for example increasing rate of infestation with increasing of the host's sizes in *Azygia lucii* and *R acus*, because their circulation in the environment is strongly influenced by cannibalism in pike, a similar case is *T clavata* infecting pike by a direct penetration of cercariae into the host's eyes However, the majority of the found changes is, more or less, of the local importance, because they are determined by concrete ecological conditions in the locality, mainly by the food composition of pike

It was observed in this locality that the diet of smaller pike (up to 40 cm in length) was mainly represented by perch (74%), while the share of cyprinids (largely roach and rudd) was the rest (26%) On the other hand, in the diet of large pike exceeding 40 cm prevailed cyprinids (mainly bream), representing some 60% and the remainder was formed by perch and pike, in the stomachs of the biggest pike (60—72 cm) only cyprinids were found It is associated, to a certain extent, with the fact that in these fishponds emptied in intervals of 7—9 years the larger perch represent only a small part of the present fish, while small perch are, mainly in the inflowing canals, very frequent, the latter are, however, eaten by smaller pike whereas the bigger pike requiring a larger sized prey feed largely on the dominant bream and other cyprinids The decreased importance of perch in the diet of large pike was observed as well by Balagurova (1962) in Lake Syamozero in the USSR It explains for example a sharp increase of the incidence and mean intensity of *R acus* infection in large pike (Fig 6D) when the source of infection are cyprinids and, on the other hand, a decrease of these values in *Acanthocephalus lucii*, *C lacustris* and *Ph obturans* (Fig 6A—C) the infection of which is acquired from perch Although the source of infection of *Azygia lucii* and *T nodulosus* is also perch, there is no decline but, quite reversely, an increase in the degree of infestation of large pike, it is probably due to the gradually increasing cannibalism of pike (secondary infections) as well as to the fact that also cyprinids may function as reservoir hosts of these parasites Such relationships may be, however, quite different in other localities

It is known for many fish helminths that their occurrence in the host and often also their maturation are subjected to seasonal changes, despite the high practical significance of such data the present knowledge in this respect is considerably incomplete Out of the parasites recorded in pike from the Mácha Lake system the seasonal changes in occurrence and maturation could be considered in 10 species only (except *D spathaceum*, *N rutili* and *E bohemicum* with rare occurrence), however, owing to a limited number of the fish examined also the data concerning some of these species are rather of orientation only Out of 10 these species, 7 (*Azygia lucii*, *Ph folium*, *T clavata*, *T nodulosus*, *Acanthocephalus lucii*, *Ph obturans* and *C lacustris*) were found in pike throughout the year, except for *T nodulosus* and *T clavata* these species did not exhibit any distinct seasonal changes in matu

ration and their adult forms containing mature eggs or larvae were recorded during all seasons On the other hand the maturation of 4 species (*B luciopercae, P percae, T nodulosus* and *R acus*) is strictly seasonal, when these become mature only in winter and spring months and after the oviposition in the spring the worms of the old generation perish, during summer months, before new infections are established, these parasites may be absent from the host, as found in *P percae* and *R acus*

There is no doubt that some of the recorded helminths have negative effects on the health condition of pike of this locality, resulting from their pathogenicity against the host, their numbers and preference to certain age groups of the fish; as the most important parasites from this view are *Triaenophorus nodulosus, Philometra obturans, Acanthocephalus lucii, Phyllodistomum folium* and *Tylodelphys clavata* which, in the case of unsuitably changed conditions (e g in composition of fish) may be a serious danger not only for pike but, at the same time, also for other breeded valuable fishes As confirmed by our observations, the presence of pike in the locality influences considerably also the helminth fauna of other economically important fish species (perch, pikeperch, eel, bream, tench, carp) which become either intermediate or reservoir hosts of larvae for the helminths maturing in pike (*T nodulosus, Ph obturans, R acus*), or subsidiary hosts of the adult forms occuring mainly in pike (*Azygia lucii, R acus*), in the locality pike have also considerable epizootological significance for the transmission and maintainance of those pathogenic non-specific parasites which attack predominantly other fishes (e g *Acanthocephalus lucii, N rutili, B luciopercae, P percae, C lacustris*)

REFERENCES

Balagurova, M V , 1962 Vozrastnye i sezonnye izmeněnija v pitanii ščuki Sjamozera. *Naučn. konfer po itogam rabot Inst biologii za 1961 g* , Petrozavodsk, pp 112—114.

Bauer, O N , Zmerzlaja, E I , 1972 Rafidaskaridoz lešča v ozerach Pskovskoj oblasti i mery borby s nim *Izv GOSNIIORCh*, 80 . 114—122

Bauer, O. N , Zmerzlaja, E I , 1973 Influence of Raphidascaris acus (Nematoda, Anisakidae) on the bream, Abramis brama *Verh Internat Verein Limnol* , 18 · 1723—1728

Bychovskaja Pavlovskaja, I E et al , 1962 Opredělitěl parazitov presnovodnych ryb SSSR Moskva—Leningrad, 776 pp

Cannon, L R G , 1971 The life cycles of Bunodera sacculata and B luciopercae (Trematoda Allocreadiidae) in Algonquin Park, Ontario *Can J Zool* , 49 1417—1429

Cannon L. R. G , 1972 Studies on the ecology of the papillose allocreadiid trematodes of the yellow perch in Algonquin Park, Ontario *Can J Zool* , 50 · 1231—1239

Carrara, O , Grimaldi, E , 1960· Su di una enzoozia parassitaria a decorso mortale in un allevamento di trote iridee *Atti Soc Ital Sci Vet* , 14

Chubb, J C , 1963 Seasonal occurrence and maturation of Triaenophorus nodulosus (Pallas, 1781) (Cestoda Pseudophyllidea) in the pike Esox lucius L of Llyn Tegid *Parasitology*, 53 419—433

Chubb, J C , 1964a Observations on the occurrence of the plerocercoids of Triaenophorus nodulosus (Pallas, 1781) (Cestoda Pseudophyllidea) in the perch Perca fluviatilis L of Llyn Tegid (Bala Lake), Merionethshire *Parasitology*, 54 481—491

Chubb, J C , 1964b Occurrence of Echinorhynchus clavula Dujardin, 1845 nec Hamann, 1892 (Acanthocephala) in the fish of Llyn Tegid (Bala Lake), Merionethshire *J Parasit* , 50 · 52—59

Engašev, V G , 1964 Sezonnaja dinamika invazirovanija ščuk nematodoj Raphidascaris acus *Tr Uzbek nauč issled inst veterinarii*, 16 199—202

Ergens, R , 1966 Results of parasitological investigations on the health of Esox lucius L in the Lipno reservoir *Folia parasit (Praha)*, 13 · 222—236.

Ergens, R , Gussev, V A , Izyumova, N. A , Molnar, K , 1975 Parasite fauna of fishes of the Tisa River basin Praha, 117 pp

Gorbunova, M., 1936 Vozrastnye izmeněnija parazitofauny ščuki i plotvy. *Učenye zap Leningrad gos. univ., ser biol* , 7 . 5—30.

Hopkins, C. A., 1959: Seasonal variations in the incidence and development of the cestode Proteocephalus filicollis (Rud. 1810) in Gasterosteus aculeatus (L. 1766). *Parasitology*, 49 : 529—542.

Izjumova, N. A., 1960: Sezonnaja dinamika parazitofauny ryb Rybinskogo vodochranilišča. *Tr. Inst. biologii vodochranilišč*, 3 : 283—300.

Kennedy, C. R., 1967: Pomphorhynchus laevis in dace of the River Avon. *Proc. IIIrd British Coarse Fish Confer., Liverpool, pp 24—26.*

Kennedy, C. R., 1975: The natural history of Slapton Ley Nature Reserve. *Field Studies*, 4 : 177—189.

Kennedy, C. R., Hine, P. M., 1969: Population biology of the cestode Proteocephalus torulosus (Batsch) in dace Leuciscus leuciscus (L.) of the River Avon. *J. Fish Biol.*, 1 : 209—219.

Komarova, M. S., 1950: K voprosu o žizněnnom cikle skrebnja Acanthocephalus lucii Müll. *Dokl. AN SSSR*, 70 : 359—360.

Kuprjanova, R. A., 1954: K biologii nematod ryb Camallanus lacustris (Zoega, 1776) i Camallanus truncatus (Rudolphi, 1814) (Nematodes : Spirurida). *Dokl. AN SSSR*, 97 : 373—376.

Leuckart, K. G. F. R., 1876: Die menschlichen Parasiten und die von ihnen herrührenden Krankheiten. Leipzig. 513 pp.

Ljajman, E. M., 1940: Novye dannye po žizněnnomu ciklu sosalščikov Bunodera luciopercae (O. F. Müller). *Bjul. Mosk obšč. isp. prirody, otd. biol.*, 49 : 173—179.

Malachova, R. P., 1961: Sezonnye izmeněnija parazitofauny někotorych presnovodnych ryb ozer Karelii (Končezero). *Tr. Karelsk. fil. AN SSSR*, 30 : 55—78.

Miller, R. B., 1943a: Studies on cestodes of the genus Triaenophorus from fish of Lesser Slave Lake, Alberta. I. Introduction and life of Triaenophorus crassus Forel and T. nodulosus (Pallas) in the definitive host, Esox lucius. *Can. J. Res. D*, 21 : 160—170.

Miller, R. B., 1943b: Studies on cestodes of the genus Triaenophorus from fish of Lesser Slave Lake, Alberta. II. The eggs, coracidia and life in the first intermediate host of Triaenophorus crassus Forel and T. nodulosus (Pallas). *Can. J. Res. D*, 21 : 284—291.

Molnár, K., 1966: Untersuchungen über die jahreszeitlichen Schwankungen in der Parasitenfauna des Kaulbarsches und des Zanders im Balaton mit besonderer Berücksichtigung der Gattung Proteocephalus. *Angew. Parasit.*, 7 : 65—77.

Moravec, F., 1969a: On the early development of Bunodera luciopercae (Müller, 1776) (Trematoda : Bunoderidae). *Věst. Čs. spol. zool.*, 33 : 229—237.

Moravec, F., 1969b: Observations on the development of Camallanus lacustris (Zoega, 1776) (Nematoda : Camallanidae). *Věst. Čs. spol. zool.*, 33 : 15—33.

Moravec, F., 1970a: Studies on the development of Raphidascaris acus (Bloch, 1779) (Nematoda : Heterocheilidae) *Věst. Čs. spol. zool.*, 34 : 33—49.

Moravec, F., 1970b: On the life history of the nematode Raphidascaris acus (Bloch, 1779) in the natural environment of the River Bystřice, Czechoslovakia. *J. Fish Biol.*, 2 : 313—322.

Moravec, F., 1971: Nematodes of fishes in Czechoslovakia. *Acta Sc. Nat. Brno*, 5 : 1—49.

Moravec, F., 1977: A new nematode parasite, Esocinema bohemicum gen. et sp. nov. (Skrjabillanidae) of the European pike. *Folia parasit. (Praha)*, 24 : 86—90.

Moravec, F., Dyková, I., 1978: On the biology of the nematode Philometra obturans (Prenant, 1886) in the fishpond system of Mácha Lake, Czechoslovakia. *Folia parasit. (Praha)*, 25 : 231—240.

Niewiadomska, K., 1960: On two cercariae of the genus Tylodelphys Dies.: T. excavata (Rud.) and T. clavata (Nord.), Diplostomatidae. *Acta Paras. Polon.*, 8 : 427—437.

Odening, K., 1976a: Der Lebenszyklus von Azygia lucii (Trematoda) — Untersuchungen im Gebiet der DDR. *Biol. Zbl.*, 95 : 57—94.

Odening, K., 1976b: Zum jahreszeitlichen Auftreten von Azygia lucii (Trematoda) bei Esox lucius (Pisces). *Zool. Anz.*, 196 : 182—188.

Osmanov, S. O., 1954: Rafidaskaridoz ryb del'ty Amu-Darji. *Dokl. AN UzSSR*, 12 : 53—56.

Pigulevskij, S. V., 1953: Semejstvo Gorgoderidae Looss, 1901. In: Skrjabin, K. I.: Trematody životnych i čeloveka, 8. Moskva, pp. 253—615.

Rauckis, E., 1974: Sezonnoe izmeněnie parazitofauny ščuki v někotorych ozerach s raznym termičeskim režimom. *Acta Parasit. Lituanica*, 12 : 63—75.

Rudometova, N. K., 1974: O žizněnnom cikle novogo parazita belogo amura — Skrjabillanus amuri — i epizootologii skrjabillanoza. *Sb. „Prudovoe rybovodstvo"*, *Moskva*, pp. 215—217.

Scheuring, L., 1929: Beobachtungen zur Biologie des Genus Triaenophorus und Betrachtungen über das jahreszeitliche Aftreten von Bandwürmen. *Z. Parasitenk.*, 2 : 157—177.

Stromberg, P. C., Crites, J. L., 1975: An analysis of the changes in the prevalence of Camallanus oxycephalus (Nematoda : Camallanidae) in western Lake Erie. *Ohio J. Sci.*, 75 : 1—6.

Suprjaga, V. G., Mozgovoj, A. A.: 1974: Biologičeskie osobennosti Raphidascaris acus (Anisakidae : Ascaridata) — parazita presnovodnych ryb. *Parazitologija*, 8 : 494—503.

Tichomirova, V. A., 1970: Rašifrovka cikla razvitija nematody Skrjabillanus scardinii Molnar, 1965. *Dokl. AN SSSR*, 195 : 510—511.
Tichomirova, V. A., 1975a: Sezonnaja dinamika zaražennosti krasnoperki nematodami semejstva Skrjabillanidae. *Sb. „Voprosy ekologii životnych", v. 2, Kalinin*, pp. 118—122.
Tichomirova, V. A., 1975b: Žiznennye cikly nematod semejstva Skrjabillanidae. *Sb. „Voprosy ekologii životnych", v. 2, Kalinin*, pp. 100—113.
Törnquist, N., 1931: Die Nematodenfamilien Cucullanidae und Camallanidae nebst weiteren Beiträgen zur Kenntnis der Anatomie und Histologie der Nematoden. *Göteborg. Kungl. Vet. Vitterh. Samh. Handl., Ser. B*, 2 : 1—441.
Vojtek, J., 1974: Metacerkárie z ryb Československa. *Folia Fac. Sci. Nat. Univ. Purk. Brun., Biol. 44*, 15 : 13—51.
Wagner, O., 1917: Über Entwicklungsgang und Bau einer Fischtänie (Ichthyotaenia torulosa Batsch.). *Jena. Z. Naturw.*, 55 : 1—66.
Wiśniewski, W. L., 1958: The development cycle of Bunodera luciopercae (O. F. Müller). *Acta Parasit. Polon.*, 6 : 289—307.
Yamaguti, S., 1971: Synopsis of digenetic trematodes of vertebrates, Part I, II. Tokyo, 1074 pp. + 349 Plts.
Žitňan, R., 1967: Helmintózne hynutie slížov na Dobšinskej priehrade. *Poľovníctvo a rybárstvo*, 19 : 5—17.
Žitňan, R., 1973: Helminty rýb Dobšinskej (Hnileckej) priehrady a ich epizootologický význam. *Biologické práce, Bratislava*, 19 : 1—89.

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NOTES ON AGE AND GROWTH OF THE BLEAK, ALBURNUS ALBURNUS (PISCES : CYPRINIDAE)

Ota OLIVA

To the memory of Professor G. V. Nikolskij, DSc. (1911—1977)

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Abstract: Age and growth of 87 specimens of the bleak, *Alburnus alburnus* (Linnaeus, 1758) from the several water bodies of Czechoslovakia was studied using scale method. Comparing results obtained with another data of native authors it seems to be probable that the growth of the bleak is better in large rivers and riverine lakes than in small rivulets. Bleaks of the age 6 + were recorded.

INTRODUCTION

The review of literature about the growth of the bleak was given by Chitravadivelu (1971). During last 20 years I have collected 4 samples of scales from bleak in several localities; the material remained unpublished, but existing relatively little knowledge of growth of this species, belonging to common "coarse fishes" made me present my results for print.

MATERIAL AND METHODS

The study of age and growth of bleak is based on following material: 21 sp. from the Vranov valley water reservoir, southern Moravia, situated on the river Dyje (24.—27. V. 1957); 8 sp. from the canal "Čierna voda" in the swampy area of the so-called "Šúr" at Bratislava, the

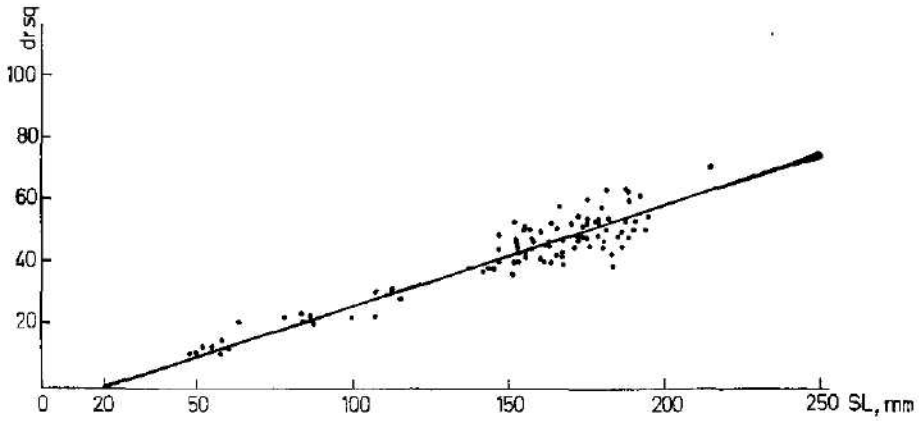

Fig. 1. Body/scale radius in bleak, *Alburnus alburnus*. dr sq = diagonal radius of the scale, SL, mm = standard (body) length in mm.

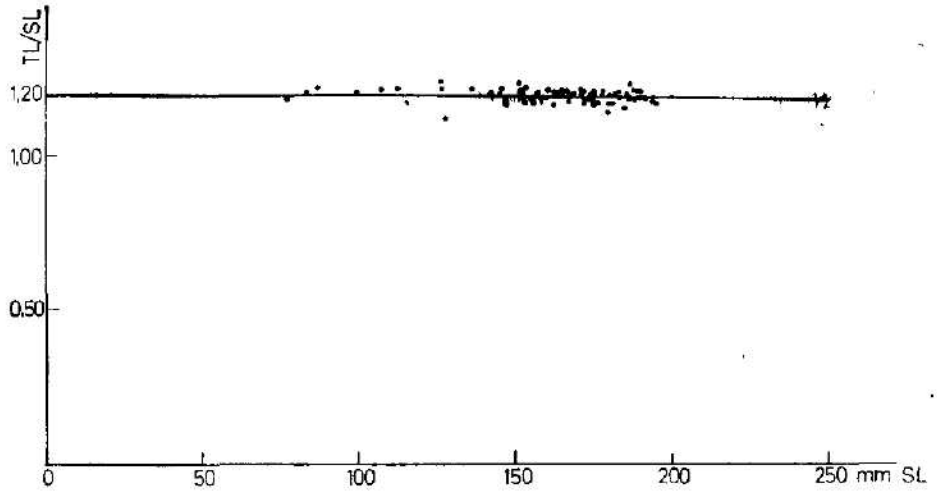

Fig. 2. Relationship between the total length (TL) and standard length (SL) in bleak, *Alburnus alburnus*.

inundation area of the river Danube, western Slovakia (25. 6. 1957) 3 sp. from the back-water "Řehákova bouda" near the village Čelákovice (21. 3. 1954), 55 sp. from Slapy valley water reservoir (summer 1958).

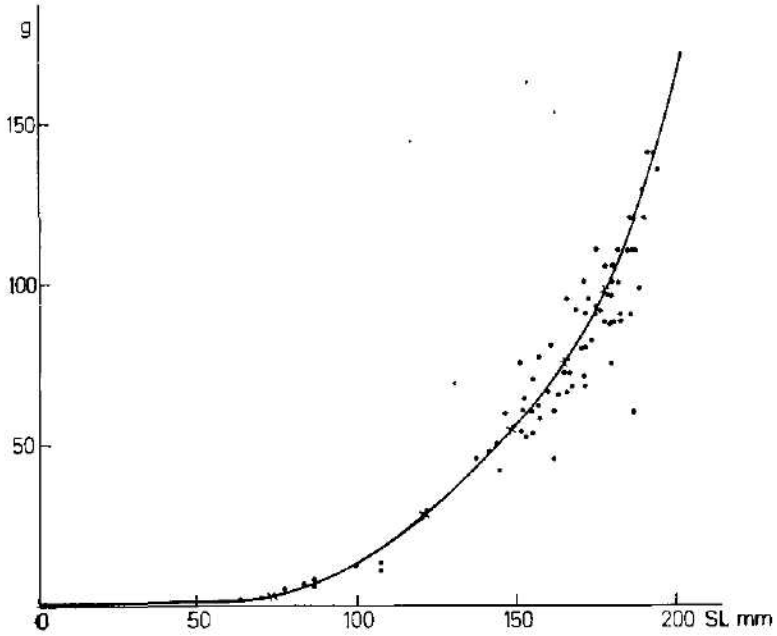

Fig. 3. Relationship between weight (g) and body (standard) length (SL mm) in bleak, *Alburnus alburnus*.

Table 1. Growth of Bleak, *Alburnus alburnus*, from the Slapy valley water reservoir

Age group	Nr. of spec.	Ave. body length at the time of capture (mm)	Ave. weight at the time of capture (grams)	Average back-calculated lengths (in mm) l_1	l_2	l_3	l_4	l_5	l_6
I	1	151	75	100	—	—	—	—	—
II	3	163	67	83	145	—	—	—	—
		min. 155	53	78	92	—	—	—	—
		max. 167	76	89	153	—	—	—	—
III	29	171	86	71	129	159	—	—	—
		min. 152	58	48	92	135	—	—	—
		max. 187	120	105	153	176	—	—	—
IV	10	181	102	69	120	147	170	—	—
		min. 153	64	50	100	123	140	—	—
		max. 195	135	88	147	176	186	—	—
IV	10	179	104	67	98	116	141	161	—
		min. 155	68	46	62	79	98	101	—
		max. 194	140	82	122	136	165	181	—
VI	2	179	105	61	86	110	125	147	168
		min. 178	105	58	81	96	120	141	162
		max. 180	105	63	90	124	135	153	174
alltogether 55 spec.		grand ave. of calculated lengths:		74	121	142	153	159	168
		minimum values		46	62	79	98	101	162
		maximum values		100	153	176	176	181	174

Table 2. Growth of Bleak, *Alburnus alburnus*, from the Vranovská valley water reservoir

Age group	Nr. of spec.	Ave. body length at the time of capture (mm)	Average weight at the time of capture (grams)	Average back-calculated lengths (in mm) l_1	l_2	l_3	l_4	l_5
I	2	113	22	68	—	—	—	—
		min. 112	21	66	—	—	—	—
		max. 114	23	70	—	—	—	—
II	3	143	48	69	126	—	—	—
		min. 137	45	59	—	—	—	—
		max. 152	51	80	—	—	—	—
III	12	154	57	73	122	143	—	—
		min. 144	42	59	102	133	—	—
		max. 163	66	87	138	155	—	—
IV	3	156	61	66	108	134	148	—
		min. 152	54	51	100	132	146	—
		max. 162	70	76	119	138	154	—
V	1	— 152	60	50	67	123	141	147
alltogether 21 sp.		grand ave. of calculated lengths:		69	118	140	148	147
		minimum values		51	100	123	146	147
		maximum values		87	138	155	154	147

Table 3. Growth of Bleak, *Alburnus alburnus*, from various Czechoslovak localities

Author/year	No. sp.	Locality	Average back-calculated lengths (in mm)							
			l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
Chitravadivelu, 1971	108	river Labe near Děčín	48	75	96	115	128	142	151	—
Chitravadivelu, 1971	18	Rivulet Stropnice, south. Bohemia	49	68	74	—	—	—	—	—
Chitravadivelu, 1971	43	River Ohře, K. Vary	50	83	—	—	—	—	—	—
Chitravadivelu, 1971	76	River Vltava, Měchenice	52	78	94	105	135	161	—	—
Chitravadivelu, 1971	21	River Vltava, Prague-Podbaba	54	87	110	—	—	—	—	—
Author	8	„Čierna voda", river Danube	60	85	—	—	—	—	—	—
Vostradovský, 1966	77	river Labe near Děčín	62	88	108	120	132	139	147	153
Author	21	Vranov valley water reservoir	69	118	140	148	147	—	—	—
Author	55	Slapy valley water reservoir	74	121	142	153	159	168	—	—
Author	3	Back-water „Řehákova bouda"	85	—	—	—	—	—	—	—
Čihař, 1961	14	Slapy valley water reservoir	91	125	152	172	187	207	—	—
Vostradovský 1963	159	Lipno valley water reservoir	93	132	148	—	—	—	—	—
Alltogether	563	specimens, mean:	60	119	120	146	151	170	151	153
		total length, mean:	72	143	144	168	181	204	181	188

Three selected scales from the row below the lateral line above the insertion of ventrals in direction backwards to anal fin were used for study from every specimen and average values obtained were used for construction of graph (Fig. 1) demonstrating body scale relationship. Einar Lea's nomogram was used for the back-calculation of lengths and respective annuli with a correction's factor 20 mm, using values obtained from 84 specimens from 4 localities (natural back-water Bezednice, canal Čierna voda, Slapy and Vranov riverine lakes). The relationship between total and standard length is evident from Fig. 2, the value of TL/SL = 1.20 and remains constant. For its construction 76 specimens from two last cited localities were used. Body length/weight relationship shows Fig. 3.

