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**EFFECTS OF JUVENOIDS ON THE NEUROENDOCRINE SYSTEM OF THE FLESH FLY  
SARCOPHAGA CRASSIPALPIS (DIPTERA)**

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Received August 31, 1979

**Abstract:** The effects of active juvenoid (isopropyl 11-methoxy-3,7-11-trimethyl-2,4 dodeca-dionoate) on the neuroendocrine system of the flesh-fly *Sarcophaga crassipalpis* Macquart have been studied. The observations indicate clearly that juvenoids not only inhibit the development and differentiation of the adult's neuroendocrine system, but they also interfere with the synthetic function of the cells causing a serious reduction in their activity. The results show also that at least part of development and metamorphosis has occurred in complete absence of endogenous metamorphosis hormones. In other words, it was possible to create an adult insect without functional neuroendocrine system.

INTRODUCTION

Pflugfelder (1939) in *Dixipus* was the first to study the effects of juvenile hormone (JH) on the endocrine system by implanting the corpora allata (ca) and observing its effects on the recipients. They found a compensatory reduction in size of the host ca. Similar observations have been reported by Doane (1961) in *Drosophila* and Ozeki (1961) in carwig *Anisolabis*. Novák and Rohdendorf (1959, cited in Novák, 1966) concluded that the reduction in the host ca was due to a high concentration of JH in the haemolymph which inhibits the function of the recipient's gland, i. e. by a feedback between the haemolymph titer of JH and growth of the ca (cf. Sláma et al., 1974).

A considerable progress in the knowledge of the action of JH has been made since the hormone was isolated (Röller et al., 1967; Mayer et al., 1968). Most of these studies were concerned with the effects of JH or its analogues on the development of external structures. However, a few papers have been devoted to the effects of juvenoid on the internal organs.

Williams (1959), Gilbert & Schneiderman (1959) observed activation of prothoracic glands after application of cecropia extracts to Saturniid pupae. It appeared that the extracts could prevent degeneration of the prothoracic glands (Gilbert, 1962). Further, Krishnakumaran & Schneiderman (1963, 1965) demonstrated that the observed prothoracotropic effects of the cecropia extracts were indeed associated with juvenile activity, since positive responses were obtained with series of synthetic juvenoids (see papers and reviews by Novák et al., 1966; Radwan; 1974; Sláma et al., Novák, 1975).

An intensive work to demonstrate the effects of juvenoids on the development and metamorphosis of higher Diptera was made by Srivastava & Gilbert (1968), Srivastava et al., (1969), Bhaskaran (1972), Sehnal & Žďárek (1976) and many others. The results were rather identical either by application of juvenoids on the last instar larvae or when they were applied at any stage during the whole period of postembryonic development. In all cases a block of metamorphosis (i. e..

Table 1. Histological changes in the median neurosecretory cells in normal and treated insects

	Average No of cells	Average surface area of the nuclei		Estimation of neurosecretion	Density of nucleoli
Second category Normal newly formed pupae	19 ± 4	280	80	3	0.3
First category Normal newly formed pharate adult	22 ± 1	500	140	5	1.1
Normal adult (before emergence)	25 ± 3	270	50	3	0.4
	28 ± 2	480	164	6	0.5
	26 ± 2	560	80	5	1.4

producing superlarvae or larval-pupal intermediates) were never obtained. The treated insects were always developed to defected adults. The defections begin in the tip of the abdomen then gradually spread forwards until the thorax and head in the most defected specimens.

In an attempt to understand the direct cause for such morphological abnormalities caused by juvenoids, it was necessary to study the effects of juvenoids on the internal organs. Unfortunately, the effect of JH or its analogues on the ns-system has not been as yet examined in Cyclorrhaphous Diptera. Therefore, the experiments were designed to study the effects of juvenoid on the ns-system as well as on the other endocrine glands. The aim is to find out the reason(s) for the inhibition of the development in some of adult structures caused by juvenoids. In other words, juvenoids affect directly these organs inhibiting (either early or completely) their developments or are their effects indirect, i. e. via the neuroendocrine system.

#### MATERIAL AND METHODS

As mentioned in the previous papers (Abou-Halawa, 1981) the most active juvenoids were found to be isopropyl 11-methoxy-3,7-11-trimethyl-2,4 dodecadienoate. All experiments were carried out using this active compound in its highest concentration (i. e. 10 µg). The methods used for histological studies have been described in a separate paper (Abou-Halawa, in print).

#### RESULTS

##### A) EFFECTS OF JUVENOIDS ON THE NEUROSECRETORY SYSTEM

The histological picture of the brain in such defected insects reveals five categories which differ remarkably according to the degree of defection and the stage at which the juvenoid was applied. The first three categories were obtained by applying the compound to the last larval instar (few hours before puparium formation) while the other two were obtained by applying several doses of the juvenoid during the whole larval development (Abou-Halawa, in print). Not less than six brains were examined for each category.

**Histological changes in the median neurosecretory cells (mnsc) of the first category**

According to the classification of Sehnal & Žďárek (1976) the insects of this category belong to score (1). They appear as adults with incomplete rotated genitalia



in males or slightly defective ones in females. In extreme cases, an abnormal 5th sternite with 4th and 5th tergites were ventrally opened or 5th to 8th sternites were not fully developed. These insects were taken from puparia, i. e. they failed to emerge.

The brains of such defective adults differ remarkably from those of the normal untreated ones. The morphological as well as histological studies indicate clearly that they corresponded to the brains of newly formed pharate adults (4 1/2—5 1/2 days after puparium formation), i. e. juvenoids inhibit the development and differentiation of the brain at early stages of pharate adult development. Histological studies on such defected brains showed clearly that the synthetic activity of the mnsce had been reduced drastically. A small amount of neurosecretory (ns-) material in the form of diffusible granules could be observed in majority of the cells. However, in some of them bigger granules could be seen and in very rare cases stained clumps were present (see Fig. 1 a). The density of nucleoli was very low being  $0,4 \pm 0,02$ , indicating that the majority of mnsce had no stainable nucleoli (Fig. 3). Furthermore, the nucleolus (if present) appeared small, faintly stained and not attached to the nuclear membrane. The average number of stainable cells was rather high ( $25 \pm 3$  cells) while the cellular and nuclear volumes were relatively small.

As mentioned in the previous papers (Abou-Halawa, in print), the insects belonging to this category appeared externally as normal fully formed adults except some deflections in their genitalia. However, they possessed an incomplete developed brain, i. e. the differentiation of their brains was inhibited at early stages of pharate adult development. A comparison between the histological picture of the mnsce in such defected brains with these in both normal newly formed pharate adult and in normal fully formed adults (just before emergence) is included in Table (1). It is evident from the table that a remarkable difference in the histology of mnsce exists between those in defected brain and in the brains of normal untreated insects. For example, the amount of material in the perikarya (by estimation) is about half of those in newly formed and fully formed adults. The same is applying on the cellular as well as nuclear volumes which are smaller in the treated insects than in the normal ones. The nucleolar density of treated insects dropped to about 28% of that in normal fully formed adult. This represents the level at which the synthetic activity of mnsce had been decreased.

#### Histological changes in the mnsce of the second category

The brains of this category were found in insects belonging externally to the same score as in the previous category. However, the insects represented the extreme margin of this score having frequent defects of the last abdominal segment. None of them (as in the first category) succeeded to emerge.

The morphological as well as histological studies on the brains indicate clearly that they correspond to the brains of newly formed pupae (2-3 days after white puparium formation), see Fig. (2a, b). A comparison between these cells and the corresponding ones in normal „untreated“ newly formed pupae and fully formed adults is representing also in Table (1). From Fig. (3), it is clear that a steep and gradual reduction in the average number of stainable cells as well as in their nucleolar density begins. However, the amount of ns-material seems to be the same as in the previous category. In both a small amount of material in the form of diffusible granules were almost present. Table (1) indicates clearly that the synthetic activity in the cells of treated insects had been decreased. The size of the cells and the amount of neurosecretion were reduced to about half of their normal values. The nucleolar density to a very low level of about 21% of that in normal adults.