RESULTS AND DISCUSSION

That the growth of bleak depends upon the source of food supply is evident, but it is interesting to observe the large ranges in single years of life in fish species whose life is not stationary, as e.g. in pike (*Esox lucius*), for details see Oliva (1956); on the contrary, bleak lives in shoals, solitary specimens being never met with, keeps to the surface from spring to autumn, does not migrate and is designated as typical pelagial planktonofagous fish (sometimes feeding also on insects, eggs and fry of other fishes, especially the larger specimens. These characteristics are repeated in practically the same words by many authors, e.g. Hamilton (1843),

Smitt (1895), Berg (1933, 1949), Jenkins (1942), Staff (1950), Dyk (1956), Muus & Dahlström (1967), Nikolskij (1971), Holčík & Hensel (1971).

The apparent wide ranges in back-calculated growth in single age groups are clearly visible in Tables 1 and 2, especially in age groups where more specimens were examined, but also in grand averages and their ranges summarized in both tables below. In the Slapy riverine lake the differences are apparent in maximum and minimum values joined with calculated lengths l_1 upto l_6. This phenomenon seems to confirm the opinion about the existence of slow and fast growing populations of the same species in one lake and their mixing due to shoal mode of life of bleak, but further studies of this problem are necessary. Maximum age of 6 + (Slapy reservoir) or 5 + (Vranov reservoir) was ascertained, in the last example accompanied by the starvation of growth in the last year of life.

SUMMARY

87 specimens of the bleak (*Alburnus alburnus*) from 4 localities in Czechoslovakia, mostly from the Slapy and Vranov riverine lakes, were examined for age and growth studies. Maximum age of 6 + years was recorded. Wide ranges in single years in calculated lengths were observed, due probably to the simultaneous presence of slow and fast growing populations in the same water body. The data compared with growth determination on further 516 specimens from another 8 Bohemian localities, based on the studies of other authors, show that only in 1 case fish of the age 8 + was recorded. The growth of the bleak is better in closed water bodies than in rivers.

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LITERATURE

Berg, L. S., 1933: Ryby. Fauna SSSR i sopredelnych stran, III, Ostariophysi, 3 : 705—845, Leningrad.

Berg, L. S., 1949: Ryby presnych vod SSSR i sopredelnych stran, 2 : 469—925, figs. 288—674, Izd. AN SSSR, Moskva—Leningrad.

Čihař, J., 1961: Růst ryb ve Slapské údolní nádrži v r. 1959. *Sborník ČSAZV*, 6 (24), 4 : 295—302.

Dyk, V., 1956: Naše ryby. 339 pages, 16 col. plates, 48 plates, 143 figs., ČSAZV Praha.

Frič, A., 1908: České ryby a jich cizopasníci. 2nd Ed., 78 pages, Fr. Řivnáč, Praha.

Hamilton, R., 1843: The natural history of British fishes, 2, 424 pages, 34 plates, Edinburgh.

Holčík, J., Hensel, K., 1971: Ichtyologická příručka, 217 pages, Obzor, Bratislava.

Chitravadivelu, K., 1971: Some observations on the growth of Alburnus alburnus (Linnaeus, 1758). *Věst. čs. spol. zool.*, 24, 4 : 241—250.

Jenkins, T. J., 1942: The fishes of the British Isles, both fresh water and salt. 408 pages, F. Warne & Co., Ltd., London—New York.

Muus, B. J., Dahlstrom, P., 1967: Europas Ferksvands Fisk. Transl. into German in 1968: BLV Bestimmungsbuch Süsswasserfische Europas, by F. Terofal, 224 pages, BLV München, Basel, Wien.

Nikolskij, G. V., 1971: Častnaja ichtiologija. 471 pages, Vysšaja škola, Moskva.

Oliva, O., 1956: K biologii štiky (Esox lucius L.). *Věst. čs. zool. spol.*, 20 (2) : 208—223, 6 plates.

Smitt, F. A., 1895: A history of Scandinavian fishes. 2nd Ed., 2 : 567—1240, P. A. Norstedt & Söner, Stockholm.

Staff, F.: Ryby slodkowodne Polski i krajów ościennych. 273 pages, Warszawa, Trzaska & Ewert.
Vostradovský, J., 1963: Ouklej obecná (Alburnus alburnus) v údolní nádrži Lipno. *Práce výzk. ústavu rybář. a hydrobiol., Vodňany*, 3 : 111—128.
Vostradovský J., 1966: Několik poznatků o rybách v řece Labi u Děčína. *Práce VÚRH Vodňany*, 6 : 155—171.

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NOTE ON THE GROWTH OF COMMON BARBEL, BARBUS BARBUS (PISCES : CYPRINIDAE)

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Dedicated to the 80th anniversary of Prof. Dr S. Hrabě DSc.

Abstract: The growth of Common Barbel, *Barbus barbus* (Linnaeus) was studied from the scales of 61 specimens collected during 1952—1976. Three samples (one from Poland) were compared, the growth was observed to be moderate.

INTRODUTION

Although the Common Barbel is a very popular fish species in Czechoslovakia, the literature on its growth is scant, the only available reference being that of Hochman (1955) concerning the growth and food of the barbel in the river Svratka (tributary of the Morava, the Danube drainage).

Later Hochman and Jirásek (1960) studied the growth of the barbel in the river Dyje, Havlena (1964) contributed to the knowledge of the growth of the barbel in the rivers Černá and Bielá Orava, Bastl, Holčík, Kirka (1975) brought the growth data of the barbel from the river Turiec, and the last important contributions to this problem are those of Peňáz, Požárová (1973) and Peňáz (1977). Therefore an attempt has been made to study its growth using scales.

MATERIAL AND METHODS

Representative scales, collected from the middle part of the body side of barbel, were washed in water and examined under the scale projector (Carl Zeiss, Jena, magnification 17. 5.). Lateral scale radius of only one selected scale of each fish was read. The anuli were recognized by clear markings.

When plotted against the body length the scale radius gave a straight line relationship with the intercept at 15 mm which was used as a correction factor for back-calculating lengths using Lea's nomogram.

RESULTS AND DISCUSSION

Results are presented in Tables 1—3. From Table 1 it can be seen that barbel lives mor than 13 years; the body length at this age varies from 470 to 540 mm The oldest female cited by Hochman (1955) measured 550 mm (body length), age 17, the oldest male reached only 256 mm of body length at the age 12 (Hochman, l.c.).

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The ranges of calculated body lengths presented in Tables 1—3 clearly demonstrate periods of unequal growth of barbel. Since the sample is drawn over a number of years such variations can be easily accounted for (Tables 1—2), but the same phenomenon can be observed in Table 3, where the material was collected during one summer in 1952. Thus it is evident that barbel does not maintain the same growth rate from year to year and the ecological conditions play a great role in determining good or bad years of growth.

Hochman (1955) proved slow growth of male barbel, when the recent angling statute permits catching of barbel above 40 cm of total length (= 331 mm of standard length); the oldest males found in his material from the river Svratka, reaching 243 mm of body length in 8 years, which is 267 mm of total length = 1.18 body length according to our data), could not be fished out. The statute length 40 cm (total length) is reached by the barbel from the rivers Berounka and Sázava, after finishing 8 years of life (Table 4) and by the females of barbel in the Svratka in 10 years of life, and by the barbels in the river Dniester after 8 years (males) or 7 years (females, see Opalatenko, 1966); in the river Dyje neither males nor females of legal size were found (Hochman, Jirásek, 1960). In the rivulet Rokytná (Peňáz, 1977) males of legal length were not found, while females reached this size after 12 years. Similar situation could be seen also in other localities (see Table 4). Therefore it seems necessary to shorten the legal size of barbel, which would permit better angling exoploitation of this species. Peňáz, Požárová (1973) and Peňáz (1977) recommended as the legal size for angling 30 cm of total length (about 246 mm of body length); this proposition can be agreed upon.

There was a lack of newly revised data concerning the maturation of barbels from Czechoslovak territory. Dyk (1956) stated the third or fourth years of life, Žukov (1965) 4 years in females (body length 30—35 cm) and second year of life in males (8.8—15.6 cm of body length); the data of the latter must be attributed to barbels in the river Neman (USSR). With regard to these data the results of Peňáz (1977) seem to be very important. According to his findings the males reach sexual maturity much earlier than females; some were sexually mature towards the end of the first year of life, the majority in the second year, the females were mature on the average, about three years later.

With regard to the results of Hochman (1955), the occurence of females older than 15 years is probable (see also Peňáz, 1977); the oldest male (13 years) found by Peňáz, Požárová (1973) measured 328 (body length) or 397 mm (total length), respectively. The oldest female (15 years) measured 515 (body length) or 605 mm (total length). The weight of the oldest male mentioned was 560 g, of the female examined 2400 g.

According to Berg (1949), the maximum body length is 80—85 cm, the weight up to 4 kg, exceptionally up to 10 kg. However, in the river Salzach at Laufen in Austria a barbel was captured in 1853 weighing 12.75 kg. The record barbel caught while angling on the British Isles weighed 8 kg and was caught in the river Lea in 1880. In 1888 one was caught in the river Thames, weiging slightly more than 7 kg (Travis Jenkins, 1942) According to Žukov (1965) the maximum length is 90 cm and weight up to 10 kg.

The largest specimens of barbel registered in this country in recent years were: in 1974 — 72 cm (TL), 5.58 kg, the river Svratka; 84 cm (TL), 5.57 kg — see Anon. 1974, the river Labe at Ústí; in 1976 — 77 cm (TL), 4.7 kg, the river Radbuza; 74 cm (TL), 4.5 kg, the river Nežárka, see Anon., 1977. Apparently, the angling

Table 1 Growth of Barbel, *Barbus barbus*, from the river Labe system (mainly lower parts of the river Berounka and Sázava), during 1962–1976

No. of spec.	Age group	Ave body length in mm at the time of capture, ranges in brackets	Average back-calculated lengths (in mm), ranges in brackets						
			l_1	l_2	l_3	l_4	l_5	l_6	l_7
2	VI	340	113 (106–119)	178 (171–188)	212 (203–220)	263 (260–266)	293 (285–300)	333 (330–335)	—
5	VII	348 (340–350)	109 (104–115)	155 (146–163)	200 (193–211)	236 (218–243)	277 (272–282)	312 (300–317)	334 (326–339)
8	VIII	369 (350–380)	102 (84–119)	141 (121–157)	184 (155–217)	231 (199–247)	273 (256–305)	307 (278–332)	333 (314–359)
3	IX	367 (340–380)	96 (87–101)	138 (127–153)	178 (158–187)	218 (182–246)	261 (202–305)	288 (231–333)	304 (255–355)
2	X	415 (390–440)	109 (91–126)	148 (119–177)	200 (173–227)	242 (215–268)	277 (257–297)	316 (297–335)	343 (311–375)
5	XI	442 (430–460)	111 (101–119)	153 (142–179)	190 (167–209)	229 (202–248)	256 (233–282)	284 (252–317)	327 (296–363)
1	XII	480	92	132	168	203	251	296	343
2	XIII	505 (470–540)	98 (96–100)	145 (139–151)	174 (163–185)	195 (179–211)	231 (209–252)	265 (243–287)	300 (271–328)
		Average	104	149	188	227	265	300	326
		Annual increments	45	39	39	38	35	26	28

			l_8	l_9	l_{10}	l_{11}	l_{12}	l_{13}
2	VI	340	—	—	—	—	—	—
5	VII	348 (340—350)	—	—	—	—	—	—
8	VIII	369	357	—	—	—	—	—
3	IX	367 (340—380)	337 (285—367)	353 (311—377)	—	—	—	—
2	X	415 (390—440)	368 (340—395)	394 (370—418)	413 (390—435)	—	—	—
5	XI	442 (430—460)	362 (344—393)	388 (376—414)	413 (397—440)	435 (419—457)	—	—
1	XII	480	375	423	454	466	473	—
2	XIII	505 (470—540)	326 (303—348)	361 (331—390)	421 (387—455)	457 (419—495)	482 (443—520)	498 (460—535)
		Average	354	384	425	452	477	498
		Annual increments	30	41	27	25	21	

Table 2. Growth of Barbel, *Barbus barbus*, from

No. of spec.	Age group	Ave. body length at the time of capture in mm, ranges in brackets	Average back-calculated lengths l_1	l_2	l_3	l_4
1	II	127	81	127	—	—
1	V	190	75	106	140	163
4	VI	209	65	92	127	158
		(190—240)	(56—81)	(77—120)	(112—151)	(142—186)
1	VII	215	58	91	129	163
3	VIII	243	62	97	128	148
		(235—260)	(55—66)	(85—105)	(114—136)	(138—156)
1	XI	340	58	85	110	151
		Average	65	97	127	155
		Annual increments	32	30	28	26

pressure nowadays causes the diminishing of large specimens of barbels; unfortunately the scales of such giant specimens are not accesible for age studies, therefore we are not informed about their age studies, therefore we are not informed about their age. The reading of scales in barbels showed that scales in specimens above 50 mm of body length are eliptical, in specimens of body length they are circular. The smallest specimen examined, body length 34 mm, the river Bečva at Lipník, 20 (8) 1950, shoved 4—8 circular lamellae on its scales in lateral field, in larger specimens, body length around 50 mm, we have found 14—16 circular lamellae and the scales showed *caudal prolongation*. The lateral radius of scale in specimens of 34—35 mm of body length measured 0.25—0.30 mm, so that the scales develop

Table 3. Growth of Barbel, *Barbus barbus*, from the

No. of spec.	Age group	Ave. body length in mm at the time of capture	Average back-calculated lengths l_1	l_2	l_3	l_4
1	I	127	75	—	—	—
1	III	185	107	146	176	—
4	V	268	99	148	184	213
		(250—292)	(84—108)	(146—150)	(172—191)	(198—226)
5	VI	321	90	147	177	217
		(303—327)	(78— 98)	(125—155)	(173—186)	(206—236)
3	VII	376	102	156	196	225
		(366—385)	(96—109)	(154—158)	(188—207)	(223—231)
5	VIII	411	99	149	183	225
		(405—426)	(83—112)	(140—164)	(179—187)	(204—244)
1	IX	440	107	146	174	204
2	XI	560	96	160	190	260
			(95— 97)	(159—161)	(188—192)	(227—293)
		Average	97	150	183	218
		Annual increments	53	33	35	38

the river Morávka, drainage of the river Odra, 1952

(in mm), ranges in brackets

l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
—	—	—	—	—	—	—
190	—	—	—	—	—	—
184	206	—	—	—	—	—
(169—221)	(182—240)					
181	175	215	—	—	—	—
179	200	224	242	—	—	—
(175—181)	(178—209)	(210—238)	(230—260)			
177	205	241	272	294	325	340
181	203	226	249	294	325	340
22		23	45	31	15	

apparently, before the barbel attains the body length of 30 mm. The use of correction factor 15 mm for back-calculation of body length seems to use to be justified.

Acknowledgement

The authors are indebted to Mr. J. Pásek who kindly offered scales and measurement of all angled barbels. The barbels from the river Morávka were collected by a group of students of the Faculty of Sciences, Charles University, organized in the summer of 1952 by Dr. M. Straškraba and Dr. E. Balon. Finally, scales of barbels from the southern Poland were loaned to us for study through the kindness of Professor W. Juszczyk (Cracow) some samples from Poland were collected also by the senior author. Thanks are also due to Ing. J. Vostradovský, CSc. for critical reading of the typescript.

river Dunajec, Wisla drainage, southern Poland

in mm, ranges in brackets

l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}
—	—	—	—	—	—	—
—	—	—	—	—	—	—
243	—	—	—	—	—	—
(232—248)						
251	298	—	—	—	—	—
(236—263)	(291—313)					
266	315	356	—	—	—	—
(252—288)	(303—323)	(344—367)				
267	314	357	386			
(242—278)	(293—328)	(345—365)	(378—392)			
242	293	350	390	432	—	—
308	367	398	422	470	502	539
(266—351)	(337—397)	(376—420)	(400—444)	(465—475)	(492—511)	(532—545)
256	311	360	392	448	502	539
55	49	32	56	56	34	

Table 4. Comparison of the growth rate (in mm) of barbel (*Barbus barbus*), from different localities

Author/year	Locality	Average back-calculated body lengths (in mm)																
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	l_{12}	l_{13}	l_{14}	l_{15}	l_{16}	l_{17}
Opalatenko – 1966 – males	Dniestr	45	104	162	212	245	265	314	340	—	—	—	—	—	—	—	—	—
Opalatenko – 1966 – females	Dniestr	48	100	166	220	282	323	356	—	—	—	—	—	—	—	—	—	—
Hochman–Jirásek – 1960 – males	Dyje	51	92	131	159	182	205	215	230	—	—	—	—	—	—	—	—	—
Peňáz – 1977 – females	Rokytná	56	85	115	146	175	205	230	255	274	296	314	336	395	—	—	—	—
Peňáz – 1977 – males	Rokytná	56	86	115	142	165	185	202	212	—	—	—	—	—	—	—	—	—
Žukov –1965	Neman	57	122	187	251	311	356	—	—	—	—	—	—	—	—	—	—	—
Peňáz – 1977 – males	Jihlava	58	93	125	152	178	200	217	237	250	—	—	—	—	—	—	—	—
Hochman–Jirásek –1960 – females	Dyje	58	114	155	195	232	269	297	319	—	—	—	—	—	—	—	—	—
Peňáz – 1977 – females	Jihlava	60	95	131	166	198	226	254	275	330	379	417	457	498	—	—	—	—
Peňáz – 1977 – males	Oslava	61	95	127	154	179	202	223	239	254	255	—	—	—	—	—	—	—
Hochman – 1955 – males	Svratka	62	100	136	168	186	214	238	243	—	—	—	—	—	—	—	—	—
Peňáz – 1977 – females	Oslava	62	101	136	174	209	240	269	288	311	327	354	373	411	429	515	—	—
Hochman – 1955 – females	Svratka	64	103	138	173	200	233	264	285	330	358	393	425	435	470	508	528	550
Authors – 1977	Morávka	65	97	127	155	181	203	226	249	294	325	340	—	—	—	—	—	—
Bastl, Holčík, Kirka – 1975	Turiec	65	102	148	188	226	257	287	307	330	327	343	366	—	—	—	—	—
Peňáz–Požárová – 1973 males	Oslava	68	103	134	158	180	201	219	233	247	268	293	310	320	—	—	—	—
Havlena – 1964	Biela Orava	69	94	122	155	184	222	263	300	343	430	467	—	—	—	—	—	—
Peňáz–Požárová – 1973	Oslava	69	105	137	163	186	209	232	252	273	311	332	347	392	444	515	—	—
Havlena – 1964	Černá Orava	75	109	156	187	213	267	341	369	399	435	469	497	528	—	—	—	—
Kostjučenko in Žukov – 1965 – males	Dněpr	76	136	199	254	269	—	—	—	—	—	—	—	—	—	—	—	—
Peňáz–Požárová – 1973 – females	Oslava	77	117	152	184	213	240	267	291	307	341	351	403	428	444	515	—	—
Kostjučenko in Žukov – 1965 – females	Dněpr	78	154	247	326	364	387	—	—	—	—	—	—	—	—	—	—	—
Authors – 1977	Dunajec	97	150	183	218	256	311	360	392	448	502	539	—	—	—	—	—	—
Starmach – 1948	Wisła	98	142	183	216	250	283	315	343	378	415	448	495	515	—	—	—	—
Authors – 1977	Berounka and Sázava	104	149	188	227	265	300	326	354	384	425	452	477	498	—	—	—	—

SUMMARY

The growth of *Barbus barbus* has been studied from 61 specimens, using scales Lateral scales radius was used for reading of anuli. Correction factor of 15 mm was used for the back calculation of lengths (body lengths). Body length / scale length relationship was found to be linear.

Back-calculated lengths show that the barbel grows relatively fast before the formation of the first annulus, the growth rate shows considerable ranges within the same year class, and also from year to year. Ecological conditions play a great role in determining good or bad years of growth. Fish of 13 + years have been recorded, though the growth rate is relatively slow. Conversion factor: total length = = 1.18 body length (in the specimens from the river Morávka).

LITERATURE

Anonymus, 1975: Vyhodnocení soutěže o rekordní úlovky ryb v roce 1974. *Rybářství*, 10 : 232—234.

Anonymus, 1977: Vyhodnocení soutěže o rekordní úlovky ryb za rok 1976. *Rybářství*, 7—8 : 164—168.

Bastl, I., Holčík, J., Kirka, A., 1975: Ichthyologický výskum karpatského oblúka. 6. Ichthyofauna chráneného náleziska hlavátky v rieke Turiec. *Acta Rer. Natur. Mus. Nat. Slov. Bratislava*, 221 : 191—233.

Berg, L. S., 1949: Ryby presnych vod SSSR i sopredelnych stran. 2. Izd. A. N. SSSR Moskva—Leningrad, 469—925.

Dyk, V., 1956: Naše ryby. 4. vyd. ČSAZV, Praha, 339 pp.

Havlena, F., 1964: Príspevok ku štúdiu veku a rastu mreny Barbus barbus (L.) z povodie Oravskej údolnej nádrže. *Zool. listy*, 13 (4) : 321—326.

Heckel, J., Kner, R., 1958: Die Süsswasserfische der österreichischen Monarchie mit Rücksicht auf die angrenzenden Länder. Leipzig, 388 pp.

Hochman, L., 1955: Příspěvek k poznání růstu a potravy parmy obecné (Barbus barbus (Linné)) v řece Svratce. *Sb. Vysoké školy zemědělské a les. fakulty; ř. A. II. Brno*: 147—159.