Another comparison should be done between the mnc of this category and those of normal newly formed pupa. The data which are also included in Table (1) clearly show that juvenoid almost inhibits the synthetic activity of the mnc. The average number of cells was as low as  $19 \pm 4$ . Cellular and nuclear volumes as well as the

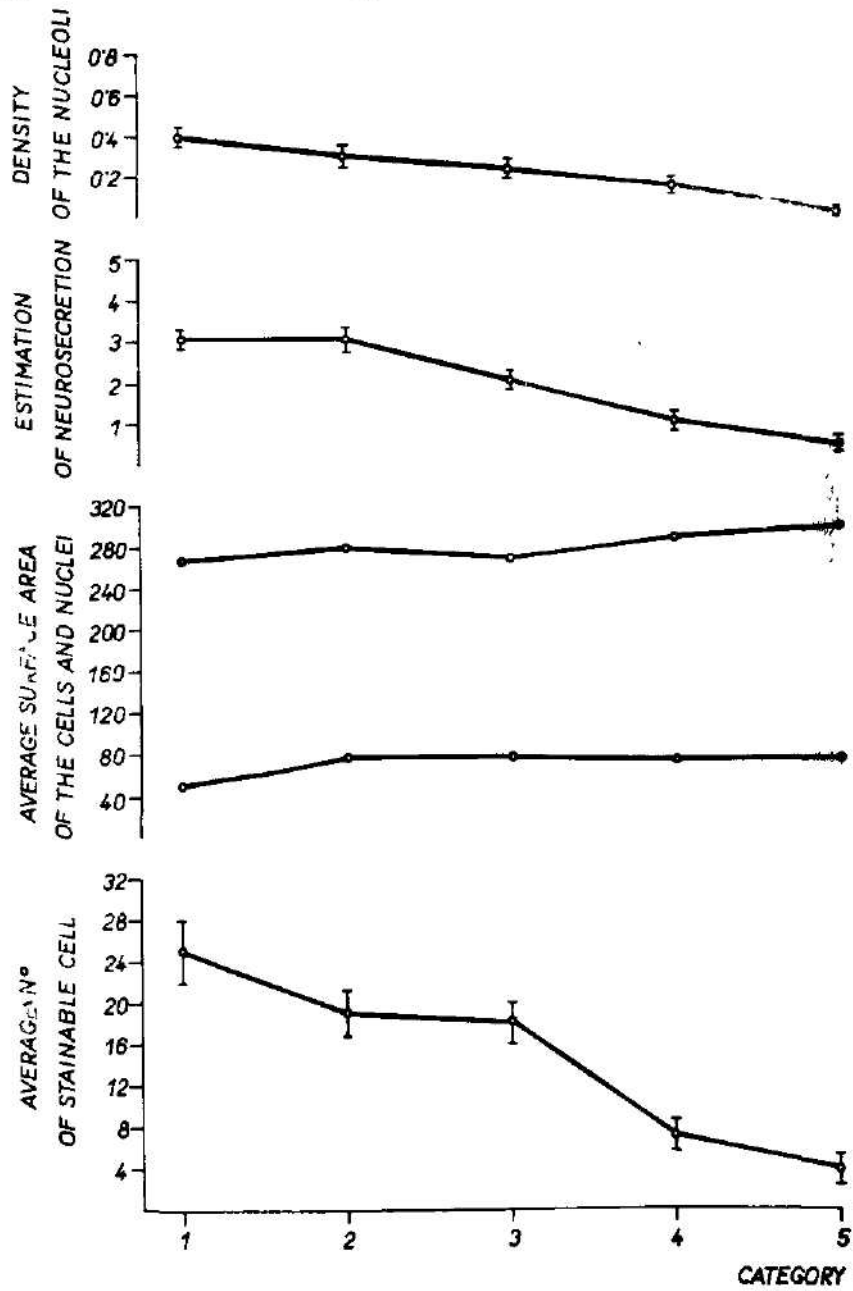


Fig. 3 Histological changes in the mnc in different categories of defected insects.

amount of neurosecretion were about half of the corresponding figures in normal newly formed pupa. Furthermore, the reduction in nucleolar density was very high in comparison with those in normal (being 0.3 in the former and 1.1 in the latter). These observations indicate clearly that, not only juvenoids inhibit the development and differentiation of the insect's brain, but also they interfere with the synthetic function of mns-c causing a serious reduction in their activity.