Hochman, L., Jirásek, J., 1960: Zhodnocení růstové intenzity produkčně rozhodujících druhů ryb v parmových úsecích řeky Dyje. *Sb. Vys. školy zemědělské a les. fakulty ř. A. Brno*: 75—92.

Opalatenko, L. K. 1966: Usač Barbus borysthenicus Dyb. Verchnego Dnestra. *Vopr. Ichthiologii*, 6 (3) : 446—453.

Peňáz, M. 1977: Populations analysis of the barb, Barbus barbus, from some Moravian rivers (Czechoslovakia). *Přír. práce ČSAV*, 10 (7) : 1—30.

Peňáz, M., Požárová, H., 1973: Růst parmy obecné, Barbus barbus (L.) v řece Oslavě. *Sborník Přírodověd. kl. západomor. muz. Třebíč*, 9 : 55—64.

Starmach, K., 1948: Wiek i wzrost brzan (Barbus barbus) polawianych w Wisle w okolicy Krakowa. Prace rol.-lesne, Polska Akademia Umiejetnosci, Kraków.

Travis Jenkins, J., 1942: The fishes of the British Isles, both fresh water and salt. 2nd Ed., London, 408 pp.

Žukov, P. I., 1965: Ryby Belorusii. Minsk, Nauka i technika. 414 pp.

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DIE NISTGESELLSCHAFTEN DER VÖGEL IM ZERSTREUTEN GRÜN IN DER SCHUTZZONE DES NATURSCHUTZGEBIETES „ANENSKÉ RYBNÍKY" BEI MARIÁNSKÉ LÁZNĚ (MARIENBAD)

Pavel ŘEPA

Eingegangen am 2. August 1977

Abstract: The bird community of a study plot of 40 ha in a farmland (10 ha of small wood and hedges and 30 ha fields and meadows) was investigated by mapping of territories. The density of bird population was 77.4—280.2 pairs/10 ha in different types of small woods and hedges, 11.5 pairs/10 ha in fields and meadows and 67.2 pairs/10 ha in whole investigated plot.

EINLEITUNG

Bei der komplexen Durchforschung der Vertebratenfauna des Naturschutzgebietes „Anenské rybníky" bei Mariánské Lázně (Kreis Tachov, Südwestböhmen) in den Jahren 1971—1974 machte ich einen Versuch, die Avifauna kleiner Remisen und Baumgruppen in der Nachbarschaft beider geschützten Teiche quantitativ zu bewerten. Die Angaben über die quantitative Bewertung der Nistsynusien der Vögel in diesen kleinen Nichtwaldbeständen von Bäumen und Sträuchern (z. B. Peitzmeier, 1950; Czarnecki, 1956; Foksowicz, Sokolowski, 1956; Turček 1958, Dircksen, Höhner, 1963; Werner, 1965; Schmidt, 1967—68; Gromadzki, 1970; Köhler, 1972: Šťastný, 1973) sind sowohl in der tschechoslowakischen als auch in der ausländischen Literatur wesentlich seltener vertreten als die analogen Angaben über verschiedene Waldtypen. Dabei bilden verschiedene Abschnitte des Nichtwaldgrünes ein bedeutendes Landschaftselement und sind von grosser Bedeutung für die Avifauna jedes Gebietes. Die Erwebung möglichst zahlreicher Angaben von diesen Standorten wäre auch aus dem Grunde nötig, dass diese kleine Baum- und Gebüschkomplexe infolge der Intensifizierung der Landwirtschaftsproduktion in der offenen Landschaft gegenwärtig in hohem Mass liquidiert werden.

In dem untersuchten Abschnitt der Schutzzone des Naturschutzgebietes „Anenské rybníky" gelang es mir einen Landschaftsabschnit aufzugangen, der in Südwestböhmen bis unlängst üblich war, der aber in der Gegenwart verschwindet. Auf etwa 40 ha Agrarlandschaft sind hier 17 verschieden grosse Bestände des Nichtwaldgrünes von etwa 10 ha Gesamtausmass (d. h. 25 % der Gesamtfläche des Abschittes) zerstreut. Es geht um einen der letzten Landschaftsreste mit so hohem Anteil an Nichtwaldgrün in der Agrarlandschaft in dem Gebiet des Kreises Tachov.

Es ist mir eine angenehme Pflicht Herrn RNDr. Karel Šťastný, CSc. aus der Institut für Landschaftsökologie der ČSAV für das durchlesen des Manuscripts und wertvolle Hinweise zu danken. Für die Übersetzung in die deutsche Sprache bin ich Herrn RNDr. Otto Winkler aus Prag zu Dank verpflichtet.

BESCHREIBUNG DES UNTERSUCHTEN GEBIETES

Geographische Lage: Südwestböhmen, Kreis Tachov, etwa 12 km S von Mariánské Lázně, unweit der Stadt Planá u Mariánských Lázní 49°50′ n. B., 12°40′ ö. L. Orographisch gehört der Abschnitt in den Bereich der Tachovská brázda-Senke, die einen Bestandteil des Böhmerwald--Systems bildet.

Seehöhe: 510 m.

Klimatische Bedingungen: Durchschn. Jahrestemperatur 6,9°, durchschn. jährliche Niederschlagsmenge 609 mm, Anzahl der Tage mit Schneedecke 61, Jahresdurchschnitt der relativen Luftfeuchtigkeit 77,5 %, jährlicher Sonnenschein 1700 Stunden.

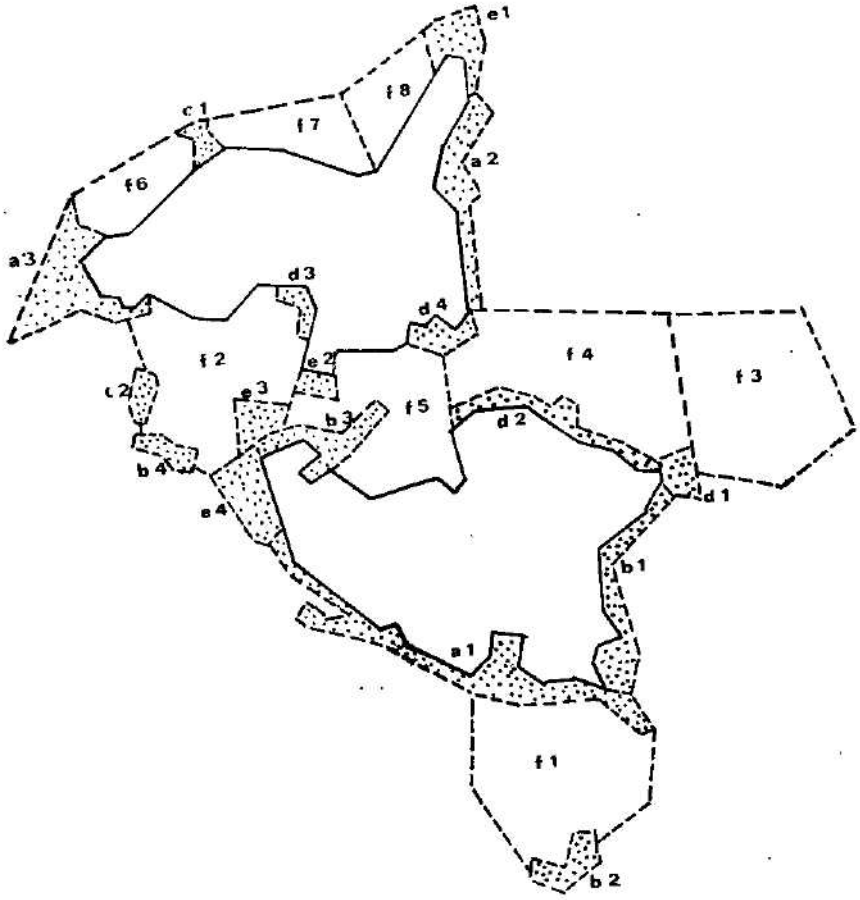

Abb. 1: Schematische Karte des untersuchten Gebietes.
Erklärungen: Dünne Linie — Teiche
Gestrichelte Linie — Grenze einzelner Abschnitte der Biotope
Kleine Buchstaben mit arabischen Ziffern entsprechen den Bezeichnungen im Kapitel „Beschreibung des untersuchten Gebietes".

Bodenverhältnisse: Bodenarten-vorwiegend Braunerden, hier und da illimerisierter Boden. Bodentypen-sandig-tonige und tonig-sandige Böden.

Charakter der umliegenden Landschaft: Ebene Gegend mit überwiegenden landwirtschaftlich ausgenutzen Flächen (mehr als 80 % Ackerboden, dauernde Rasenbestände sind nur geringfügig vertreten). Arme Kiefernwälder bedecken nur etwa 1/3 der Gesamtfläche. Häufig kommen kleinere Feldteiche vor.

Charakter des untersuchten Abschnittes: etwa 40 ha Felder und Wiesen mit zerstreuten verschiedenen Typen von Feldwäldchen und Gebüschen, die etwa 1/4 des gesamten Abschnittes bedecken. In der Mitte des Abschnittes befinden sich 2 Teiche (19 ha und 25 ha).

Grösse des untersuchten Abschnittes: 42,47 ha davon 32,69 ha Felder und Wiesen und 9,78 ha Baum- und Sträuchbestände.

Umgebung des untersuchten Abschnittes: Bebaute Felder (92 % der Grenzlänge), Teich (2 % Grenzlänge), Feldwäldchen (6 % der Grenzlänge). Entfernung von dem nächsten zusammenhängenden Waldkomplex 900 m, Entfernung von der nächsten Siedlung (Stadt Planá u Mar. Lázní) — 1 km, Entfernung von dem nächsten einzelstehenden Gebäude (St.-Ann-Kloster) — 200 m.

Beschreibung einzelner Teile (kleine Buchstaben und arabische Ziffer, unter denen die einzelnen Biotope und deren Teile beschrieben werden, entsprechen den Bezeichnung in der Abb. 1).

a) Ältere gemischte Baumbestände mit grösserer Fläche als 1 ha — 3 Abschnitte, Gesamtfläche 5,46 ha.

1. Ein Wäldchen aus Erlen, Espen und Pappeln mit Beimischung weiterer Gehölzarten (Sommereiche, Fichte, Weide usw.). Baumhöhe 20—25 m, Dicke der Stämme 14—35 cm, Deckungsgrad 75 %. In der Strauchschicht Weidensträucher, stellenweise Schlehdorn u. a. Höhe bis 3 m, Deckungsgrad 40 %. Krautschicht spärlich, stellenweise fehlend. Fläche 1,22 ha.

2. Verwilderter Park — in die Untersuchung nur ein zu Damm des Teiches Velký Anenský anliegender Teil eingeschlossen. Ein alter Bestandt mit sehr bunter Artenzusammensetzung (Berg- und Spitzahorn, Sommereiche, Fichte, Kiefer, Erle Espe usw.). Baumhöhe 25—30 m, Dicke der Stämme 15—60 cm, Deckungsgrad 70 %. In der Strauchschicht vorwiegend Hasel, Höhe bis 5 m, Deckungsgrad 30 %. Krautschicht sehr arm, zumeist ganz fehlend. Fläche des untersuchten Teiles 0,58 ha, der ganze Park nimmt ca 7 ha ein.

3. Ein Mischwäldchen. Es besteht aus einem südlichen Teil, der von einem unternassten Erlenbruch (Höhe 15—20 m, Dicke der Stämme 10—20 cm, Deckungsgrad 60 %) mit einem spärlichen Unterwuchs der Weidensträucher (Höhe bis 4 m, Deckungsgrad 40 %) und einem dichten Bestand von Carex sp. gebildet ist, und aus einem nördlichen Teil, wo sich ein Fichtenwäldchen (Baumhöhe bis 25 m, Dicke der Stämme 40 cm, Deckungsgrad 70 %) mit Beimischung von Laubbäumen, ohne Strauch- und Krautschicht, befindet. Beide Teile sind durch einen Bestand alter Eichen und Ahorne verbunden, der vom Damm eines kleinen Teiches auslauft. Fläche 3,66 ha.

b) Ältere die Fläche von 1 ha nicht überschreitende gemischte Baumbestände — 4 Abschnitte Gesamtfläche 1,53 ha.

1—2. Bestände auf kurzen Teichdämmen, aus alten Bäumen (Sommereiche, Bergahorn, Fichte, Birke, Gemeine Eberesche, Weide u. a.) bestehend. Höhe bis 25 m, Dicke der Stämme 30—60 cm, Deckungsgrad 60 %. Die Strauchschicht besteht aus Hasel, Hagedorn, Himbeerstrauch, Schlehdorn (Höhe bis 3 m, Deckungsgrad 40 %). Krautschicht sehr spärlich. Flächen 0,25 ha und 0,74 ha.

3. Eine alte Weidengruppe in der Wiese (Höhe 30 m, Dicke der Stämme 50—70 cm, Dekkungsgrad 40 %). Strauchschicht aus Weidensträuchern (Höhe bis 2 m, Deckungsgrad 60 %). Krautschicht sehr spärlich. Fläche 0,39 ha.

4. Eine gemischte Remise in der Wiese. Alte Bäume (vorwiegend Fichte, Espe, Birke), Höhe 20 m, Dicke der Stämme 10—30 cm, Deckungsgrad 75 %. Strauchschicht aus Hagedorn, Hasel und Rotem Hornstrauch (Höhe bis 3 m, Deckungsgrad 30 %. Krautschicht sehr spärlich. Fläche 0,15 ha.

c) Kleine Fichtenbestände — 2 Abschnitte, Gesamtfläche 0,32 ha.

1—2. Fichtenbestände (Höhe bis 30 m, Dicke der Stämme 30 cm, Deckungsgrad 90 %) mit einem Unterwuchs von Trauben-Holunder (Höhe bis 2 m, Deckungsgrad 20 %, ohne Krautschicht. Flächen 0,20 und 0,12 ha.

d) Junge kleine Laubbaumbestände ohne Strauchschicht. — 4 Abschnitte, Gesamtfläche 0,80 ha.

1—3. Espenbestände (Höhe 10—15 m, Dicke der Stämme 10 cm, Deckungsgrad 60 %), in der Strauchschicht nur Himbeersträucher (Höhe 1 m, Deckungsgrad 20 %), spärlich Unterwuchs aus Brennesseln. Flächen 0,47, 0,12 und 0,12 ha.

4. Erlenbruch (Höhe 15 m, Dicke der Stämme 15 cm, Deckungsgrad 70 %), ohne Strauchschicht, spärlicher Unterwuchs aus Brennesseln. Fläche 0,11 ha.

e) Sumpfige Abschnitte, mit Weidensträuchern spärlich bewachsen — 4 Abschnitte, Gesamtfläche 1,67 ha.

Tab. 1. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops
a — ältere Mischbaumbestände von mehr als 1 ha Fläche
Untersuchte Fläche: 5,46 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Streptopelia turtur — TS	2,9	1,1
Falco tinnunculus — BG	3,7	1,4
Cuculus canorus — BG	2,9	1
Asio otus — BG	1,8	0,7
Dendrocopos major — TS	2,7	1
Picus viridis — TS	1,8	0,7
Lanius collurio — TS	1,8	0,7
Lanius excubitor — TS	1,8	0,7
Parus major	14,3	5,4
Parus caeruleus	9,1	3,5
Parus montanus	3,3	1,2
Parus palustris	7,3	2,7
Certhia familiaris	5,5	2,1
Sitta europaea	2,7	1,0
Troglodytes troglodytes	5,5	2,1
Prunella modularis	1,8	0,7
Turdus pilaris — TS	32,1	12,1
Turdus merula — TS	22,7	8,7
Turdus philomelos — TS	14,3	5,5
Erithacus rubecula	9,9	3,8
Sylvia curruca	5,1	2,0
Sylvia communis	6,9	2,6
Sylvia atricapilla	6,4	2,4
Sylvia borin	2,7	1,0
Phylloscopus collybity	12,6	4,8
Phylloscopus trochilus	15,4	5,9
Carduelis chloris — TS	8,2	3,1
Carduelis carduelis — TS	6,0	2,3
Fringilla coelebs	43,8	16,7
Emberiza citrinella — TS	3,7	1,4
Passer montanus — TS	1,8	0,7

Anmerkung: TS = Teilsiedler, BG — Brutgast
Gesamte absolute Densität: 260,5 Paar pro 10 ha
Bereinigte Densität: 204,8 Paar pro 10 ha
Anzahl nistender Arten: 31

Unternässte, je nach Jahreszeit von 10—30 % überschwemmte Abschnitte. Eine Baumschicht fehlt. Die Strauchschicht besteht aus Weidensträuchern (Höhe bis 5 m, Deckungsgrad 30—50 %). Krautschicht aus dichtem Bestand von Seggen, Binsen und Gemeiner Teichsimse. Flächen 0,90, 0,25, 0,40 und 0,12 ha.

f) Landwirtschaftliche Flächen — 8 Abschnitte, Gesamtfläche 32,69 ha.
In die Zählung wurden auch Vögel eingeschlossen die einsame Feldsträucher und Strauchgruppen bis zu 0,1 ha Grosse bewohnten.
1. Mahdwiese mit einsamen Sträuchern — 8,00 ha.
2. Bestände mehrjähriger Mengsaat — 6,45 ha.
3—8. Äcker mit Getreidekulturen, von Rainen gesäumt, mit einsamen Bäumen und Sträuchern. Flächen 1,05, 2,20, 1,10, 1,10, 8,00 und 6,45 ha.

METHODIK

Die Feststellung nistender Paare führte ich mittels der Methode der Kartierung von Nistbezirken durch (Enemar 1959, Šťastný 1974). Die Aufnahmen wurden i. J. 1974 am 12.,

Tab. 2. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops
b — ältere gemischte Baumbestände von weniger als 1 ha Fläche
Untersuchte Fläche: 1,53 ha

Art	Densität Paaren pro 10 ha	Dominanz in Prozent
Streptopelia turtur — BG	5,2	1,3
Falco tinnunculus — BG	6,5	1,6
Cuculus canorus	3,9	1,0
Dendrocopos major — TS	0,7	0,2
Dendrocopos minor — TS	6,5	1,6
Sturnus vulgaris — TS	6,5	1,6
Lanius collurio — TS	6,5	1,6
Parus major	21,6	5,3
Parus caeruleus	13,1	3,2
Parus montanus	5,9	1,9
Parus palustris	7,8	1,4
Sitta europaea	3,9	1,0
Turdus pilaris — TS	45,0	11,2
Turdus merula — TS	31,8	7,5
Turdus philomelos — TS	28,9	5,1
Erithacus rubecula	8,3	2,5
Sylvia curruca	22,3	5,5
Sylvia communis	17,7	4,3
Sylvia atricapilla	5,8	1,4
Sylvia borin	11,2	2,7
Phylloscopus collybita	17,0	4,2
Phylloscopus trochilus	22,2	5,4
Motacilla alba	6,5	1,6
Carduelis chloris — TS	20,2	4,9
Carduelis carduelis — TS	5,2	1,3
Carduelis cannabina — TS	6,5	1,6
Fringilla coelebs — TS	53,0	11,2
Emberiza citrinella — TS	17,6	4,3
Passer montanus — TS	6,5	1,6

Gesamte absolute Densität: 413,8 Paar pro 10 ha
Bereinigte Densität: 280,2 Paar pro 10 ha
Anzahl nistender Arten: 28

19. und 26. April, 5., 12., 17., 24. und 29. Mai, 7., 16., 23. Juni, meist zwischen 6—10 Uhr, vollgezogen. Jeder Besuch dauerte 3—4 Stunden. Bei 75 Paaren von den insgesamt festgestellten 287 Paaren wurde das Vorkommen bestätigt durch den Fund des Nestes während des Nistens oder später im Herbst, nach dem Laubabfall.

Die ermittelten Angaben der Abundanz wurden auf Densität (pro 10 ha) und Dominanz (Palmgren, 1930) umgerechnet. Bei „Mischflächen", die aus einer Mosaik verschiedener Bestände zusammengesetzt sind, kann geschehen, dass es nicht richtig ist das ganze Paar in jenen Bestand einzurechnen, in dem es sein Nest hat, das ein Nistbereich auch die benachbarten Bestände einschliessen kann. Puchstein (1966) teilt daher beim Beziffern der Paaranzahl, die als Unterlage für die Berechnung der Densität dient, diese „Grenzpaare" unter verschiedene Bestände nach dem Verhältnis ein, in dem Fälle des Vorkommens in einzelnen Aufnahmen in beiden (oder auch mehreren) Beständen angetroffen wurden. Diese Methode benützte ich in einigen Fällen, wo es sich um Grenze zwischen zwei Typen der Baumbestände handelte. Die meisten Fälle in unserem Gebiet betraf jedoch die in Baumbeständen nistenden Arten, deren Bereich auch die Felder und Wiesen einschloss. Hier scheucht der Beobachter die Vögel bei Nahrungssuche sehr leicht auf, so dass ihr Vorkommen beiderseits der Grenze in verschiedenen Aufnahmen nicht so objektiv vermerkt werden kann wie es Puchstein (1966) an der Grenze zweier Baumbestände zu tun vermochte. Das Übergreifen einiger in Baumbeständen nistenden Arten durch

Tab. 3. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops c — kleine Fichtenwäldchen
Gesamtfläche 0,32 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Corvus corone — BG	31,2	10,1
Parus major	18,7	6,3
Turdus merula — TS	28,0	9,1
T. philomelos — TS	28,0	9,1
Sylvia communis	31,2	10,1
Phylloscopus collybita	21,9	7,4
Carduelis chloris — TS	31,2	10,1
Fringilla coelebs — TS	105,0	36,0
Emberiza citrinella — TS	9,3	3,2

Gesamte absolute Densität: 304,5 Paar pro 10 ha
Bereinigte Densität: 173,0 Paar pro 10 ha
Anzahl nistender Arten: 9

einen Teil ihres Nistbereiches (Nahrungssuche) in die Felder habe ich durch Bezeichnung sogenannter Ganz- und Teilsiedler und Brutgäste (siehe z.B. Dircksen, Höhner 1963) ersichtlich gemacht. Als Teilsiedler bezeichne ich jene Art, die auf der untersuchten Fläche ihr Nest hat, aber die Nahrung nicht nur hier, sondern auch in benachbarten Biotopen sammelt. Die Brutgäste sind Arten, die auf der bezüglichen Fläche zwar nisten, aber ihre Nahrung auf anderen Flächen suchen, oder Arten, deren Revier so gross ist, dass die untersuchte Fläche nur ein kleines Fragment davon darstellt. Ausser der gesamten absoluten Densität habe ich in den Tabellen auch sog. bereinigte Densität angeführt, wo die Brutgäste nicht eingerechnet und die Teilsiedler nur mit 50 % eingerechnet werden.

Beim Vergleich der Synusien von Vögeln in verschiedenen Biotopen benütze ich den Sörensenschen Index und Renkonensche Zahl (siehe z. B. Pikula 1976). Den Sörensenschen Index berechne ich als $\frac{2c}{a+b}$, wo c = Anzahl der in beiden Synusien vorkommenden Arten, und a, b = Anzahl der Arten in einzelnen Synusien. Die Renkonensche Zahl wird ermittelt, wenn für die verglichenen Synusien Paare der Dominanzwerte für jede Art (in der ersten und zweiten Synusie) gebildet werden. Die gesuchte Zahl stellt dann die Summe aller kleineren Werte von jedem Paare dar.

ERGEBNISSE

Die Ergebnisse der Untersuchungen sind in Tab. 1—6 zusammengefasst, wo für einzelne Biotope die Angaben über die Densität und Dominanz aller nistenden Arten enthalten sind. In Tab. 7 sind analoge Angaben für den ganzen untersuchten Abschnitt zu finden.