#### Histological changes in the mns-c of the third category

According to the classification of Sehnal and Žďárek (1976) the insects of this category belong to the score (IV). The most conspicuous morphological effects are the undeveloped genitalia and the lack of sclerotization in the last abdominal segments. Indeed, it was rather difficult to recognize (either morphologically or histologically) whether the brains of these defected insects correspond to larval, pupal or adult brains. The difficulties were mainly due to a high rate of degeneration which occurred in many parts of the brain and was often visible as high vacuolation (Fig. 2c).

Histological studies of this category indicate that the mns-c show a gradual degeneration. The nuclei lose their definitive structure due to deformation occurred in their membrane. The cytoplasm of majority of cells stains uniformly reddish and the elementary granules cannot, so far, be observable. The average number of stainable cells as well as the density of nucleoli were drastically reduced (Fig. 3).

#### Histological changes in the mns-c of the fourth category

The brains of this category and of the proceeding one were taken from insects which were severely affected. This was carried out by applying several doses of active juvenoid during the whole larval development (Abou-Halawa, in print). The main characteristics of these defected adults were that the development of the external structures have been arrested at various stages of differentiation. The eyes remain yellow as in the middle period of pharate adult (6 1/2 days after pupariation) and a few bristles were present on the head. The thorax was partially developed with fewer microchaetae and the abdomen was entirely undifferentiated.

Histological studies on the mns-c of this category (included in Figs. 3, 4 & 5). These indicate that the system was in the last step "just" before complete degeneration. The average number of the mns-c which could be detected by the specific PAF-stain was only  $7 \pm 2$  cells. This represents about 27% of those in normal fully formed adults. In another words about 73% of the cells have been degenerated. Furthermore, the remaining few cells possessed a very low level in the density of their nucleoli (less than 0.2) and the amount of neurosecretion was at the minimum level. These results indicate that the majority of mns-c have been degenerated and the remaining cells were, without doubt, non-functional.

#### Histological changes in the mns-c of the fifth category

As mentioned before the brains of this category (as in the previous one) were taken from insects extremely defected by applying several high doses of the juvenoid. Histological observations on the brains of these insects revealed clearly that the mns-c have been completely degenerated. It was difficult to find such cells by the most specific stains for neurosecretion: PAF-stain (Fig. 6a) and Heidenhein's stain (Fig. 6b). However, the cells which considered as ns-c by their position in the pars intercerebralis were very few (one or two cells). These cells were without ns-material in their perikarya and they were without nucleoli (Fig. 6 a). The results which indicate that such insects have no ns-system.

It is to be noted here that the insects of this category as well as of the previous ones were living at the time of autopsy (2 days after the emergence of the controls). This view is based on several facts: (i) Some insects were movable at the time of dissections; (ii) Preliminary experiments were done to determine the time-needed for these defected insects to die. The results indicated that they were alive for three days after the emergence of controls, thereafter they died in the fourth and fifth days.

One further point should be mentioned here, viz the photographs represented for each category. These photographs were the typicals found in the majority of the examined brains. At least three brains out of six (i. e. 50% of the specimens) should be similar and representing the typical for a given category. The remaining were almost found as intermediates between the different categories. Some of these intermediates belong to the previous category, the others to the proceeding one. The data in the curves and tables represent the average of the whole brains examined in each category.

#### B) EFFECTS OF JUVENOIDS ON THE RING-GLAND

The general histological picture of the ring-gland in treated specimens reveals three categories. The classification was mainly based on the presence or absence of the chromophile cells in the corpus cardiacum (cc) and on counting the number of R-cells in the ring-gland. It has been observed during these studies that individual variations were high, that in similar defected insects belong to the same score possessed greatly different ring-glands. For this reason not less than 12 specimens were examined in each experiments and the total number was 75 ring-glands. The photographs provided represent (as in the case of the ns-system) the typical for each category i. e. the majority of glands examined.

#### Histological changes in the ring-gland of the first category

The ring-glands of this category were found in the less defected insects (scores I & II) by applying juvenoid on the last instar larvae ready to pupariate. Histological studies indicate that the differentiation of the ring-glands was inhibited during early stage of insect metamorphosis. The view is supported by counting the number of R-cells. It has been found that the average number of these cells (counted in 14 specimens) was  $240 \pm 13$ . By comparing this figure with data obtained by the present author in a separate paper (in preparation) concerned with the histological changes occur in the ring-gland during the normal postembryonic development, it seems possible to conclude that they are similar to those in normal newly formed pupae (36–60 hours after pupariation). However, the histological studies show a great differences. The most conspicuous ones occurred in the peritracheal glands and could be summarized as follows:

- 1) The cell membranes clearly appear in the normal newly formed pupae while they are deformed in the treated ones.
- 2) The perikarya of the R-cells are very large in the normal as seen in the big spaces between their nuclei. However, in the defected glands the nuclei are very condensed possessing a very narrow cytoplasmic areas between them.
- 3) The nuclei are regular in shape, appear either spherical or oval having a conspicuous nuclear membranes; but in the treated insects the nuclei of R-cells are irregular in their shape due to a deformation occurring in their membranes.

- 4) Most of the cells in normal untreated insects contain one or two (rarely three) nucleoli which stain intensively with basophilic dyes while they are almost absent in the glands of this category. The chromatine granules were scattered in the nuclear sap of these defected glands.

These observation clearly indicate that R-cells in these defected glands are non-functional rather than that their synthetic activity has been decreased.

#### Histological changes in the ring-gland of the second category

The ring-glands of this category and of the proceeding one were taken from insects treated with repeated high doses of juvenoid. They were extremely defected and belonged to scores V & VI according to the classification of Sehnal & Žďárek (1976). General morphological observations as well as histological studies on the ring-glands with their adjacent structures as the aorta and proventricules indicated that these organs succeeded to complete their differentiation upto adult forms. The average number of R-cells was  $140 \pm 15$  which may 'roughly' indicate that the stage at which their differentiation was inhibited in the last two days of adult development, i. e. 2-days before emergence (Fig. 7b).

Histological studies on the R-cells of such defected glands indicated (as clearly seen in Fig. 7b) that the cellular as well as the nuclear membranes were deformed. The nucleoli in the majority of them were absent and when present (in very few cells) they were small and faintly stained with basophilic dyes. The observations which indicate that these cells (as in the previous category) seem to be non-functional.

It is clear from the same figure that the ca seems to be still active. No deformations could be observed in the nuclear membranes and the whole gland is sheathed by a well developed connective tissues. Furthermore, the histological data indicate that the nuclei are fairly large (their average surface area is  $96 \pm 8$  ( $\mu^2$ )) possessing a big and clear nucleoli. The density of nucleoli was also high. This indicates that the majority of cells have nucleoli, i. e. the cells of the ca (unlike those of the R-cells) are still functional. The view is further supported by the presence of the extracellular vacuoles between the above mentioned two glands. This vacuole which is clearly seen in Fig. 7b represents a reduced volume from the corpus allatum after a stage of active release a detailed account of such vacuoles will be published in a separate paper.

The third constituent of the ring-gland, i. e. the cc could be hardly seen most probably due to the absence of the chromophile cells which were undifferentiated.

#### Histological changes in the ring-gland of the third category

In many points of view the ring-glands of this category are rather similar to those in the previous one. As mentioned above all were taken from the extremely defected insects obtained by applying repeated doses of active juvenoid.

Morphological and histological studies indicate that the differentiation of these glands was inhibited during adult development. However, minor differences occur in the number of R-cells as well as in the presence of chromophile cells. The average number of R-cells was higher than those in the second category being  $180 \pm 9$  cells indicating that their differentiation might be inhibited at younger stages of adult development. By comparing this number with those during normal development (in preparation) it seems possible that they correspond to a stage of 4-days before adult emergence.

The similarity between these glands and those in the second category was mainly observed in the histology of R-cells. Both possessed a deformed cellular and nuclear



membranes as well as no clear nucleoli could be observed. These observations indicate that such cells are almost non-functional. The chromophile cells which never seen before (in the treated insects) are visible in the glands belong to this category. Fig. 8b indicates that such cells succeeded to differentiate but they failed completely to be functional. Their nuclei are hardly visible due to the disappearance of their membrane and neither the nucleoli nor any of chromatine material could be seen in the sections. The effects on the ca seem to be smaller; some of nuclei in this gland are still clear, relatively large and contain basophilic big nucleoli. However, the nucleolar density was very low being 0,4 and indicate that the synthetic activity of these glands had been drastically reduced. Furthermore, the collagenous connective tissues sheath which enclosed the corpus allatum and separates it from the neighbouring R-cells seems to be deformed (Fig. 8a).