Die wesentlich höhere Densität nistender Vögel im Biotop b im Vergleich mit Biotop a (sie besitzen eine analoge Zusammensetzung, doch unterscheiden sich durch die Grösse der Bestände) bringt eine weitere Bestätigung der allgemeinen Regel, dass kleinere Flächen der Bestände eine höhere Densität der Vögel aufweisen als grössere Flächen derselben Bestände. Da die Grösse der Bestände von allen weiteren Biotopen eher der Grösse der Bestände von Biotop b nahe steht, müssen die Densitätswerte mit diesem verglichen werden, während Biotop a ausser Betracht bleiben muss. Dabei erweist sich als geeigneter die Werte der bereinigten Densität zu benützen, die von den Unterschieden der Grösse untersuchter Flächen weniger beeinflusst werden. Aus dem Vergleich wird ersichtlich, dass Biotop b (kleinere gemischte Baumbestände) eine höchste Densität aufweist; es folgen Bio-

Tab. 4. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops d — junge Baumbestände ohne deutliche Strauchschicht
Gesamtfläche: 0,80 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Parus major	42,5	15,0
Parus caeruleus	12,5	4,2
Parus montanus	6,2	2,2
Turdus pilaris — TS	12,5	4,4
Turdus merula — TS	25,0	8,7
Turdus philomelos — TS	18,7	6,3
Sylvia curruca	32,7	11,4
Sylvia communis	3,7	1,3
Phylloscopus collybita	12,5	4,4
Phylloscopus trochilus	11,2	4,0
Carduelis chloris — TS	8,7	3,1
Carduelis carduelis — TS	11,2	4,0
Carduelis cannabina — TS	21,2	7,5
Fringilla coelebs — TS	51,3	18,0
Emberiza citrinella — TS	12,5	4,4

Gesamte absolute Densität: 282,4 Paar pro 10 ha
Bereinigte Densität: 208,5 Paar pro 10 ha
Anzahl nistender Arten: 15

tope d (junge Laubbaumbestände ohne auffallende Strauchschicht) und c (kleinflächige Fichtenbestände), und die weit geringste Densität weist Biotop e (zerstreute Weidenbestände auf Nassgallen) auf. Ganz analog ist die Lage auch beim

Tab. 5. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops e — vernässte Abschnitte mit Weidengebüsch
Gesamtfläche 1,67 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Parus major	3,0	4,0
Parus palustris	3,0	4,0
Turdus merula — TS	6,0	8,0
Erithacus rubecula	6,0	8,0
Saxicola rubetra	3,0	4,0
Sylvia curruca	16,0	21,5
Sylvia communis	1,8	2,4
Phylloscopus collybita	4,8	6,4
Phylloscopus trochilus	4,2	5,6
Carduelis chloris — TS	1,8	2,4
Emberiza schoeniclus	5,4	7,2
Emberiza citrinella — TS	19,4	18,2
Acrocephalus scirpaceus	6,0	8,0

Gesamte absolute Densität: 77,4 Paar pro 10 ha
Bereinigte Densität: 63,6 Paar pro 10 ha
Anzahl nistender Arten: 13

Tab. 6. Zusammensetzung der Nistsynusie der Vögel in Abschnitten des Biotops f — Felder und Wiesen einschliesslich kleiner Strauchgruppen
Gesamtfläche 32,69 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Perdix perdix	0,6	5,2
Vanellus vanellus	2,4	23,2
Gallinago gallinago	0,3	2,6
Lanius excubitor — BG	0,3	2,6
Parus major — TS	0,3	2,6
Turdus merula	0,3	2,6
Erithacus rubecula — TS	0,3	2,6
Saxicola rubetra	0,3	2,6
Sylvia curruca — TS	0,7	6,0
Phylloscopus collybita — TS	0,3	2,6
Phylloscopus trochilus — TS	0,3	2,6
Motacilla alba	0,3	2,6
Alauda arvensis	4,0	34,7
Emberiza schoeniclus	0,3	2,6
Emberiza citrinella	0,3	2,6
Passer montanus	0,5	4,7

Gesamte absolute Densität: 11,5 Paar pro 10 ha
Bereinigte Densität: 9,9 Paar pro 10 ha
Anzahl nistender Arten: 16

Vergleich der Anzahl nistender Vogelarten in einzelnen Biotopen, nur mit einer Ausnahme, dass die Artenzahl in Biotopen a und b so gut wie dieselbe ist.

Die Artenzusammensetzung der Nistsynusien verglich ich mittels der Sörensenschen Indexe (Tab. 8). Die grösste Ähnlichkeit weisen Biotope a und b auf, woraus folgt, dass die Artenzusammensetzung der Nistsynusie der Vögel in älteren Laubmischwäldchen durch unterschiedliche Grösse deren Flächen nicht allzu beeinflusst wird. Von den übrigen Biotopen steht diesen der Biotop d am nächsten, der jedoch zugleich eine relativ hohe Ähnlichkeit mit weiteren Biotopen (c und e) aufweist. Dies ist durch den Umstand verursacht, dass er von den gewöhnlichsten Arten besiedelt wird, die in allen Biotopen vorkommen. In den übrigen Biotopen treten zu diesen weitere Arten hinzu, die für den bezüglichen Biotop in gewissem Masse (wenigstens gegenüber den hier untersuchten Biotopen) spezifisch sind, und dadurch werden die übrigen Biotope untereinander mehr unterschiedlich. Eine verhältnismässig hohe Ähnlichkeit der Felder und Wiesen mit den Baum- und Strauchbeständen wird durch die Arten verursacht, die in einsamen Strauchgruppen nisteten. — Verfolgt man die Vertretung einzelner Arten, dann nisten *Parus major*, *Turdus merula*, *Phylloscopus collybita*, *Emberiza citrinella* in allen Biotopen, d. h. auch in Feldern mit einzel stehenden Sträuchern. *Sylvia communis* und *Carduelis chloris* nisteten in allen Biotopen, ausgenommen Felder und Wiesen, *Sylvia curruca* und *Phylloscopus trochilus* dagegen in allen Biotopen einschliesslich Felder und Wiesen (einzel stehenden Sträuchern), nicht aber in Fichtenwäldchen. *Turdus philomelos* und *Fringilla coelebs* nisteten in allen vier Biotopen mit hohen Bäumen (a, b, c, d), *Turdus pilaris*, *Parus coeruleus* und *Carduelis carduelis* in allen Biotopen mit Bäumen, ausgenommen Fichtenwäldchen (a, b, d).

Tab. 7. Zusammensetzung der Synusie nistender Vögel im ganzen untersuchten Abschnitt
Gesamtfläche 42,47 ha

Art	Densität in Paaren pro 10 ha	Dominanz in Prozent
Gallinago gallinago	0,2	0,3
Perdix perdix	0,5	0,7
Asio otus	0,2	0,3
Falco tinnunculus	0,7	1,0
Vanellus vanellus	1,9	2,8
Streptopelia turtur	0,5	0,7
Cuculus canorus	0,5	0,7
Dendrocopos major	0,5	0,7
Dendrocopos minor	0,2	0,3
Picus viridis	0,2	0,3
Corvus corone	0,2	0,3
Lanius collurio	0,5	0,7
Lanius excubitor	0,2	0,3
Parus major	3,9	5,8!!
Parus caeruleus	1,9	2,8
Parus montanus	0,8	1,2
Parus palustris	1,3	1,9
Certhia familiaris	0,7	1,0
Sitta europaea	0,5	0,7
Troglodytes troglodytes	0,7	1,0
Sturnus vulgaris	0,2	0,3
Prunella modularis	0,2	0,3
Turdus pilaris	6,0	8,9!!
Turdus merula	5,2	7,6!!
Turdus philomelos	3,1	4,7
Erithacus rubecula	2,0	3,0
Saxicola rubetra	0,5	0,7
Sylvia curruca	3,2	4,8
Sylvia communis	1,9	2,8
Sylvia atricapilla	1,0	1,5
Sylvia borin	0,7	1,0
Phylloscopus collybita	3,0	4,5
Phylloscopus trochilus	3,4	5,0!!
Acrocephalus scirpaceus	0,2	0,3
Motacilla alba	0,5	0,7
Alauda arvensis	3,1	4,6
Carduelis chloris	2,2	3,3
Carduelis carduelis	1,3	1,9
Carduelis cannabina	0,7	1,0
Fringilla coelebs	9,3	13,0!!
Emberiza schoeniclus	0,2	0,3
Emberiza citrinella	2,2	3,2
Passer montanus	1,0	1,5

Gesamte Densität: 67,2 Paar pro 10 ha
Anzahl nistender Arten: 43

Ich verglich einzelne Biotope auch aufgrund der quantitativen Zusammensetzung der Nistsynusien der Vögel (Dominanz). In Tab. 9 sind die Werte des Renkonenschen Indexes für alle Paare der Biotope angegeben. Die grösste Übereinstimmung ergibt sich wiederum zwischen Biotopen a und b, von den übrigen Biotopen steht wieder Biotop d diesen am nächsten. Biotop c ist jedoch nach diesem Index den

Tab. 8. Sörensensche Indexe zum Vergleich der Artenzusammensetzung von Synusien nistender Vögel in einzelnen Biotopen der Schutzzone des Naturschutzgebietes „Anenské rybníky"

Biotop	A	B	C	D	E	F
A	XX	84	40	66	45	38
B		XX	43	71	49	41
C			XX	69	54	32
D				XX	60	40
E					XX	66
F						XX

übrigen Baumbiotopen (a, b, d) deutlich ähnlicher als die Nassgallen mit Gebüsch (e). Wiesen und Felder unterscheiden sich diesmal deutlich von den übrigen Biotopen.

Vergleicht man unter einzelnen Biotopen die Zusammensetzung dominanter Arten (über 5 % Dominanz — Palmgren, 1930), dann ergibt sich, dass wiederum eine gute Übereinstimmung herrscht zwischen Biotopen a und b, denen wieder Biotop d am nächsten steht. Weit unterschiedlicher sind die dominanten Arten im Biotop c und insbesondere im Biotop e. Die Felder und Wiesen (Biotop f) beherbergen natürlich ganz andere dominante Arten.

Einige Arten zeigten eine hohe Dominanz in mehreren Biotopen. Die Art *Parus major* war dominant in allen Biotopen mit Ausnahme der Felder und Wiesen. *Turdus philomelos, Turdus merula* und *Fringilla coelebs* gehörten zu dominanten Arten in allen Biotopen mit Bäumen (a, b, c, d). *Sylvia curruca* war ebenso dominant in vier Biotopen, sie bevorzugte jedoch Biotope mit Sträuchern (a, b, e, f) und meidete Biotope mit schlecht entwickelter Strauchschicht (c, d).

DISKUSSION

Ein Vergleich der ermittelten Angaben über die allgemeine Densität einzelner Bestandstypen mit den Angaben anderer Autoren ist nur in vereinzelten Fällen möglich. Ausser der Artenzusammensetzung und Struktur der Bestände beeinflussen die Vogelbesiedlung auch weitere Faktoren, wie die Art des unmittelbar benachbarten Bestandes, der Gesamtcharakter der umgebenden Landschaft, die Seehöhe

Tab. 9. Renkonensche Zahlen zum Vergleich der Dominanz einzelner Arten in Synusien nistender Vögel in Biotopen der Schutzzone des Naturschutzgebietes „Anenské rybníky"

Biotop	A	B	C	D	E	F
A	XXXX	76,8	68,9	37,1	48,2	17,8
B		XXXX	63,9	39,6	46,7	24,2
C			XXXX	39,9	51,3	19,0
D				XXXX	26,4	10,4
E					XXXX	19,0
F						XXXX

und geographische Lage. Einen sehr starken Einfluss auf die Densität übt auch, wie schon oben erwähnt, die Grösse der untersuchten Baumkomplexe aus (Dircksen, Höhner, 1963). Es ist daher nicht überraschend, dass z. B. Grosse (1942) in einem kleinen Laubhain, Czarnecki (1956) in einem Park in Feldern, Foksowicz et Sokolowski (1956) in einem Schutzbaumstreifen in Feldern, Peitzmeier (1950) in kleinen Wäldchen, Puchstein (1966) in einem Mischbestand am Seeufer oder Šťastný (1973) auf Teichdämmen eine Densität nistender Vögel fanden, die 150 Paar pro 10 ha nicht überschreitet, d. h. kleinere Werte, als ich in den Baumbeständen in der Schutzzone des Naturschutzgebietes „Anenské rybníky" festgestellt habe. Alle erwähnten Bestände besassen wesentlich grössere Flächen (durchwegs mehr als 5 ha). Eine vergleichbare Angabe ist z. B. bei Werner (1965) zu finden, der in einem etwa 4 ha grossen Feldwäldchen, dessen Bestandszusammensetzung dem hier untersuchten Biotop a ähnlich war, eine Densität von etwa 150 Paar pro ha, d. h. wiederum eine niedrigere, fand. Ich bin der Ansicht, dass in diesem Fall die Tatsache zum Ausdruck kam, dass das von Werner (l. c) untersuchte Wäldchen einsam in Feldern stand. Czarnecki (1956) untersuchte einen etwa 4 ha grossen, mit alten Bäumen bewachsenen Feldfriedhof und fand eine Densität, die der von mir festgestellten Densität für Biotop a nahe steht (190 Paar pro 10 ha). Ähnlich auch Dircksen, Höhner (1963) ermittelten in einem gemischten Wäldchen von ca. 2 ha Grösse eine absolute Densität von 240 Paar pro 10 ha und eine bereinigte Densität von 177 Paar pro 10 ha, d. h. wiederum Werte, die meinen Angaben für Biotop a sehr nahe sind. Dieselben Autoren fanden auch in einem 0,4 ha grossen Erlen-Pappelbestand 278 Paar pro 10 ha (bereinigte Densität 167 Paar pro 10 ha), was mit meiner Angabe für Biotop d, dessen Charakter diesem Wäldchen entspricht, in gutem Einklag ist. Die Angabe über die Densität der Vögel in Feldgebüschen [Gromadzki (1970), Schmidt (1970)], unterscheiden sich deutlich von unserem Biotop e, da auch der Charakter des Bestandes unterschiedlich ist.

Interessant ist auch der Wert der allgemeinen Densität nistender Vögel im ganzen untersuchten Abschnitt (Felder und Abschnitte der Baum- und Strauchbestände zusammen). Auf einem 40 ha grossen Abschnitt der Agrarlandschaft, wo der Anteil der Flächen mit Baum- und Strauchbeständen etwa ein Viertel ausmacht, wurden 67,2 Paar pro 10 ha festgestellt, was den Werten nahe steht, die in verhältnismässig dicht besiedelten Waldbeständen festgestellt werden (vgl. z. B. die bei Novikov (1962) zusammengefassten Angaben). So z. B. auf einer etwa gleich grossen Fläche des krautreichen Urwaldbuchenwaldes im Naturschutzgebiet „Diana" bei Rozvadov stellte ich eine Densität der Nistsynusie der Vögel von 76—89 Paar pro 10 ha fest, d. h. keine 10 % mehr (bisher unpubliziert). Dabei kann dieser Bestand als der besterhaltene Rest der Naturwälder gewertet werden, die im ganzen Gebiet des böhmischen Teiles des Oberpfälzer Waldes und dessen Vorgebirges vorkommen. Die vorliegenden Ergebnisse heben daher die Bedeutung des zerstreuten Grünes in der Landschaft für die Vogelbesiedlung in genügenden Masse hervor.

ZUSAMMENFASSUNG

1. Im Jahre 1974 wurde in der Schutzzone des Naturschutzgebietes „Anenské rybníky" bei Mariánské Lázně (Marienbad, Kreis Tachov, Südwestböhmen) eine Ermittlung der qualitativen und quantitativen Zusammensetzung von Synusien nistender Vögel mittels der Methode der Kartierung von Nistrevieren vorgenommen. Es wurden 42,47 ha der die beiden geschützten Teiche umgebenden Landschaft untersucht; davon entfallen 9,78 ha auf Baum- und Strauchbestände und 32,69 ha auf landwirtschaftlich ausgenützte Flächen.

2. 17 Abschnitte wurden in 5 Biotopentypen eingeteilt: a — ältere gemischte Baumbestände, deren Fläche 1 ha überschreitet; b — ähnliche Bestände von weniger als 1 ha Fläche; c — kleine Fichtenfeldwäldchen, d — junge Baumbestände mit minimal entwickelter Strauchschicht, e — Weidengebüschbestände auf Nassgallen. Die Densität und Dominanz nistender Vogelarten in einzelnen Bestandstypen sind in Tab. 1—5, analoge Angaben für Felder und Wiesen in Tab. 6 und die Angaben für den ganzen untersuchten Abschnitt in Tab. 7 zusammengefasst.

3. Die allgemeine Densität nistender Paare im untersuchten Abschnitt betrug 67,2 Paar pro 10 ha, was einen verhältnismässig hohen Wert auch im Vergleich mit den in Waldbeständen ermittelten Angaben darstellt. Dadurch wird die Wichtigkeit kleiner Elemente des Nichtwaldgrünes in der Landschaft für die Vogelwelt nachgewiesen.

LITERATUR

Czarnecki, Z., 1956: Materialy do ekologii ptaków gniezdzących w śródpolnych kępach drzew. *Ekol. polska, A* 4 : 397—417.

Dircksen, R., Höhner, P., 1963: Quantitative ornithologische Bestandsaufnahme im Raum Ravensburg-Lippe. *Abh. des Landesmuseums f. Naturkunde zu Münster in Westfalen*, 25 (3) : 1—111.

Enemar, A., 1959: On the determination of the size and composition of a passerine bird population during the breeding season. A methodological study. *Var Fagelvärld, Suppl.*, 2 : 1—114.

Foksowicz, T., Sokolowski, J., 1956: Ptaki w zadrzewieniu ochronnym pod Rogaczewem w województwie Poznańskim. *Ekol. polska, A* 18 : 307—350.

Grosse, A., 1942: Zur Vogelwelt des Kaujrsees und seiner Umgebung. Korrespondenzblatt des Naturforscher-Vereins zu Riga, Posen 64 : 21—25.

Köhler, K.-H., 1972: Die Vogelwelt eines Bahndammes in Sommer und Winter. *Orn. Mitt.*, 24 (12) : 255—259.

Novikov, G. A., 1962: Die geographisch bedingten Unterschiede in der Siedlungsdichte der Waldvögel im europäischen Teil der UdSSR und in den angrenzenden Ländern. *Falke*, 9 : 376—382 und 403—406.

Peitzmeier, J., 1950: Untersuchungen über die Siedlungsdichte der Vogelwelt in kleinen Gehölzen in Westfalen. *Natur u. Heimat*, Münster, *10* : 30—37.

Pikula, J., 1976: Metodika výzkumu hnízdní bionomie ptactva. MOS Přerov, SZN Praha.

Puchstein, K., 1966: Zur Vogelökologie gemischter Flächen. *Vogelwelt*, 87 (6) : 161—176.

Schmidt, E., 1967—68: Vogelbestandsaufnahmen in Feldhecken in der Umgebung von Budapest. *Zool. Abh. Staat. Mus. f. Tierkunde Dresden*, 29 : 77—84.

Šťastný, K., 1973: Využití ptáků a savců pro charakterizaci hrází Třeboňska z hlediska krajinné ekologie. Kand. dis. práce na ÚKE ČSAV — pracoviště Říčany, unpubliziert, 165 pp.

Šťastný, K., 1974: Návrh jednotné metodiky kvantitativního výzkumu ptáků. Zprávy MOS 1974 : 13—21.

Turček, F. J., 1958: Dreviny, vtáky a cicavce z niektorých pásov kriačin v poliach. *Biol. práce*, 4 (8) : 47—67.

Werner, J., 1965: Der Vogelbestand eines Feldgehölzes in Ostthüringen. *Orn. Mitt.*, 17 (9) : 181—184.

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ADRENAL RESPONSES TO CROWDING IN SOFT-FURRED FIELD RAT RATTUS MELTADA

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Abstract: In *Ratus meltada* (Gray) the left adrenal is aléays heavier than the right one. The correlation coefficient between the body weight and adrenal glands is statistically significant ($n = 41$, $p < 0.01$). There is a highly significant relationship between the duration of stress and strain, and intensity of overcrowding and decrease in adrenal weight.

INTRODUCTION

Adrenal cortical function in a number of species of mammals increases with increase in population size (Christian, 1963; Christian and Davis, 1964; Christian et al., 1965; Ghosh et al., 1968). This effect has been attributed to the enhanced social interaction caused by an increase in the population density (Bronson, 1965). Little is known about such adrenal responses to crowding for wild rodents occuring in India. The present study is related to adrenal responses to population crowding in male soft-furred field rat *Rattus meltada* (Gray).

MATERIAL AND METHODS

Four groups (I–IV) of laboratory reared male *Rattus meltada* (Gray) consisting of 3, 6, 9 and 12 individuals respectively, were overcrowded in a limited space of (40 × 40 cm) 1,600sq cm. The animals having approximately equal body-weight and the same maturity status were fed equally. Three replications of each group were sacrificed after an interval of 4, 6 and 8 days. The right and left adrenals were cleared from the adhering materials and weighed on an electric balance. Simultaneously, 43 specimens of *R meltada* collected from the fields were dissected, their adrenals removed and correlation between body-weight and paired adrenal weight was calculated.

RESULTS AND DISCUSSION

In *Rattus meltada* (Gray) the left adrenal is always heavier than the right one. The relationship between the body-weight and the adrenals is positive (Fig. 1). The correlation coefficient is 0.457, which is statitically significant at 5% level ($n = 41$, $p < 0.01$). Similar positive relationship between the adrenals and the body weight has been shown in field voles *Microtus agrestis* (Chitty and Clarke, 1963) and in *Tatera indica indica* (Jain, 1970, 1971)

The statistical interpretation of analysis of variance reveals that there is a highly significant relationship between the duration of stress and strain and intensity of overcrowding and decrease in adrenal weight at 5% level of significance (Table I). The difference between the adrenal weight of Ist and IVth

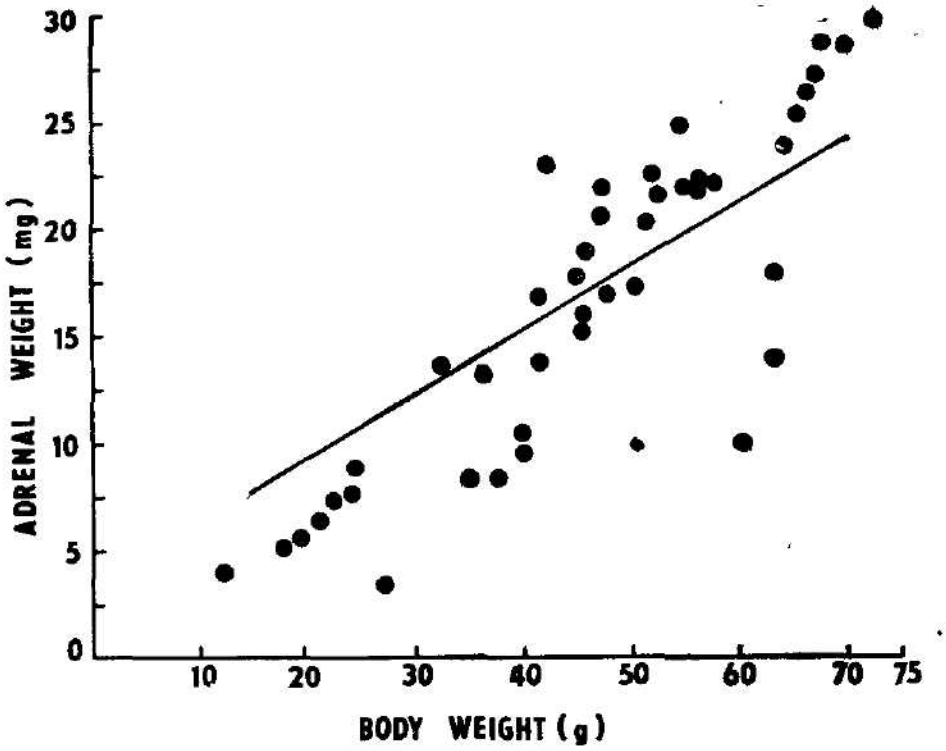

Fig. 1: Relatioship between body weight and adrenal glands.

Table 1. Statistical analysis

Group No. Intensity of overcrowding	Duration of overcrowding Adrenal wt. (mg) both right and left four days	six days	eight days	Total
$I_{(3)}$	11.76 ± 1.95	11.66 ± 1.02	11.53 ± 2.24	34.95
$II_{(6)}$	11.36 ± 1.05	11.15 ± 1.35	10.76 ± 2.99	33.27
$III_{(9)}$	11.05 ± 1.57	10.72 ± 3.72	10.58 ± 1.88	32.26
$IV_{(12)}$	11.26 ± 4.27	10.30 ± 1.71	9.72 ± 0.84	31.26
Total	45.44	43.83	42.59	131.86

Analysis of variance

Source of variance	D. F.	S. S.	M. S.	F.
Between groups	3	2.4128	0.8043	211.8
Between duration of overcrowding	2	1.5211	0.7605	200.01
Error	6	0.227	0.0038	
	11	3.9566		

groups after 8 days and of Ist and IIIrd groups after 4 days is also highly significant. In all the 4 groups, the difference between mean adrenal weight and duration of overcrowding after 4, 6 and 8 days is significant. This difference after 4 and 8 days in groups Ist and IInd is insignificant, and in the group IV it is significant at 5% level. Similar significant decline has been reported in adrenal weights of overcrowded females of *Meriones hurrianae* (Chosh et al., 1968).

REFERENCES

Bronson, F. H., 1965: Proceedings of the International Commission on laboratory animals (Academic Press, Inc., New York)

Chitty, H. and Clarke, J. R., 1963: The growth of the adrenal glad of laboratory and field voles and changes in it during pregnancy. *Can. J. Zool.*, **41**: 1025–1034

Christian, J. J., 1963: Cited in Physological mammology vol. I, edited by M. V. Mayer and R. C. Van Gelder (Academic Press, Inc., New York) pp. 189

Christian, J. J. and Davis, D. E., 1964: Adrenal glands in female voles (Microtus pennsylvanicus) as related to reproduction and population size. *J. Mamm.*, **47**: 1–18

Christian, J. J., Lloyd, J. A. and Davis, D. E., 1965: The role of endocrine in the self-regulation of mammalian population. *Recent. Progr. Hormone Res.*, *21*: 501–577

Ghosh, P. K., Jain, A. P. and Taneja, G. C., 1968: Adrenal Response to Crowding in Indian Desert Gebril·Meriones hurrianae. Jerdon. *Ind. J. Exp. Biol.*, **6**: 162–163

Jain, A. P., 1971: Adrenal weight in relation to duration of pregnacy and pauched body weight in Indian gerbil, Tatera indica Hardwicke. *Ann. Arid. Zone.*, **9**: 45–48

Jain, A. P., 1971: Adrenal weight in Indian gerbil, Tatera indica indica Hardwicke as related to body weight and reproductive activity. *Ann. Arid. Zone*, **10**: 279–288

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SPERMATOPHORES OF SOME ORIBATIDS OF THE FAMILY LIACARIDAE (ACARINA : ORIBATEI)

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Abstract: Description, drawings and detailed dimensions of spermatophores and sperms of 9 species of Oribatids from 4 genera of the family *Liacaridae*, laying of spermatophores, their picking up by females and destruction by harmful agents.

INTRODUCTION

During laboratory culturing of the below listed species of Oribatei of the family *Liacaridae* their spermatophores were gathered and observed, as well as the ways of laying spermatophores in culturing cells, picking them up by females, damage done and destruction of spermatophores by different unfavourable factors. The structure of spermatophores of the following cultivated species was examined particularly: *Liacarus coracinus* (C. L. Koch, 1841), *Liacarus subterraneus* (C. L. Koch, 1841), *Liacarus nitens* (Gervais, 1844), *Liacarus xylariae* (Schrank, 1803), *Dorycranosus infissus* (Gunhold, 1953), *Dorycranosus moraviacus* (Willmann, 1951), *Xenillus clypeator* Robineau-Desvoidy, 1839, *Xenillus tegeocranus* (Hermann, 1804), *Adoristes ovatus* (C. L. Koch, 1839).

MATERIAL AND METHODS

The examined spermatophores were obtained and observed during the cultivation of the above mentioned species of Oribatids in Petri-dishes of 40 mm in diameter; these were covered by a substrate composed of plaster of Paris and charcoal (mixture 9 : 1) at the bottom.

On this slightly wet substrate a piece of semi-decayed wood, soil and other substrates were placed, on which and in which postembryonal stages of the examined species were cultivated. Spermatophores were transferred from the surface of these substrates and especially from the walls of the culture-dishes on the point of a preparatory needle into a medium prepared in advance and imbedded in permanent slides.

Experiments were done with the following embedding slide mounting mediums: Swann, Amman's lactophenol, lactophenol according to Beer, glycerol, PVA lactophenol and lactic acid. The most suitable was glycerol diluted with distilled water from 1 : 25 up to 1 : 10, and Amman's lactophenol. Other mediums including undiluted glycerol, were too thick and the spherical capsules of spermatophores were cracking in it, because of the pressure of the cover glass, and especially because of the great difference of the osmotic pressure. Consequently it was necessary to prevent quick evaporation of water from the drop of the medium on the slide. In lactic acid the spherical capsule was dissolved, even if diluted.

Staining of some spermatophores was done by adding a colouring matter into a drop of the medium placed on the slide. Borax-carmine, congo-red, methylene-blue, methylene-green, saphrarine and gray-blue ink of the mark "Gama" for fountain pens were used. All the colouring matters stained the spherical capsules of spermatophores (except the methylene-green), as well as the central and lateral supports. The stalk of the spermatophore remained unstained. It was stained only partially in pale green or pale blue by methylene-green, methylene blue and ink.

Among the used staining matters most suitable were borax-carmine, saphranine and ink. Borax-carmine produced intensive staining of sperms, colouring differentially the content of

the spherical capsule including supports. It does not dye the stalk. It mixes well with glycerol and with lactophenol according to Beer. In Swann and PVA-lactophenol it causes hardening. Saphranine does not dye so intensively and does not dye sperms at all. Similarly congo-red, which becomes paler later and then turns brownish. Methylene-green dyes well sperms in a slightly sour environment. Otherwise it stains, slightly indifferentially, the other components of the spherical capsule and the stalk, and the spherical body remains invisible. Methylene-blue stains especially, quite distinctly also the spermal ring, but not so much the individual sperms and membrane with interior structures of the spherical capsule, except spherical body. Black-blue ink "Gama" for fountain pens stains, intensively and differentially, the spherical capsule, in which the spermal ring with sperms and funnel are dyed dark blue. The stalk and the both supports were stained pale green, the liquid substance above the funnel became pale violet. Spherical body remained colourless.

The objects placed under a cover glass were immediately sealed with aceton lacquer and observed, measured, designed and photographed by means of light microscope.

MORPHOLOGY OF SPERMATOPHORES

The nomenclature of the different parts of the spermatophore was taken from works listed in the bibliography. A new name "funnel" is being used for the newly discovered funnel-shaped body. The funnel has a basal insertion, most often at the circumference of the lateral support, and sometimes it touches the central support at the bottom of the tube-shaped part, so that it can lean upon it for support. Its upper part is enlarged in a funnel-shaped form and meets approximately in the equatorial level with the membrane of the upper hemisphere of the spherical capsule and of its lower hemisphere also, separating them one from an other. The distribution of the individual parts of the spermatophore see in Fig. 1, comparison of shapes and dimensions of spermatophores of the examined species is found in Fig 2 and Tab. 1.

The stalk of the spermatophore is enlarged on its base, which makes it possible to adhere solidly to a larger part of the surface of the substrate; it becomes progressively narrower in the upward direction. Its cross-section is usually triangular with sunken walls and with oblong tops being Y-shaped or T-shaped. Contrary to the sparmatophores of the family *Damaeidae* (Cancela da Fonseca, 1969), the stalk of the spermatophore of the family *Liacaridae* is not bent in any way under the supports of the spherical capsule and does not make here forms discovered

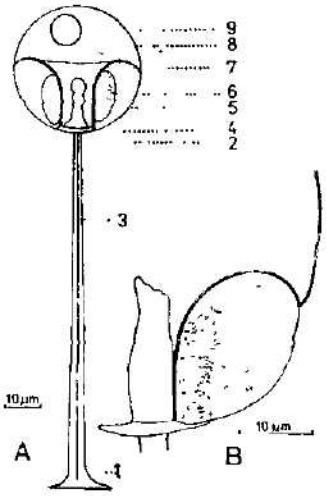

Fig. 1A. Structure of a spermatophore of the family *Liacaridae* (*L. coracinus*). 1 — base of pedicel, 2 — top of pedicel, 3 — rib on the pedicel, 4 — lateral support, 5 — central support, 6 — spermal ring, 7 — funnel, 8 — membrane of the upper hemisphere, 9 — spherical body, 6—9 — spherical capsule.

Fig. 1B. A part of the spherical capsule of spermatophore in *D. moraviacus*.

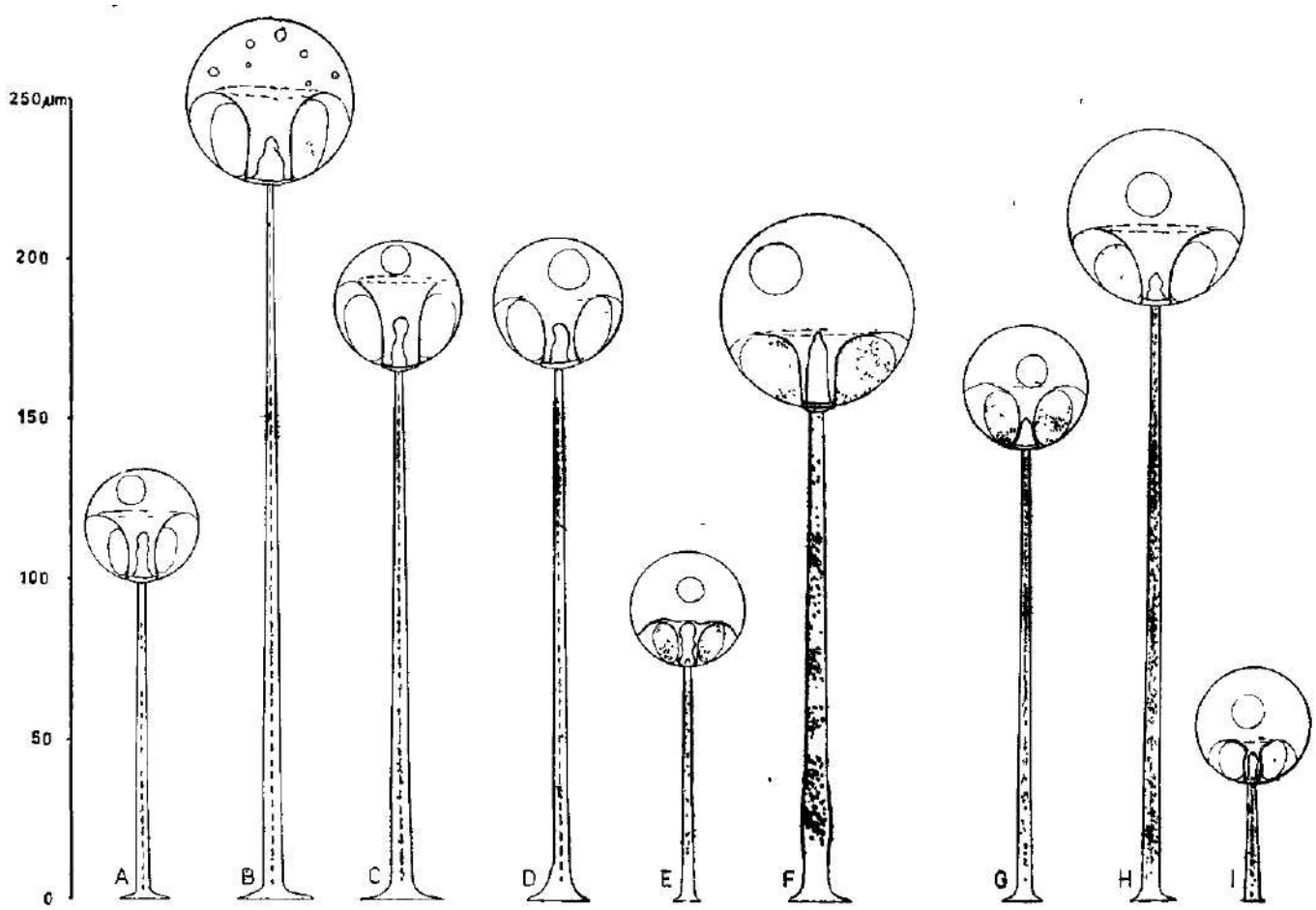

Fig. 2. A comparison of the spermatophores of cultured species of the family *Liacaridae*.
A — *L. coracinus*, B — *L. subterraneus*, C — *L. nitens*, D — *L. xylariae*, E — *D. infissus*, F — *D. moravicus*, G — *X. clypeator*, H — *X. tegeocranus*, I — *A. ovatus*. Partially schematised.

by the same author in *Damaeus quadrihastatus*. Stalks of spermatophores are fragile and easily break when dealt with; this, of course, is their function. They must easily break off from the spherical capsule of the spermatophore, which the female receives into her genital opening. By examination of the remnants of stalks, from which the females took away spherical capsules, their breaking off was established exactly under the lateral support of the spherical capsule.

The length of the stalks depends, in the first place, on the size of the species of Oribatid. Shereef (1972) discovered in other groups of Oribatei that the length of the spermatophore is in correlation with the length of the 1st and 4th pair of legs. The established length of spermatophores of the examined species of the family *Liacaridae* is shown in Tab. 1. But the length of the stalk is not in correlation with the size of the spherical capsule of the spermatophore. Relatively small spherical capsules in relation to the length of the stalks has *L. subterraneus* (index 2 = 4.33), while the shortest stalk in relation to the height of the spherical capsule is found in *A. ovatus* (index 2 = 1.12).

The thickness of the stalk is a quite distinguishing trait. Relatively very thick stalks are in spermatophores of the genera *Dorycranosus* and *Adoristes*, very thin are those of the genus *Liacarus*, as is demonstrated in Tab. 1 and Fig. 2.

The surface of the stalk of the genus *Liacarus* is completely smooth, it appears transparent. In older specimens it may become mat, which is obviously caused by the attached bacterias or algae. The very opposite is the surface of stalks in *D. moraviacus*, which is remarkably covered with rough granulation and is opaque even in the fresh stage. Less striking is the granulated surface of stalks in *D. infissus*, *X. tegeocranus*, *X. clypeator* and *A. ovatus*. The granulation of the surface of stalks does not change, even after the action of lactic acid, in which the stalks do not dissolve. This proves that this granulation is not caused by attached bacterias or algae, which dissolve in lactic acid. The organic substance of the stalk is probably

Table 1 (Part 1). Dimensions of spermatophores

Species	Total length of spermatophore	Length of pedicel	Diameter of pedicel	
			basal	apical
L. coracinus	110.0–144.1	83.8–110.0	4.7–6.5	2.0–2.6
	133.98 ± 4.57	98.36 ± 3.44	5.51 ± 0.19	2.25 ± 0.08
L. subterraneus	260.0–286.3	208.0–296.0	4.8–8.1	2.0–3.1
	276.23 ± 4.46	238.77 ± 7.96	6.00 ± 0.32	1.98 ± 0.22
L. nitens	185.0–230.0	154.6–197.8	5.0–9.2	2.1–2.8
	208.99 ± 6.45	169.62 ± 4.79	6.78 ± 0.48	2.45 ± 0.08
L. xylariae	192.0–250.0	125.0–203.0	3.9–6.7	1.6–2.2
	267.66 ± 6.41	163.95 ± 6.74	5.18 ± 0.18	1.94 ± 0.06
D. infissus	89.0–124.4	52.4–86.4	3.7–6.5	2.1–2.4
	109.71 ± 3.06	73.17 ± 2.67	4.41 ± 0.28	2.20 ± 0.04
D. moraviacus	186.0–244.4	139.0–175.0	6.8–10.4	3.4–5.2
	215.15 ± 8.62	152.97 ± 4.77	8.54 ± 0.38	4.31 ± 0.22
X. clypeator	123.2–209.5	92.0–167.7	4.2–5.3	2.1–2.7
	180.50 ± 7.92	142.61 ± 5.77	5.02 ± 0.09	2.41 ± 0.06
X. tegeocranus	230.4–274.9	178.0–199.1	5.2–8.1	2.2–4.1
	242.00 ± 5.12	185.70 ± 4.08	6.36 ± 0.33	2.89 ± 0.22
A. ovatus	62.9–79.9	34.1–47.1	5.0–6.5	2.4–3.9
	72.84 ± 2.57	38.31 ± 1.58	5.36 ± 0.14	2.91 ± 0.23

chitinous. Stalks are only slightly dyable in alkaline and acidic staining substances. Mostly they remain completely colourless. Legg (1973a) in his histochemical experimentation discovered lipids, polysacharid and proteins in stalks of spermatophores of the pseudoscorpion *Chthonius ischnocheles*. Dates concerning the chemical composition of parts of the spermatophores of *Oribatei* are lacking in literature up to this time.

Lateral and central support of the spherical capsule are not separated between themselves really, nor are they composed of different organic substances. They are inserted in the apical end of the stalk of the spermatophore. Lateral support has the form of a shallow, irregularly bounded plate, in which the base of the spherical capsule is situated. Exceptions are in *D. infissus* and in *A. ovatus*, where the lateral support is reduced into 3 small apophyses (Fig. 10A, 10B). The base of the funnel, sometimes the spermal ring and always the membrane of the lower hemisphere of the spherical capsule, are leaning against the lower part of lateral support. Central support is set very close to the lateral support, usually in its centre, but it can be quite misaligned (Fig. 4D). It fills up the lower part of the funnel, which can hold tightly to it (Fig. 1B). In *A. ovatus* and *D. infissus* the base of the funnel is always leaning against the central support, because the lateral support does not suffice to support it (Fig. 2E, 2I).

Central support of various species of the family *Liacaridae* is of different size and shape (Tab. 1, Fig. 2) so that it can be used as a systematical character. It usually becomes narrower to the top and turns into a rounded area, but in *D. infissus*, contrariwise, it becomes larger on the top and ends with a globular point (Fig. 2E, 6A, 10A). Cross section of the central support is not always circular. It can be triangular or flat; in this case the plane is indented at the edges (Fig. 1B). In *L. nitens* a spirally coiled central support was also found (Fig. 10C). The top of the central support is bent down sometimes (Fig. 9F). A great morphological variability of this figure exists within the family *Liacaridae*.

of examined species of the family *Liacaridae*. (μm)

Spherical capsule		Central support		Lateral support	
height	diameter	height	diameter	height	diameter
26.2–41.9	28.9–47.1	10.5–15.7	2.6–5.2	1.6–2.6	6.5–13.6
35.46 ± 1.29	34.87 ± 2.36	13.22 ± 0.91	3.47 ± 0.27	2.30 ± 0.09	9.93 ± 0.73
49.7–61.0	46.0–65.5	10.5–15.6	5.7–9.3	1.1–2.6	13.1–18.9
55.16 ± 1.78	51.74 ± 2.90	13.67 ± 0.58	7.76 ± 0.26	1.69 ± 0.16	14.65 ± 0.34
33.0–52.0	29.0–57.6	12.8–17.5	3.4–5.4	2.1–4.0	10.5–18.3
43.81 ± 3.46	48.41 ± 3.12	15.25 ± 0.48	4.78 ± 0.22	2.96 ± 0.25	14.51 ± 0.90
33.8–47.0	31.5–46.0	11.0–21.–	3.4–8.1	2.4–5.2	6.7–18.9
41.76 ± 1.39	40.13 ± 1.42	11.34 ± 1.27	5.17 ± 0.43	3.04 ± 0.23	12.92 ± 0.99
28.0–39.3	26.2–39.3	10.5–13.1	3.7–5.2	1.3–2.3	3.4–5.5
35.76 ± 0.90	35.28 ± 1.20	11.48 ± 0.37	4.66 ± 0.20	1.80 ± 0.13	4.81 ± 0.18
47.0–88.4	50.0–78.0	18.0–23.5	5.2–7.8	2.6–2.7	9.2–13.0
60.19 ± 4.25	60.63 ± 3.61	20.91 ± 0.92	6.59 ± 0.29	2.63 ± 0.19	11.02 ± 0.48
23.7–52.0	28.9–47.1	6.0–10.8	2.6–5.2	1.8–2.4	5.4–10.0
38.70 ± 0.33	37.17 ± 1.69	7.50 ± 0.41	3.64 ± 0.31	2.08 ± 0.04	7.66 ± 0.40
49.8–75.9	49.8–73.4	5.4–13.2	3.9–5.6	2.1–2.6	7.8–11.8
56.30 ± 2.09	55.05 ± 2.20	7.42 ± 1.00	4.63 ± 0.27	2.33 ± 0.08	9.43 ± 0.53
23.6–44.5	26.2–42.0	5.2–9.2	2.8–3.8	1.3–2.1	4.9–7.8
34.05 ± 2 50	36.42 ± 2.39	7.60 ± 0.67	3.33 ± 0.15	1.64 ± 0.12	6.08 ± 0.43

Table 1.

Species	Spherical body			Spermal
	number	diameter	height	diameter
L. coracinus	1	6.7—13.1	11.5—14.4	18.3—21.8
		8.36 ± 0.74	12.00 ± 0.85	19.90 ± 1.08
L. subterraneus	5—18	1.0—7.0	20.0—21.3	30.5—42.5
	7	2.10 ± 0.65	20.50 ± 1.40	34.75 ± 2.17
L. nitens	1	7.4—9.0	20.1—28.8	32.0—39.2
		8.68 ± 0.31	23.37 ± 1.36	34.14 ± 2.53
L. xylariae	1	4.1—14.8	15.7—23.5	18.3—36.7
		12.19 ± 0.76	20.10 ± 0.97	32.15 ± 3.10
D. infissus	1	5.3—10.4	10.0—13.1	21.0—23.5
		7.87 ± 0.44	10.38 ± 0.78	22.31 ± 1.55
D. moraviacus	1	5.2—26.0	18.0—20.1	44.5—52.4
		15.92 ± 4.02	19.18 ± 1.83	49.13 ± 3.72
X. clypeator	1	2.4—12.0	13.0—19.5	20.0—34.1
		9.16 ± 1.69	15.60 ± 1.15	26.24 ± 2.05
X. tegeocranus	1	4.0—20.9	13.0—23.5	34.1—42.0
		13.90 ± 3.07	15.65 ± 0.93	39.30 ± 1.80
A. ovatus	1	5.2—14.4	10.5—15.7	21.0—24.0
		10.50 ± 1.06	12.16 ± 0.77	22.23 ± 0.96

The lateral support is usually set at the end of the stalk in a discernible wrinkle. During observation in lactic acid, in which supports do not dissolve, the same as stalks, they seem to form a single morphological unit with the stalk (Fig. 9E—F, 10A—B). But in solutions of some staining matters a different composition of organic substances in stalk and supports is proved, because the stalk remains colourless, while the lateral and the central supports are stained thoroughly. Since they do not dissolve in the lactic acid as the other stainable parts of the spherical capsule of the spermatophore, it is obvious that the supports have a different chemical composition from the stalk and from the remaining parts of the spherical capsule, and, consequently that in the genital organs of male there exists a special gland which is producing them.

Funnel is thin on its top, around the periphery of the spherical capsule, approximately in its equatorial plane, but at the bottom, around the central support, there is quite a thick membrane. At the top it also forms a boundary between the membrane of the upper and lower hemispheres of the spherical capsule of the spermatophore, and often it is contiguous with the membrane of the spermal ring (Fig. 1A—B). It seems, in view of Fig. 1B and 7F that the membrane of the funnel is a continuation of the membrane covering the upper hemisphere of the spherical capsule, and that this funnel-shaped figure has been caused by the pressure of the spermal ring on the lower hemisphere around the central support and by the weight of the contents of the upper hemisphere. The spermal ring is attached to the funnel from the exterior side, so that the funnel separates it from the central support.

The funnel of the spherical capsule is a soft membrane, stainable easily in acid and alkaline substances. It dissolves easily in lactic acid. It is obviously semipermeable, in order to permit the material exchange between sperms accumulated in the spermal ring, and the content of the upper hemisphere of the spherical capsule of the spermatophore. In spermatophores of *D. infissus* 3 strong ribs are discernible,

(Part 2)

ring	Funnel			
thickness	total height	height of tube	upper diameter	lower diameter
6.5—7.9	14.5—31.5	13.0—18.3	27.0—47.1	6.0—10.5
5.98 ± 0.42	22.40 ± 1.27	14.50 ± 1.36	34.45 ± 3.18	8.20 ± 0.22
10.4—18.5	31.4—31.5	20.0—21.0	40.0—60.2	10.5—21.0
12.26 ± 0.74	31.50 ± 0.16	20.73 ± 0.26	48.22 ± 2.76	15.21 ± 0.53
10.5—15.0	23.5—31.4	13.2—23.6	34.0—37.0	10.5—13.2
11.16 ± 0.51	30.11 ± 0.35	20.67 ± 0.98	35.17 ± 2.93	11.40 ± 0.31
7.9—13.1	18.3—20.9	8.0—19.5	28.8—31.5	6.3—10.5
10.56 ± 0.83	20.44 ± 0.64	11.96 ± 1.16	29.51 ± 1.69	8.15 ± 0.15
5.8—8.00	12.0—15.6	8.2—11.5	23.5—28.9	5.0— 7.9
7.80 ± 0.21	12.92 ± 0.77	11.10 ± 0.37	24.80 ± 1.37	7.52 ± 0.30
10.0—18.3	15.3—31.5	15.3—21.3	52.0—55.0	9.2—13,1
17.71 ± 0.39	21.16 ± 1.19	16.87 ± 0.94	53.12 ± 1.81	11.20 ± 0.41
11.2—15.3	21.0—22.9	12.0—18.6	21.2—35.3	5.5—11.0
11.34 ± 0.56	21.85 ± 0.71	15.10 ± 0.79	26.40 ± 2.30	7.80 ± 0.26
10.5—15.7	18.0—26.2	10.5—19.5	34.0—54.0	7.9—11.6
13.30 ± 0.71	23.40 ± 1.28	15.26 ± 0.87	42.61 ± 2.17	8.37 ± 0.47
6.5—9.1	11.0—18.0	10.5—13.1	23.5—29.0	5.2—8.0
7.80 ± 0.24	13.56 ± 1.04	10.81 ± 1.15	26.40 ± 1.82	6.42 ± 1.15

which ramify from the top of the central support and are stiftening the funnel (Fig. 5E—F). In spermatophores of *D. infissus* the top of the central support is always surrounded by a thick substance, out of which the above mentioned ribs proceed as its part (Fig. 2E, 5E—F, 6A). Similar thickness of the membrane of the upper part of the funnel, noticed in a spermatophore of *L. coracinus* stained in ink (Fig. 3A), is not connected with the central support, which always remains free on the top. In other specimens of *L. coracinus* the membrane of the funnel appears thin even under the same kind of staining.

Spermal ring forms a substantial part of the lower hemisphere of the spherical capsule. It is completely enclosed in the capsule. In some cases it spoils the regular spherical outline of the capsule of the spermatophore (Fig. 7F). It is a deformation caused generally when fixing the slide.

Formation of sperms is always of the packet type (Woodring and Cook, 1962). The sperms are generally accumulated in small packets of spheroid or ovoid shape (Fig. 6A) which form together 3 spermal bags (Fig. 7B, 8E), disposed around the base of the funnel into a contiguous spermal ring. Spermal bags are covered with a very thin, almost indiscernible membrane, which is holding the accumulated spermal bags together (Fig. 6C, 7F). It is impossible to find out whether they contain, immediately after laying of spermatophores, already mature spermatozoids or still spermatids. But the shape of sperm does not change even in older spermatophores. Woodring and Cook (1962a) were also unable to solve this problem with the sperms of *Ceratozetes cisalpinus*. In addition to the sperms, spermal bag contain also dark, small, round bodies (Fig. 4B, 4F, 5C, 6B, 6F, 7D, 8B). They are obviously the remainders of cells nourishing maturing sperms.

The shape of sperms is thread-like (*L. coracinus, L. subterraneus, L. nitens, D. infissus*), long spindle-shaped (*L. xylariae*), long cylindrical with oblong tips (*X. clypeator*), short cylindrical with oblong tips (*X. tegeocranus, D. moraviacus*), and ir-

Table 1. (Part 3)

Species	Sperms number	Sperms size	Index 1	Index 2
L. coracinus	28 – 61	24.8 – 36.7 × 0.3 – 0.4	4.20 – 3.44 3.78	3.20 – 2.62 2.77
L. subterraneus	240 – 260	10.5 – 15.7 × 0.5 – 0.7	5.23 – 4.69 5.00	4.85 – 4.18 4.33
L. nitens	250 – 260	7.0 – 10.0 × 0.2 – 0.3	5.60 – 4.42 4.77	3.80 – 4.68 3.87
L. xylariae	180 – 210	8.1 – 14.0 × 0.6 – 1.0	5.68 – 4.17 4.97	4.32 – 3.70 3.93
D. inflessus	104 – 210	8.0 – 18.0 × 0.5 – 0.6	3.18 – 2.43 3.07	2.20 – 1.87 2.05
D. moraviacus	266	6.0 – 8.3 × 0.5 – 0.8	3.96 – 2.76 3.57	1.98 – 2.96 2.54
X. clypeator	230 – 352	3.9 – 5.2 × 0.6 – 1.1	5.24 – 4.02 4.66	3.91 – 2.95 3.68
X. tegeocranus	170 – 230	13.0 – 15.0 × 1.2 – 1.3	4.63 – 3.62 4.30	3.57 – 2.62 3.30
A. ovatus	238	1.0 – 1.4 × 1.0 – 1.4	2.66 – 1.80 2.14	1.44 – 1.06 1.12

Explanatory notes
upper line = marginal dimensions, i.e. minimum and maximum dimension;
lower line = mean dimension ± mean-root – square error;
index 1 = total length of spermatophore/height of sphaerical capsule;
index 2 = height of pedicel/height of sphaerical capsule.
10 – 19 individuals measured of each species

regular spheroid (*A. ovatus*), as is shown in Fig. 3D, 4B, 4F, 5D, 6B, 6F, 7D, 8B, 8F. It is possible to use different shape and size of sperms (Tab. 1) for the classification of species within the family *Liacaridae*.

Inside the sperm an S-shaped up to a spirally winding, prolonged fibre, of a very dark colour, is often perceptible (even without staining) (Fig. 5D, 6F, 7D, 8B). Similar structure of sperms was found by means of an electronic microscope by White and Storch (1973) on a thrombidiform mite *Abrolophus rubipes*. They found out that the sperm of this species had a dark, thread-like nucleus surrounded with the agglomerates of mitochondrions, and peripheral sections filled with smoothly walled reservoirs. Sperms of the family *Liacaridae* have also probably a dark thread-like nucleus.

Spermal bags are fixed at the tube of the funnel and often they do not reach up to its top, nor to the lateral support, and they do not fill the whole volume of the lower hemisphere with the exception of the space of the funnel. Thus the space between the membrane covering the lower hemisphere and the outside periphere of the spermal ring also remains free (Fig.1A, 2A—I, 3A, 6D). But in many cases spermal ring fills the whole of this space (Fig. 1B, 4D, 5A, 6C—D, 7F). Dimensions of the examined spermal rings are indicated in Table 1.

Spermal ring and sperms themselves dye well in all used staining substances Sperms stain best in boraxcarmine, slightly in methylene-green. The thin membrane of the lower hemisphere also can be stained well. This thin membrane merges with the lateral support of the spherical capsule and with a thicker membrane covering

the upper hemisphere of the spherical capsule at the point of contact with the exterior edge of the funnel. The thinness of the membrane of the lower hemisphere and its very little mechanical strength very often cause — during handling — a rupture of the spherical capsule of the spermatophore, and spermal bags as well as sperms are released. This, however, is due to the physiology of fertilization.

Spherical body is an approximately spherical figure floating in the liquid substance of the upper hemisphere of the spherical capsule. The dimensions of the observed categories of spermatophores are indicated in Table 1, but these dimensions are rather variable. In the spermatophores of *L. subterraneus* it is usually divided into several small bodies.

It is obviously a gas bubble, as in some spermatophores, divided into two parts by handling, it did not mix with the liquid substance of the upper hemisphere of the spherical capsule, or with the slide mounting medium. However, it is neither a product of material exchange of the spermatophore, since it is regularly found in the freshly laid spermatophores, nor does it grow with the age of the spermatophore. Its composition and significance are still unknown. It stains slightly in methylene-blue.

Upper hemisphere of spherical capsule of spermatospore is filled with a liquid substance, in which the spherical body and small granules are floating. A thin membrane covers the surface of the upper hemisphere. It is not yet known whether it originates independently or by hardening of the surface of the drop of the liquid substance. This membrane is very sticky on the surface. Whenever it touched the glass wall of the cultivating dish while I was trying to separate the spermatophore from the substrate, the spherical capsule of the spermatophore always stuck to the glass, and broke when I tried to separate it. That is why foreign bodies easily stick to the spherical capsule, for example fungal spores, and grow into the capsule as a hypha (Fig. 3C). Inside of the capsule there is favourable environment for hypha's development. A new hypha uses the content of the spherical capsule as a nutrition substrate and develops quickly into thick or ray-shaped mycelium. Spermatophores thus attacked appear like a stalked *Heliozoa*, conidiophore or a spermatophore of a different animal group (Fig. 10E—F).

The unstained spherical capsules of spermatophores of the family *Liacaridae* are almost transparent in the upper hemisphere in the freshly laid spermatophores. Later on they are whitish, almost opaque and have a smooth surface. The membrane covering the upper hemisphere stains well in all the staining substances used, with the exception of methylene-green and methylene-blue. The liquid substance inside the upper hemisphere is also stained, but not as intensively as the membrane of its surface. This liquid substance serves as environment obviously enabling the material exchange of sperms, and probably contains also pheromones. The pheromones prevent the spherical capsule from being picked up by a female of another species.

Morphological differences of spermatophores of examined species of the family Liacaridae are shown in the enclosed pictures, especially in Fig. 2, which is partially schematished, and also in the indications in Table 1. Some of the more expressive characteristics were, for the purpose of determination, arranged synoptically in Table 2. This helps to follow the distinctions among the spermatophores of examined species of the family *Liacaridae*.

Table 2. Differential characters of the spermatophores of some *Liacaridae* species

Species	Index 2	Character of pedical	Number of spher. bodies	Lateral support	Central support	Shape of the funnel	Shape of sperms
L. coracinus	oca 3 : 1	smooth, medium slender 95—110 µm	1	saucer-shaped, medium wide, a little arched up	high, slender, reaches to 3/4 height of funnel, gradual passage into lateral support	rather high, medially arched	thread-like, straight
L. subterraneus	oca 4 : 1	smooth, very slender 200—300 µm	5—18	saucer-shaped, very wide, a little arched up	low, thick, reaches to 1/3—1/2 height of funnel, gradual passage into lateral support	rather high, medially arched	long, stick-shaped, many times curved
L. nitens	oca 4 : 1	smooth, medium slender 150—200 µm	1	saucer-shaped, medium wide, very arched up, also irregularly jagged	high, slender, reaches to 1/2 height of funnel, sharp passage into lateral support	high, a little arched	thread-like, straight
L. xylariae	oca 4 : 1	smooth, medium slender 125—210 µm	1	saucer-shaped, medium wide, a little arched up	rather high, reaches to 1/2—3/4 height of funnel, gradual passage into lateral support	rather high, medially arched	long, spindle-shaped
D. infissus	oca 2 : 1	slightly granulated or rugged, medium slender 50—90 µm	1	not distinct, 3 bits only, not overlapping the width of centr. support above	high, almost to the top of the funnel, coated with a mass protruding into 3 protuberances	rather low, medially arched, contiguous to central support	long, almost thread like, a little curved
D. moravicus	oca 3,5 : 1	distinctly rugged or granulated, rather thick 140—170 µm	1	only a narrow border, slightly overlapping the width of central support	high, almost to the top of the funnel, thick	rather low, flat arched, almost straight	short, stick-shaped, with rounded ends

Table 2. Continue

X. clypeator	cca 3,5 : 1	slightly granulated, medium slender 90 – 170 μm	1	saucer-shaped, narrow, only a little overlapping the base of central sup., a little arched	low, reaches to 1/2 height of the funnel, thick on the base, slender on its top, gradual passage into lateral support	medium high, medially arched	short, stick-shaped, with rounded ends
X. tegocranus	cca 4 : 1	slightly granulated, medium slender 180 – 200 μm	1	saucer-shaped, narrow, only a little overlapping the base of central sup., a little arched	low, reaches to 1/2 height of the funnel, thick on the base, slender on its top, sharp passage into lateral support	medium high, very arched	long, stick-shaped, with rounded ends
A. ovatus	cca 1 : 1	slightly or medium granulated, thick 35 – 50 μm	1	not distinct, 3 small bits only	rather high, reaches to 3/4 height of the funnel, medium thick, its top globular, gradual passage into lateral support	rather low, under the extension narrowed and again extended, contiguous to lateral support laterally	irregular globules

Explanatory note
Index 2 = height of pedicel / height of spherical capsule

Some males of *L. subterraneus* lay spermatophores immediately after being taken from the collecting containers under Tullgren funnels, as soon as they come into an environment with higher humidity, sometimes even several within a few minutes. Other cultured species start to lay them in the culturing dishes only, on the 7th up to the 9th day generally. The same after the hatching of the male from the tritonymph

All examined species lay spermatophores on places most frequented by adult mites, especially in the proximity of food, and preferably on a smooth substrate This condition is best fulfilled by the smooth walls of the culturing Petri-dishes, where the majority of spermatophores have been found. But no spermatophore has been found on the cover of a dish, although adults are often dwelling there. It is therefore surprising that in quite frequent cases, some spermatophores found on pieces of semi-decayed wood are laid almost vertically, and the spherical capsule is hanging down from the stalk fixed at the top. Their normal direction is upwards from the surface to which they are attached.

The agglomerations of spermatophores are also very often laid on the plaster--charcoal substrate, near the food (*Pleurococcus* sp.) mostly, and near semi-decayed wood on which adults are living. They lay spermatophores on this wood in the same measure as on the plaster-charcoal substrate. Most spermatophores are laid on the surface of the wood, but they are often laid also into holes and fissures. Less frequently adults lay the spermatophores on the surface of semi-decayed treeleaves. Very few have been found on Pleurococcus, which the adult mites are eating. Only in individual cases the spermatophores are laid on other small objects in culturing dishes.

X. clypeator laid spermatophores, in addition to the above mentioned places, on notogasters of other adult individuals, one to two pieces, *X. tegeocranus* only exceptionally.

X. clypeator laid 56 spermatophores, out of which 34 were laid on notogasters of other individuals, in one day. This is caused by the fact that they are crawling one over the other, if they are too many in the culturing cell. *A. ovatus* lays his spermatophores on the upper part of the wall of a dish, almost exclusively just under the cover. Spermatophores of this species are only exceptionally found elsewhere.

I did not observe in detail the process of the laying of spermatophores. 4 adult mites of *L. subterraneus*, taken out of an almost dry collecting dish under Tullgren funnel and put into a humid dish with a plaster substrate and with glass cover, laid 7 spermatophores on the plaster substrate within 3 minutes, while I was taking out some mites from another collecting dish. Therefore I did not notice whether they lifted up the posterior part of their bodies, as it is described by Pauly (1956) regarding *Belba geniculosa*. He distinguishes 7 phases during the laying of spermatophores and adds that the laying of spermatophores by *Liacarus tremellae* (= *L. subterraneus*) is analogous with the laying of spermatophores of *Belba geniculosa*. The fact that mites cultured in darkness were disturbed by handling and illumination during observation was obviously the reason, why I was unable to observe the process of the laying of spermatophores later on.

According to my observations, the male of cultured species of the family *Liacaridae* lays his spermatophores on the above mentioned places either individually or in agglomerations of three up to six, rarely up to 18 pieces in one lot, within

short intervals of time. 4 males of *L. subterraneus* laid 63 spermatophores in one day. The supposition that they lay spermatophores in aggregations within a short time is proved by fact that these agglomerations of spermatophores were found in contiguous straight or curved rows, one after another. Distances among the spermatophores in one row are usually regular, most often about 3 lengths, minimaly 2 lengths of spermatophores. Sometimes these distances are longer, 1—2 mm. Therefore, the male must advance and leave the laid spermatophores behind him. The shape of the row is influenced by the shape of the substrate on which the male is laying them. For example, straight rows of spermatophores are found on the pine needles, because the male can advance along its length only. The rows of spermatophores on a glass wall, on the plaster substrate or on the semi-decayed wood are often curved archwise or spirally, because the male can change his direction.

If the row of spermatophores was spirally curved, or the agglomeration of spermatophores was composed of two or more rows, the distance between the adjacent rows was equal to the width of the body of an adult mite at least, or larger.

The laying of spermatophores by *L. subterraneus* and *D. moraviacus* was observed even in the absence of females. As for the other cultured species this possibility remains a conjecture.

The laying of spermatophores is conditioned by a high relative humidity of air, as has been proved by the immediate laying of spermatophores of *L. subterraneus* after their transfer into a humid vessel. Optimum relative humidity of air for laying is about 80—90%. At the humidity of approximately 60% the males of cultured species have already stopped the laying of spermatophores, with the exception of *X. clypeator* and *X. tegeocranus*. Their resistence to a lower relative humidity is probably in harmony with their arboricolous style of life. In a dry environment spermatophores suffer from drying out of the content of spherical capsules. Their capsules are shrinking and they are not accepted by females. In the case of the relative humidity of about 60% this happens even in the course of one day.

Picking up of spermatophores by females was not directly observed either, but all spherical capsules were never picked up from the agglomeration of laid spermatophores. For example only 5 spherical capsules were picked up from the agglomeration of 7 spermatophores in *D. infissus*, in *X. clypeator* 6 from 11, in *A. ovatus* 6 from 11. It certainly depends on the number of females, but because of the undeveloped genital dimorphism it was impossible to establish their number and the number of males in the culture. It could be done only after they perished and were subsequently dissected or cleared and depigmentated at least. It was also proved that females do not pick up spherical capsules from spermatophores older than 3 days. After that time spherical capsules change their colour into milky opaque and are often shrinking, if there is drier environment in the culturing dish. At a higher humidity of air spherical capsules are often attacked by fungal spores or by air-mycelium from the fungi growing on the substrates in culturing dishes. When the spherical capsule is picked up by the female, it breaks off from the stalk immediately under the lateral support, as it could be seen on the stalks left after the capsule was picked up.

Males and females of *L. coracinus*, *L. subterraneus* and *L. nitens* eat the whole spermatophores including stalks in the culture. The same has not been proved in the other cultured species, but is not excluded. The same phenomenon was observed in *Belba geniculosa* by Pauly (1956) and in *Scheloribates parabilis* by Woodring (1965).

Spermatophores are eaten by a collembol *Onychiurus armatus* also, as observed in one of the culturing dish with *L. coracinus*. Collembols got into the culturing dish with the food for mites by chance. Old remaining spermatophores are usually destroyed by moulds. Some spermatophores are individually destroyed even by oribatids, when they are not moving carefully enough.

DISCUSSION

Stalks of spermatophores of the family *Liacaridae* differ from stalks of the family *Damaeidae* (Taberly, 1957; Cancela da Fonseca, 1969; Shereef, 1972) and *Belbidae* (Pauly, 1952, 1956; Shereef, 1972) in that they are not bent under the spherical capsule, as it was already shown by Taberly (1957) in his drawings of the spermatophores of *L. coracinus*, *L. subterraneus* and *X. tegeocranus*. Straight stalks appear also in the representatives of families *Oppiidae* (Shereef, 1972), *Ceratozetidae* (Taberly, 1957; Woodring and Cook, 1962a, b; Rockett and Woodring, 1966), *Haplozetidae* (Shereef, 1972), *Hermanniidae* (Taberly, 1957; Bäumler, 1970), *Galumnidae* (Woodring, 1965; Rockett and Woodring, 1966), *Oribatulidae* (Woodring, 1965), *Euzetidae* (Taberly, 1957).

In all spermatophores which were described and depicted up to now, the base of the stalk fixed to the substrate is irregularly extended and their cross-section is also probably triangular with hollowed walls (i.e. Y-shaped or T-shaped), which is the most advantageous shape from the point of view of firmness and material economy for a required height of stalk. Woodring and Cook (1962b) say that this cross-section is determined by the pressure of a still liquid material through penial sclerites.

The surface of the stalk was depicted by Cancela da Fonseca (1969) in *Damaeus quadrihastatus* as covered with soft short hair. In the genus *Liacarus* the surface of the stalk is smooth, in the genera *Dorycranosus*, *Adoristes* and *Xenillus* it is slightly to noticeably granulated or tuberculous. Particles of the substrate are often attached to the surface of the stalk, as they stuck to the matter of the stalk during the laying of spermatophore before it became rigid (Fig. 3F, 4C).

The height of the stalk and of the whole spermatophore is in correlation with the size of the species of the mite. Shereef (1972) indicated that it is in correlation with the length of the 1st and 4th pairs of legs. He is obviously influenced by the drawings of Pauly (1952, 1956), who had depicted *Belba* sp. with an uplifted hysterosoma and with raised legs of the 4th pair. Pauly (1956) says that an analogous way of laying spermatophores as in *Belba* sp. he also observed in oribatids with short legs, such as *Liacarus tremellae* and *Euzetes seminulum*. Bäumler (1970) made similar observation in *Hermannia gibba*.

The thickness of the stalk is also very characteristic of the individual species of the family *Liacaridae*. There are only a few indications in the literature regarding the thickness of the stalk, but without any comparison.

Central and lateral supports (Woodring and Cook, 1962b) were earlier called by a collective name columella by Pauly (1956). The shape and size of the central and lateral support of the spherical capsule is, in fact, very variable within the family *Liacaridae*, but it is different among other cultured species of this family and can be used for distinction of their spermatophores. Schematic drawings of the shapes of columella of some oribatids were presented by Taberly (1957) and after him by other above mentioned authors.

The size of spherical capsule is not in correlation with the size of the species of

mite. Small species have relatively large capsules on low stalks. In the family *Liacaridae* this is confirmed by the facts collected in Table 1 (index 1 and 2). Rockett and Woodring (1966) depicted a spermatophore of *Pergalumna omniphagous* within the frame of the description of a new species having an average length of 0.58 mm. Its spermatophore has the spherical capsule as high as the stalk, and relatively large. Similarly Shereef (1972) depicted a spermatophore of *Oppia concolor* with a relatively large spherical capsule on a short stalk.

The former authors described and depicted the cluster of sperms almost as a spherical or hemispherical formation, filling up almost the whole volume of the spherical capsule of the spermatophore (Woodring and Cook, 1962a) or a substantial part of spherical capsule from the bottom (Pauly, 1956; Bäumler, 1970), or they did not depict them at all. Shereef (1972) depicted spermal ring in the lower hemisphere of the spherical capsule of various oribatids, a funnel around the central support and its connection with the membrane of the upper and lower hemisphere, although he did not describe them. He also indicated the spherical body. The structure of the spherical body of the spermatophore of the family *Liacaridae* is, in the main aspects, identical with the structure of the spherical capsule of spermatophores of other groups described by Shereef (1972). But it does not exclude the possibility that the thread-like outgrowths, standing up radially from the surface of the spherical capsule of *Granuloppia* sp., are outgrowths of a parasitic fungus which has attacked the spherical capsule. Shereef (1972) depicted this spermatophore and called these outgrowths setules. Similar attacks of parasitic fungi were not rare in my cultures (Fig. 10E—F). Moreover a conidiophore of a fungus might also be mistaken for a spermatophore (Fig. 10D).

According to Pauly (1956), the shape of sperm was depicted for the first time by Michael (1884) in *Belba geniculosa*. Michael indicated that it is stick-shaped, 2.5 μm long. Pauly (1956) confirms Michael's observation in *Belba geniculosa*, *B. gracilipes* and *B. clavipes*. Woodring and Cook (1962a) depicted sperms of *Ceratozetes cisalpinus* as shortly cylindrical, rounded, with a spherical dark nucleus. Similar shortly cylindrical shape of sperms were indicated by Shereef (1972) for representatives of various families. He also indicated their size: length 0.8—3.0 μm, diameter 0.5—1.8 μm.

A quite different shape of sperms can be found in the examined species of the family *Liacaridae*. It is almost spherical in *A. ovatus*, short- or long-cylindrical with rounded tips (stick-shaped) in *D. moraviacus*, *X. clypeator* and *X. tegeocranus*. In *L. xylariae* it is long spindle-shaped, while in other species of the genus *Liacarus* and in *D. infissus* it is thread-like. There is an S-shaped up to spirally coiled very dark fibre, lying lengthwise in the cylindrical and spindle-shaped sperms. This fibre is discernible even without staining.

Similar interior structure of sperms were discovered by Witte and Storch (1973) in a thrombidiform mite *Abrolophus rufipes*. They found out, by means of an electronic microscope that its spindle-shaped spermatozoa possess a dark, thread--like nucleus which is surrounded by clusters of mitochondrions (crista type), and filled out with smooth-walled cisterns in the periphery. The spermatozoa produced are covered with one of the three secretory products. Woodring and Cook (1962a) were unable to distinguish in sperms of *Ceratozetes cisalpinus* if they are spermatozoids or spermatids, because the metaphase plate appeared as a dark line under oil immersion. The same problem persists in sperms of the family *Liacaridae* which I observed under the same conditions.

Different shapes of sperms exist also in various subfamilies of the family *Bdellidae*: spherical, ovoid up to stick-shaped, as indicated by Alberti (1974). Dark coiled fibres inside the sperms of various shapes are also noticeable in various *Pseudoscorpions* (Legg, 1973b). No tail was found on any spermatozoid of oribatid mites, but sperms of the mite *Ornithodorus moubata* (*Ixodidae*) have tails, as described thoroughly by Breucker and Horstmann (1968).

Preference of smooth places for the laying of spermatophores was proved by various authors mentioned above also for other groups of oribatid mites, but up to present the laying of spermatophores on notogasters of other individuals, which I observed in *X. clypeator* and, to a lesser degree, in *X. tegeocranus*, has been not mentioned in the literature.

Presence of females in the culturing dish is not necessary for the laying of spermatophores within the family *Liacaridae*. The same fact was found by Cancela da Fonseca (1975) in *Damaeus verticillipes*. Shereef (1972) established that males of *Spatiodamaeus subverticillipes* did not lay spermatophores in the absence of females, while in other 15 species cultured by him, the presence of females was not a required condition. Woodring and Cook (1962b) pointed out that the presence of females stimulates males to a higher productivity of spermatophores.

The picking up of spermatophores by females is obviously directed with pheromones. The size and surface of the spherical capsule of spermatophores is not so different in various groups of oribatid mites to be a leading factor in itself. Legg (1973a) considers to be the source of pheromone attracting females of the pseudoscorpion *Chthonius ischnocheles* a drop of liquid substance hanging in the middle of the stalk of spermatophore. Alberti (1974) admits this possibility in the family *Bdellidae* (Thrombidiformes), in which also the presence of females is not necessary for the laying of spermatophores. In oribatids the source of pheromones could be the liquid substance in the upper hemisphere, or possibly its membrane alone.

Woodring and Cook (1962b) indicate that females pick up only the most freshly laid spermatophores, no more than one hour old. In culturing dishes with *L. coracinus* older spherical capsules were picked up by females, maximally three days old. The possibility of preserving fertility of spermatophores depends to a great extent on the environment in which they are laid. In a dry environment they are quickly drying out and they are loosing the power of appeal for females. The above mentioned authors say that at the 50% relative humidity of air the spherical capsule shrinks in one day. At the high relative humidity of the air (i.e. 90—100%), which is most favourable for expansion of fungi, spherical capsules are soon attacked by bacteria and fungi.

Eating of spermatophores by males and females of *L. coracinus*, *L. subterraneus* and *L. nitens* in my observations is confirmed by previous observations of Pauly (1956) in the genus *Belba*, and Woodring (1965) in *Scheloribates parabilis*.

CONCLUSION

The present work studies the morphology and biology of the laying of spermatophores of 9 species from 4 genera of the family *Liacaridae*. During the experimentation morphological differences of spermatophores and sperms of examined species of oribatids have been identified and a determinative table arranged. Previous findings by other authors were confirmed, namely that of the length of the spermatophore is in correlation with the size of the species of the mite. It has been established that the size of the spherical capsule of the spermatophore is not in

correlation with the size of the mite. In small species spherical capsules are relatively larger than in large species of mites, and they are attached to very short stalks.

Biological differences in the laying of spermatophores of the examined species are not considerable. Females pick up only freshly laid spermatophores, maximally 3 days old. It has been proved that laying of spermatophores is done in the absence of females in 2 species, in others this phenomenon is possible. Laid spermatophores were eaten by both males and females of 3 species, and this is not excluded within the other species. Included is also information about the destruction of spermatophores by other organisms. The laying of spermatophores on notogasters of other individuals in the culture is described for the first time.

REFERENCES

Alberti, G., 1974: Fortpflanzungsverhalten und Fortpflanzungsorgane der Schnabelmilben (Acarina : Bdellidae, Trombidiformes). *Ztschr. Morph. Tiere*, 78 : 111—157.

Bäumler, W., 1970: Morphologie, Biologie und Ökologie von Hermannia gibba (C. L. Koch) (Acarina : Oribatei) unter Berucksichtigung einiger Begleitarten. Teil I. *Ztschr. Angew. Entomol.*, 66 : 257—277.

Breucker, H., Horstmann, E., 1968: Die Spermatozoen der Zecke Ornithodorus moubata (Murr). *Ztschr. Zellforsch.*, 88 : 1—22.

Cancela da Fonseca, J. P., 1969: Le spermatophore de Damaeus quadrihastatus Märkel et Meyer (Acarien, Oribatei). Proc. 2nd Int. Congr. Acarology, 1967, Budapest 1969, 227—232.

Cancela da Fonseca, J. P., 1975: Notes oribatologiques. *Acarologia*, 17 : 320—330.

Hampl, B., Šilhanová, L., 1957: Klíč k určování technicky důležitých plísní. Praha, SNTL, 130 pp.

Legg, G., 1973a: Spermatophore formation in the pseudoscorpion Chthonius ischnocheles (Chthoniidae). *J. Zool.*, 170 : 367—394.

Legg, G., 1973b: The structure of encysted sperm of some British Pseudoscorpiones (Arachnida). *J. Zool.*, 170 : 429—440.

Litvinov, M. A., 1967: Opredelitel mikroskopitcheskich potchvennych gribov. Leningrad, Nauka, 304 pp.

Pauly, F., 1952: Die „Copula" der Oribatiden (Moosmilben). *Naturwiss.*, 39 : 572—573.

Pauly, F., 1956: Zur Biologie einiger Belbiden (Oribatei, Moosmilben) und zur Funktion ihrer pseudostigmatischen Organe. *Zool. Jb., Abt. 3*, 84 : 275—328.

Rockett, C. L., Woodring, J. P., 1966: Biological investigations on a new species of Ceratozetes and of Pergalumna (Acarina : Cryptostigmata). *Acarologia*, 8 : 511—520.

Shereef, G. M., 1972: Observations on oribatid mites in laboratory cultures. *Acarologia*, 14 : 281—291.

Taberly, G., 1957: Observations sur les spermatophores et leur transfert chez les Oribates (Acariens). *Bull. Soc. Zool. Fr.*, 82 : 130—145.

Witte, H., Storch, V., 1973: Licht- und Elektronenmikroskopische Untersuchungen an Hodensekreten und Spermien der Trombidiformen Milbe Abrolophus rubipes (Trouessart, 1888). *Acarologia*, 15 : 441—450.

Woodring, J. P., Cook, E. F., 1962a: The internal anatomy, Reproduction, Physiology and Molting Process of Ceratozetes cisalpinus (Acarina — Oribatei). *Ann. Ent. Soc. Amer.*, 55 : 164—181.

Woodring, J. P., Cook, E. F., 1962b: The biology of Ceratozetes cisalpinus Berlese, Scheloribates laevigatus Koch, and Oppia neerlandica Oudemans (Oribatei), with a description of all stages. *Acarologia*, 4 : 101—137.

Woodring, J. P., 1965: The biology of five new species of Oribatids from Louisiana. *Acarologia*, 7 : 564—576.

The figures 3—10 will be found at the end of this issue.

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Griffin, D. R.: **The Question of Animal Awareness.** The Rockefeller University Press, New York; 1976, 2nd edition 1977; pp. 135; price 8.95 US Dollars; ISBN 87470-020-5.

Professor in ethology at The Rockefeller University, Donald R. Griffin, is known as an authority whose investigations are concentrated especially on questions of the nature of animal orientation and communication. Many pioneer works are associated with his name; they have ranged from hearing of fish to migration of birds. However most famous is Dr. Griffin for his extensive work on the orientation of bats. He is the author of the modern conception of echolocation and that was he who coined this very term. In addition to many scientific papers, Dr. Griffin is the author of five books, two of which: Listening In The Dark and Bird Migration were awarded high prizes of The National Academy of Sciences. The fifth in the sequence, the last so far Griffin's book: The Question of Animal Awareness has already achieved in a period of only one year its second edition and the acceptance of it indicates that it has no debt to the value of previous author's books.

In this little book, the author goes in for the questions of animal communication, he reviews and takes a closer look at methods and results of contemporary research in this branch of ethology and physiology. The book is charged with verbatim quotations of many authors. Thanks to this fact the reader may draw his own first-hand conclusion which would not be distorted by interpretation of the intermediary — Dr. Griffin.

At the best analysed examples — the using of the sign language in trained chimpanzees and the symbolic communication by honeybees, professor Griffin shows and describes in details the versatility, complexity, and also the, to a certain extent, symbolism of the communicative behaviour of animals. He concludes that these as well as other communicative systems hold many basic properties of human language though in a much simpler form. In the same time he asks many fundamental questions and tries to find an answer upon them. Is it language that sets man apart from other animals? Are the animals capable of conscious behaviour, have they mental images? The author states that all the available evidences indicate that there cannot be any large dichotomy between the human language and animal communication however more likely there are large quantitative differences – namely in complexity of signals and in range of intentions.

Having confronted assertions of various authors, some of whom assume human thinking to be inseparably connected or even identical with the language while others e. g. strict behaviourists suppose mental experiences to be identical with neurophysiological processes, and having analysed the results of many ethological experiments, Griffin concluded that there must be qualitative evolutionary continuity (though no identity) of mental experiences among the Metazoa. Hence it seems to be conceited to assert that the mental experiences are a unique atribute of a single species — Man. The author asks in the same time why scientists do shy away from the concept of continuity in animal mental experiences, if they accept biological evolution in animals?

The book is not illustrated. It is completed with an extensive bibliography and indexes. It is excellently written. I suppose that the author may be rightly called — because of his rich English — as Shakespeare of scientific style.

This little nevertheless exciting and interesting book may be recommended to zoologists especially to ethologists, evolutionists as well as to psychologists and philosophers.

H. Burda

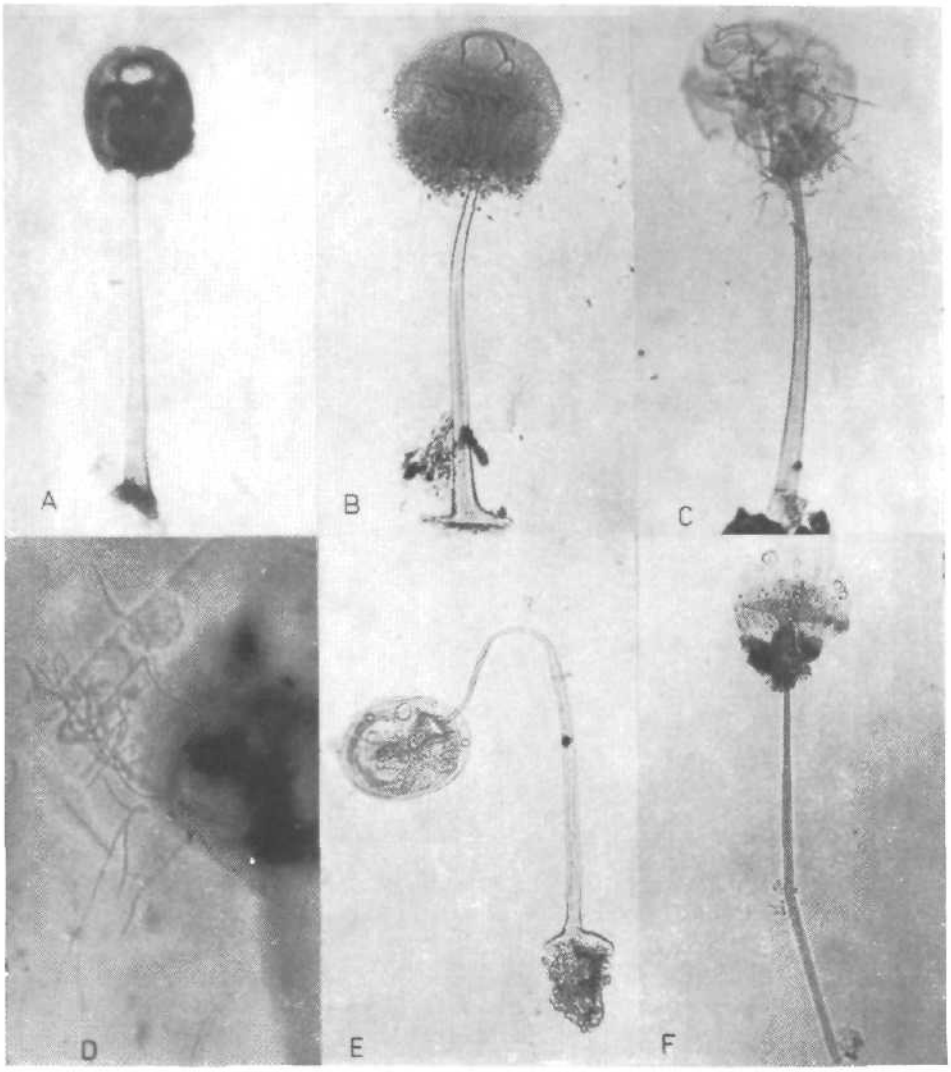

Fig. 3A—D. Spermatophores of *Liacarus coracinus*. A — Total length 122.1 μm. Overstained with boraxcarmine. B — Total view. Total length 186 μm. Internal structure of the spherical capsule. Boraxcarmine. C — Total view. Total length 144.1 μm. Damaged spherical capsule. In the middle articulated fungal hypha, in the bottom thread-like sperms. Boraxcarmine. D — Thread-like sperms. Size 28.8—36.7 × 0.3—0.4 μm. Boraxcarmine.
Fig. 3E—F. Spermatophores of *Liacarus subterraneus*. E — Total view, the stalk is bend. Diameter of spherical capsule 44 μm, its height 55 μm. Spermal sacs missing. Boraxcarmine. F — A spermatophore without the base of its stalk. Total length 286.3 μm. Visible spherical bodies, membrane of the upper hemisphere, funnel and loosed spermal sacs. Boraxcarmine.

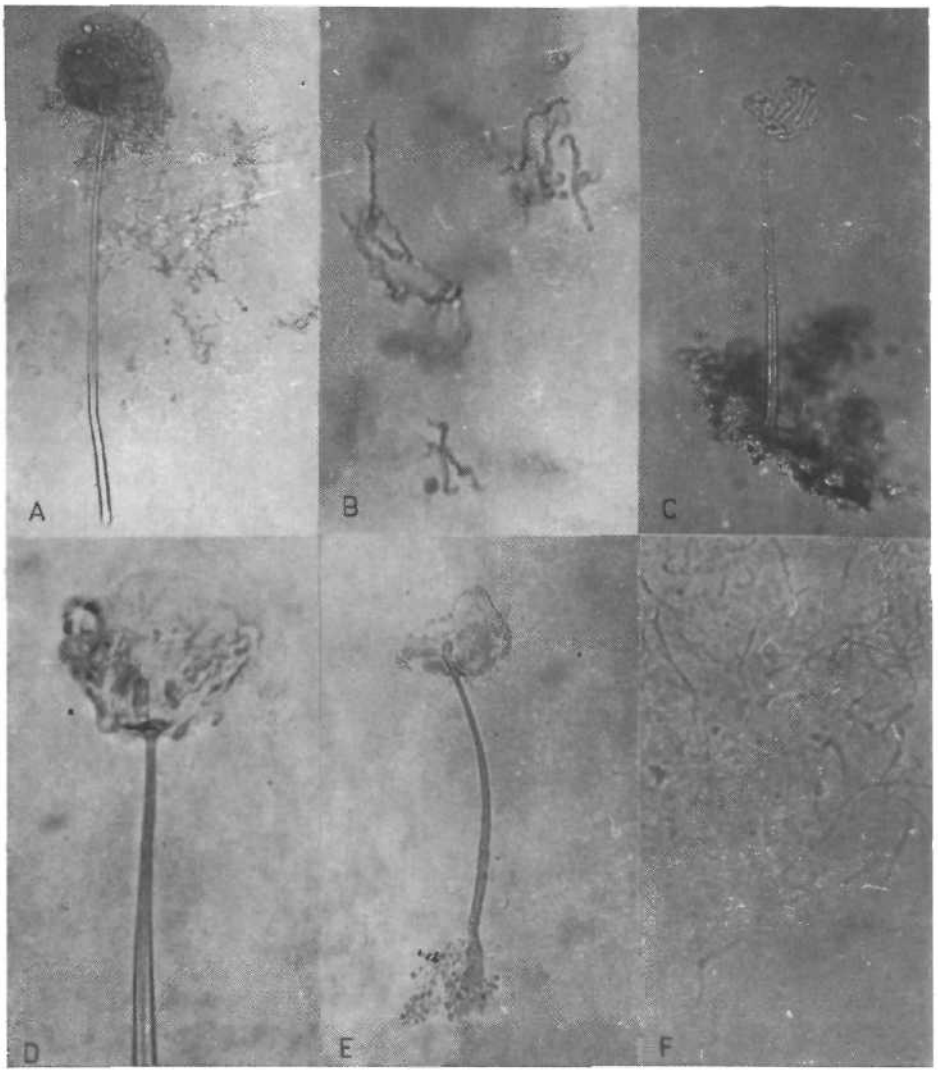

Fig. 4A—B. Spermatophores of *Liacarus subterraneus*. A — A spermatophore without the base of its stalk. Total length 282.8 μm. Sperms loosed from spermal sacs. Boraxcarmine. B — Sperms. Size 11.9—14.5 × 0.9—1.1 μm. Dark thread-like nucleus inside. Boraxcarmine.
Fig. 4C—F. Spermatophores of *Liacarus nitens*. C — Total view. Total length 183.4 μm. Partially damaged spherical capsule. Cells of Pleurococcus sp. fixed to the stalk from substrate. Polychromatic methylene-blue. D — Spherical capsule without the upper hemisphere and a part of the stalk. Diameter of spherical capsule 52.4 μm. Central support attached excentrically on the lateral one. Polychromatic methylene-blue. E — Total view. Total length 214.9 μm. Crushed spherical capsule. On the left a spermal bag, on the right loosed sperms. A sharp of the pedicel visible in its lower part. Congo red. F — Thread-like sperms. Size 7—10 × 0.2—0.3 μm. Congo red.

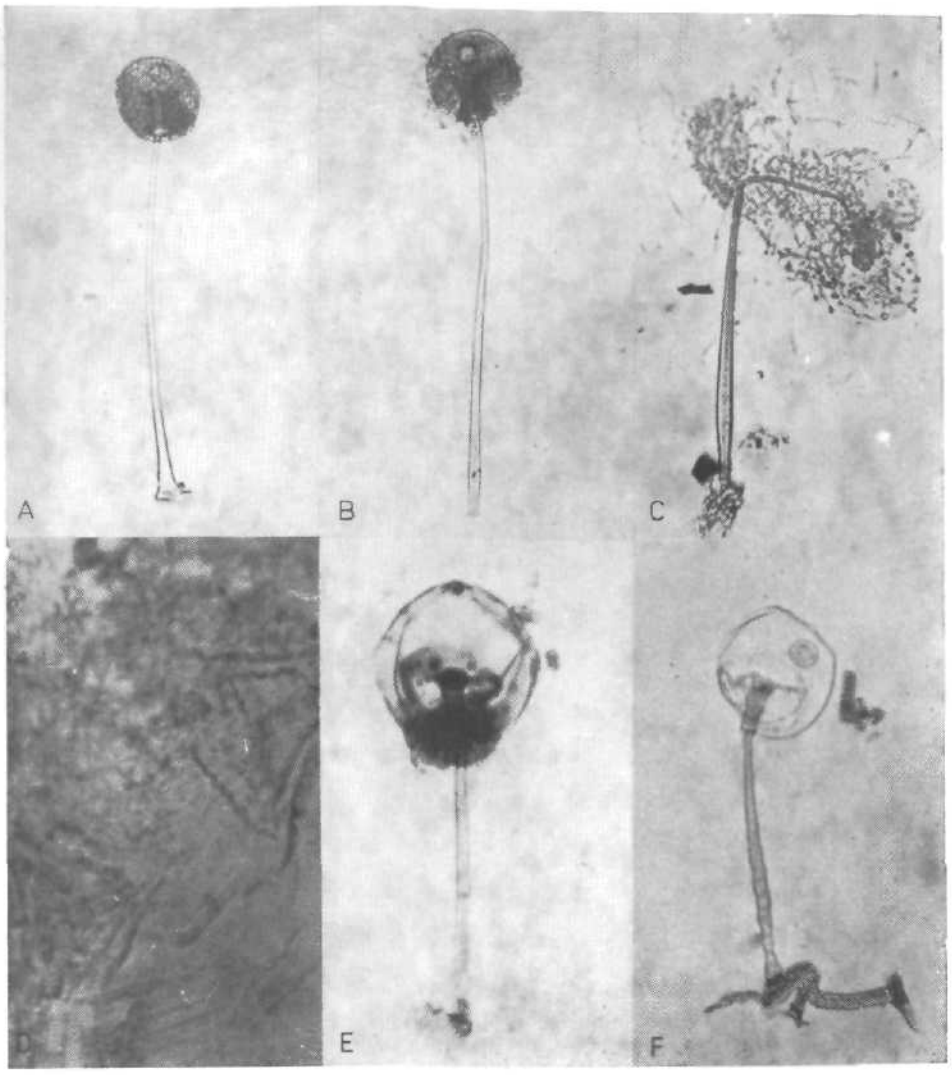

Fig. 5A—D. Spermatophores of *Liacarus xylariae*. A — Total view. Total length 167.7 μm. Visible internal structure of the spherical capsule. Boraxcarmine. B — A spermatophore without the base of the stalk. Total length 186 μm. Y-shaped cross-section visible on the bottom of the stalk. Partially crushed spherical capsule, sperms expansioned from its lower hemisphere. Boraxcarmine. C — A crushed spermatophore with loosed sperms. Height of central support 12.4 μm. Congo red. D — spindle-shaped sperms. Size 9—10 × 1.0—1.1 μm. Spiral-shaped nucleus inside. Boraxcarmine.

Fig. 5E—F. Spermatophores of *Dorycranosus infissus*. E — Total view. Total length 104.8 μm. Stained with blue ink. F — Total view, spermal ring missing. Total length 110 μm. Methylene-green.

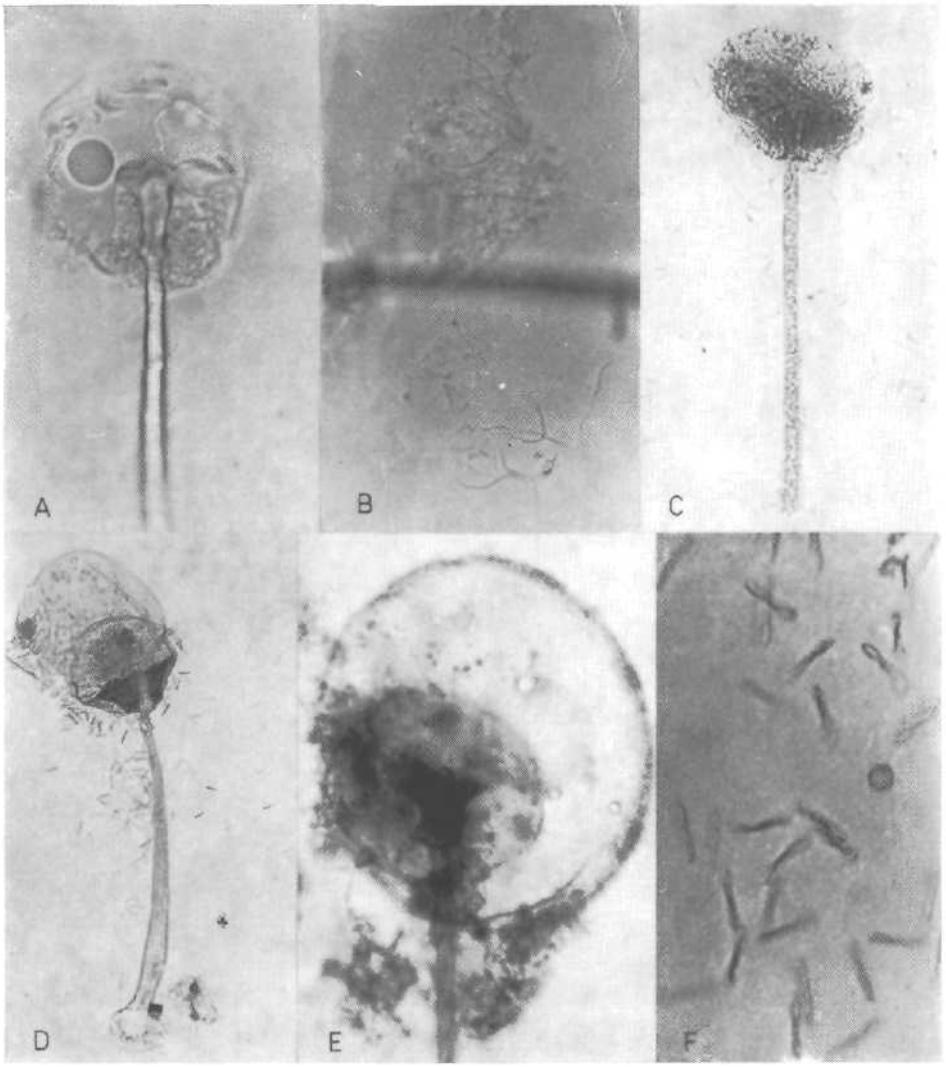

Fig. 6A—B. Spermatophores of *Doryacrnosus infissus*. A — Spherical capsule and a part of the stalk. Diameter of the spherical capsule 39.3 μm. Visible the upper hemisphere with spherical body, connection of the membrane of upper hemisphere with the edge of funnel, shape of central and lateral support, its connection with apex of stalk and sperms rolled up into spermal packets forming spermal sacs. Methylene-green. B — Thread-like sperms. Size 13—18 × 0.5—0.6 μm. Methylene-green.

Fig. 6C—F. Spermatophores of *Dorycranosus moraviacus*. C — A spermatophore without the base of pedicel. Total length 208 μm. Triangular cross-section on the bottom of the stalk, rugged surface of the stalk, shape of central and lateral support, loosed sperms from spermal sac on the left and partially on the right. Boraxcarmine. D — A spermatophore with partially crushed spherical capsule. Total length 259 μm. Loosed sperms. Boraxcarmine. E — Spherical capsule with expansioned spermal sacs. Diameter of the spherical capsule 78 μm. Spherical body and funnel are visible. Boraxcarmine. F — Stick-shaped sperms. Size 7.0—8.3 × 0.8—0.9 μm. S-shaped and spiral-shaped dark nucleus inside. Boraxcarmine.

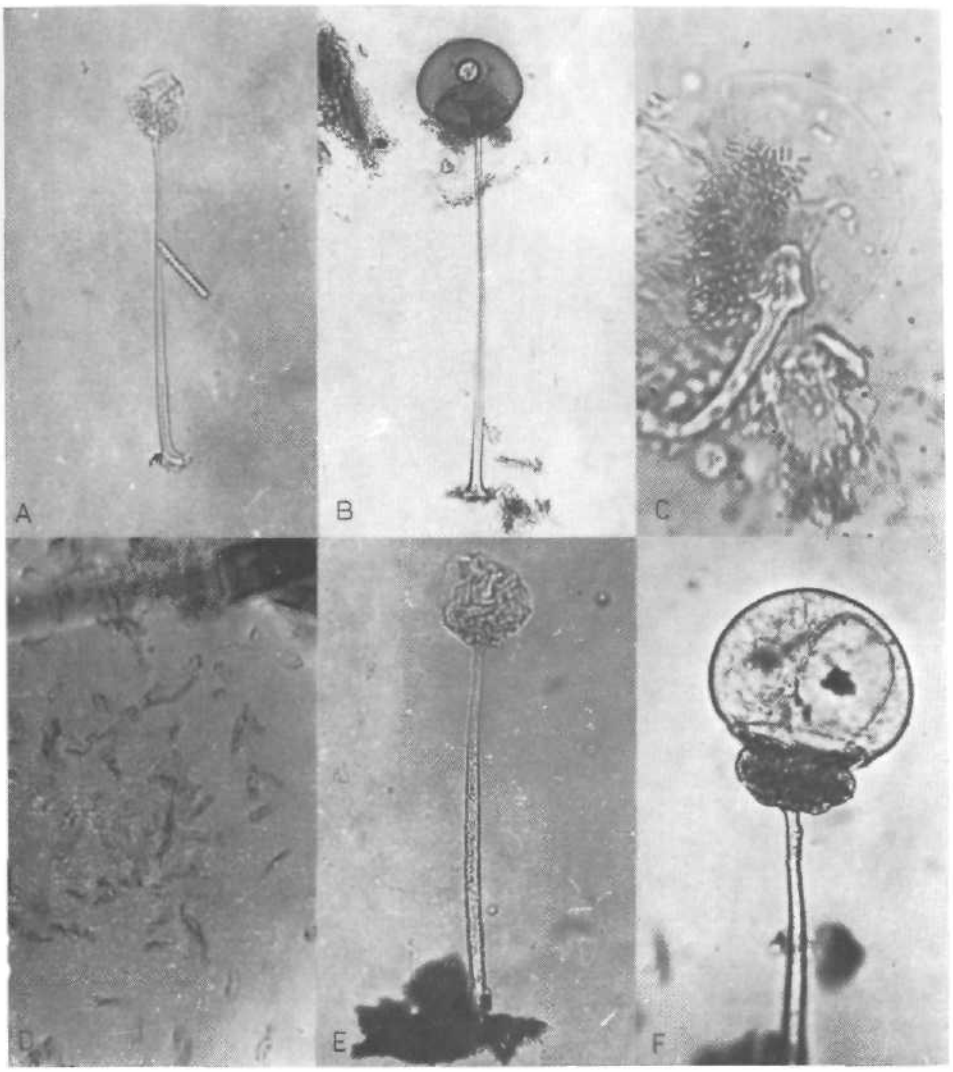

Fig. 7A—D. Spermatophores of *Xenillus clypeator*. A — Total view. Total length 167.7 μm. Methylene-green. B — Total view, spermal sacs expansioned. Total length 208 μm. Upper hemisphere and spherical body and the funnel are clearly visible. Boraxcarmine. C — Spherical capsule with supports and spermal sacs. Some loosed sperms visible. Height of spherical capsule 37.4 μm. Boraxcarmine in lactophenol by Beer. D — Stick-shaped sperms. Size 3.9—5.2 × × 0.6—1.1 μm. S-shaped or spiral-shaped dark nucleus inside.

Fig. 7E—F. Spermatophores of *Xenillus tegeocranus*. E — Total view. Total length 256.7 μm. Spherical capsule damaged partially in the upper part. Unstained. F — Spherical capsule and a part of the stalk. Diameter of spherical capsule 73.4 μm. Upper hemisphere drawn up. Connection of its membrane with the edge of funnel is visible, connection of the membrane of the lower hemisphere along with them. Spermal packets forming spermal sacs around the base of the funnel. Unstained.

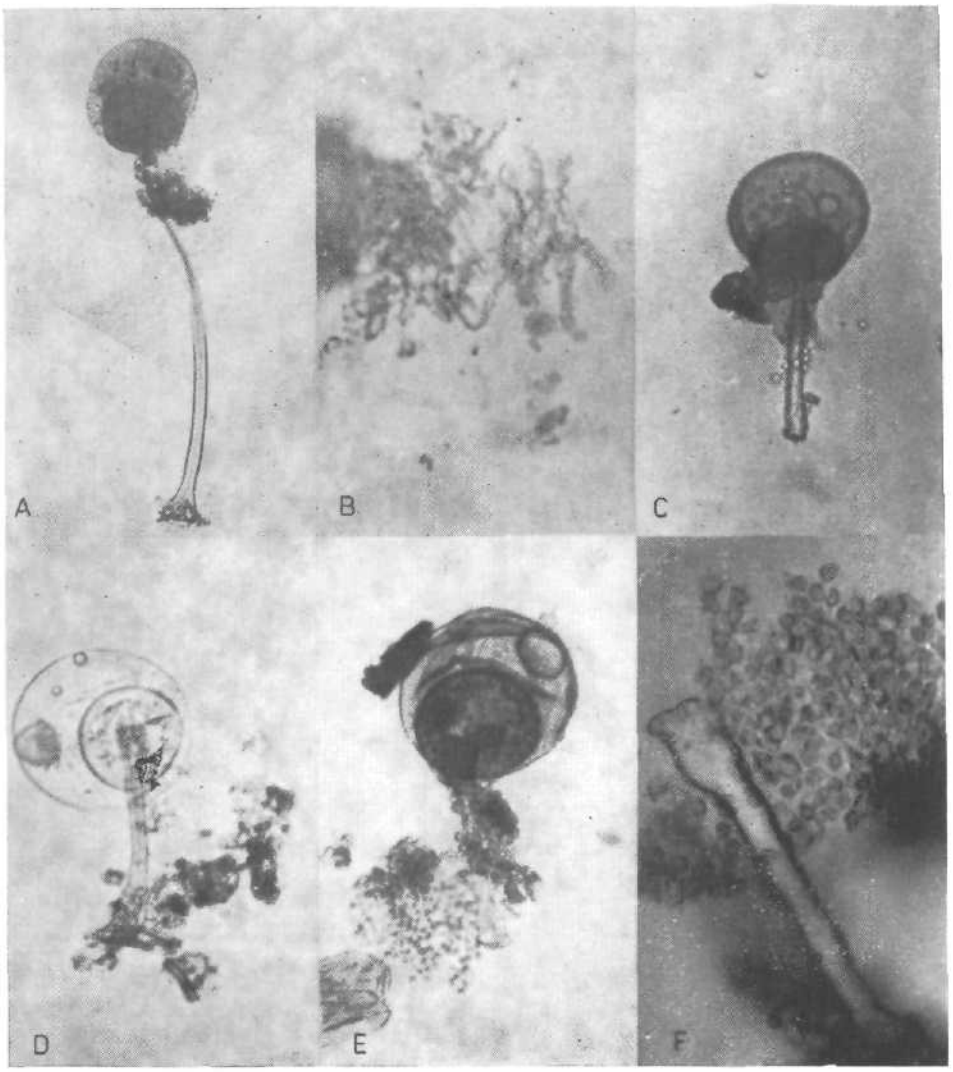

Fig. 8A—B. Spermatophores of *Xenillus tegeocranus*. A — Total view. Total length 227 μm. One of the spermal sacs crushed, with some loosed sperms. Boraxcarmine. B — Stick-shaped sperms. Size 13—15 × 1.2—1.3 μm. Spiral-shaped dark nucleus inside. Boraxcarmine.
Fig. 8C—F. Spermatophores of *Adoristes ovatus*. C — Total view. Total length 65.5 μm. Extruded sperm sacs and some loosed sperms. Boraxcarmine. D — Total view. Total length 68.1 μm. Sperm ring is missing. Spherical capsule with spherical body, funnel, central and lateral support are visible. Three ribs of pedice I are distinct too. Unstained. E — Total view. Total length 78.6 μm. Loosed sperms from spermal sacs are visible. Boraxcarmine. F — Globular sperms. Size 1.0—1.2 μm. Boraxcarmine.

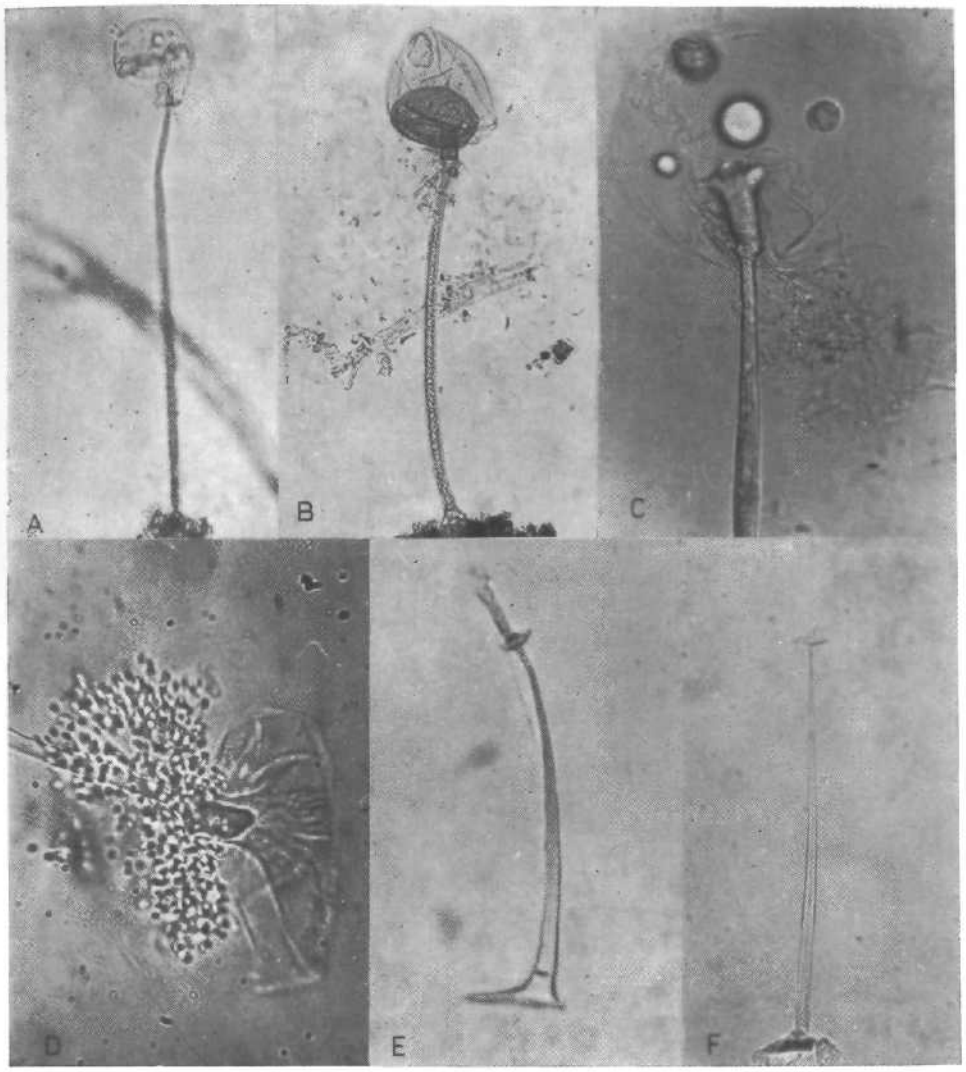

Fig. 9. A — A spermatophore of *L. subterraneus*. Total length 275.6 μm. Spermal ring is missing, membrane of the lower hemisphere damaged. Unstained. B — A spermatophore of *X. clypeator*. Total length 196.3 μm. Spermal ring is missing, loosed sperms are around the spermatophore. Boraxcarmine. C — Upper part of a spermatophore of *D. infissus*. Diameter of spherical capsule 39.3 μm. Central support surrounded with a dense mass protruding into 3 protuberances. Sperms extruded from the lower hemisphere. Methylene-green. D — Extruded spermal ring, lateral and central support, and funnel of a spermatophore of *X. clypeator*. Diameter of the upper part of pedicel 2.2 μm. Methylene-green in Amman's lactophenol. E — Pedicel and supports of the spermatophore of *L. coracinus*. Total length 115.3 μm. Milk acid. F — Pedicel and supports of the spermatophore of *L. xylariae*. Total length 178 μm. Milk acid.

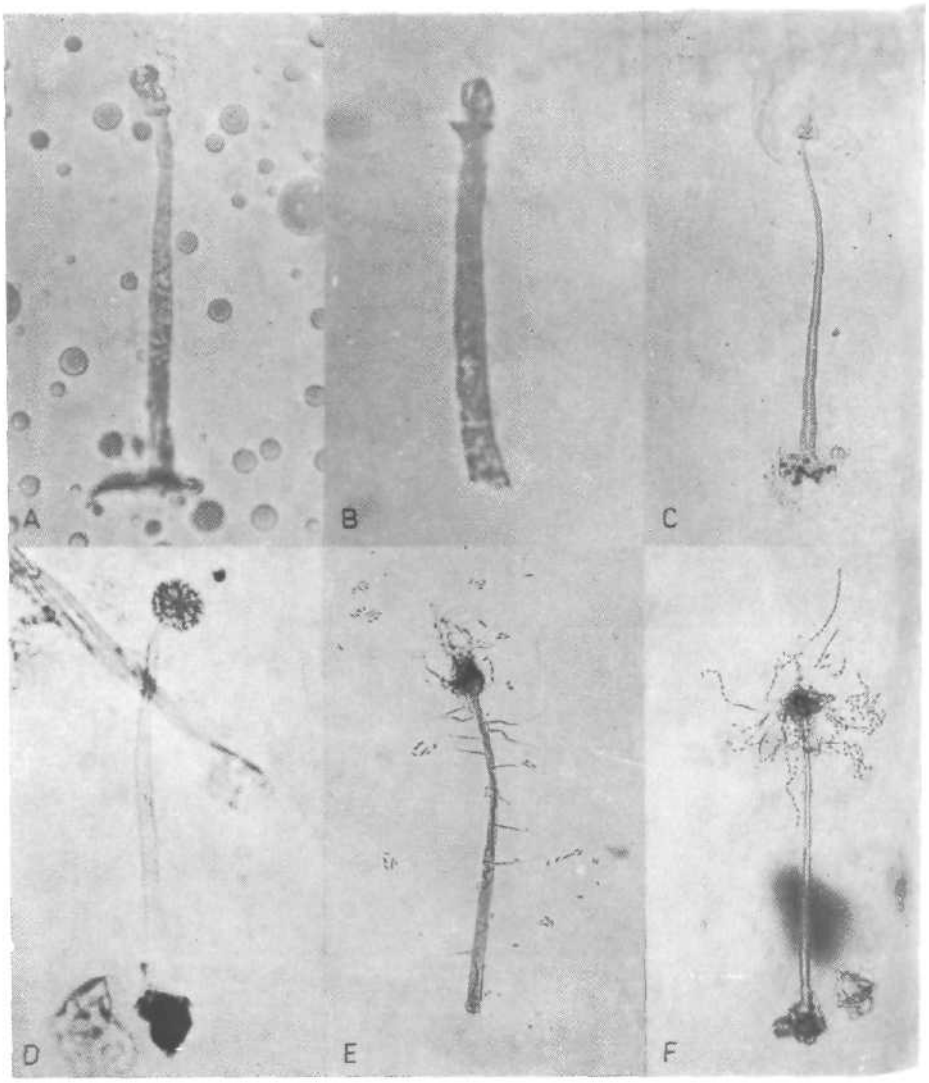

Fig. 10. A — Pedicel and supports of a spermatophore of *D. infissus*. Total length 89.1 μm. Milk acid. B — Pedicel and supports of a spermatophore of *A. ovatus*. Total length 73.4 μm. Milk acid. C — A spermatophore of *L. nitens*. Total length 212.2 μm. Spiral-shaped central support. Congo red. D — A conidiophore of *Aspergillus flavus*, similar to the spermatophore of an oribatid mite. Total length 128 μm. Unstained. E — An older spermatophore of *L. rykoriae* attacked with *Cephalosporium sp.* Hyphas, conidiophores and conidiums are visible. Total length of spermatophore 141.8 μm. Boraxcarmine. F — A spermatophore of *X. clypeatus* attacked with *Fusidium terricola*. Total length of spermatophore 174 μm. Saphranine.

POKYNY PRO AUTORY

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

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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: Cypridinidae), 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. spol. zool.*, 39 : 111—119.

Přepis cyrilice proveďte podle mezinárodních pravidel vědecké transliterace (nikoliv fonetické transkripce) — viz ISO Recommendation R 9. International System for the transliteration of cyrillic 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 : 3, 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 očíslujte 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. spol. zool. Viničná 7, 128 44 Praha 2.

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