#### DISCUSSION

The foregoing experiments indicate the drastic histological changes induced in the neuroendocrine system and the extent to which such active compounds are interfering with the function of this system. Although only small defects occurred in the external structures (see Abou-Halawa, 1981) the internal organs were seriously upset by juvenoids. Most of the emerging flies possessed non-functional endocrine system and in the extreme cases appeared even a complete degeneration of this system. In other words, it was possible to create an adult insect without functional endocrine system. This interesting and, indeed, unexpected results clearly show that at least part of development and metamorphosis occurred in complete absence of endogenous metamorphosis hormones.

No available information concerns the effects of juvenoids on the ns-system. With regard to the other endocrine glands, there are very few ones dealing with their effects on the prothoracic gland and on the ca in some insect groups but none in higher Diptera. Gilbert et. al., (1959) and Williams (1959) observed activation of prothoracic glands after application of *Cecropia* extracts to Saturniid pupae. Moreover, Krishnakumaran & Schneidermann (1963, 1965) demonstrated that the observed prothoracotropic effects of the *Cecropia* extracts were indeed associated with the juvenile activity. Similar observations are described in the work by Radwan (1974) on cockroaches. The same have been observed in *Sarcophaga* and it was interesting to observe that the only larval structure preserved after application of juvenoid is the R-cells (the corresponding component to prothoracic gland in the other group of insects). All the larval structures (both external and internal) have been degenerated in the due time except the R-cells which did not complete their degeneration. The amount of the cells preserved was found to be in relation with the dose of juvenoid applied and consequently with the degree of defects. More cells were preserved in highly defected insects and vice versa. The ability of juvenoids to prevent degeneration and breakdown of the prothoracic glands is a widespread phenomenon associated with extralarval or extra-pupal moults (Sláma et. al., 1974). However, in higher Diptera such phenomenon was not applicable and hence it was impossible to get extra-larval or extra-pupal moults after treatment with juvenoids. Žďárek & Sláma (1972) were able to induce extralarval moult by applying high doses of ecdysoids but not with juvenoids. The reason for this is still uncertain. Due to the great diversity of insects, there are conflicting reports with regard to the role of hormones in controlling the metamorphosis of insects. According to Novák (1966) who reviewed the problem in many insects, the

metamorphosis can only take place when the JH concentration falls below its effective concentration. A similar statement was made by Wigglesworth (1970). In higher Diptera it has been found that development and metamorphosis can exist in the presence of high concentration of exogenous JHa and in absence of endogenous metamorphosis hormones.

From the available information, it seems as a fairly firmly established fact that hormones are the master of insect development and metamorphosis. In their absence, growth, moulting and metamorphosis will be inhibited. Examples; Williams (1947, 1948) and several others (cf Wigglesworth, 1970) have shown that a stage corresponding to natural diapause can be induced by the removal of the brain, the source of activation hormone (AH). Scharrer E. (1952) has shared this view point and attributed the natural diapause to a temporary interruption of the activation hormone (AH) production. The same was reached by Novák (1966) who has shown that larval and pupal diapause is due to the lack of AH and (therefore) the moulting hormone (MH). In this connection it is important to refer to the work of Okasha (1965) who attributed the failure of moulting of *Rhodnius* at 36 °C to the absence of brain hormone. Also the work of Thomson (1965) who believed that the failure in the development of the ovaries in the sugar-fed flies is due to the absence of brain hormone which did not release and store in the nsc. Žďárek (personal communication) after reactivation of diapausing pupae by ecdysterone and acetone believes that such compound stimulates the nsc to release the AH, i. e. such compounds break diapause and reactivate the insect indirectly via the ns-system.

Although there was no direct evidence to support any one of the above mentioned suggestions and due to the absence of information concerning the effects of juvenoids on the neuroendocrine system in higher Diptera, the present author was in accordance with these opinions. Therefore, it was theoretically believed that the defections caused by juvenoids in adult structures (both external and internal) should be also an indirect effect, i. e. via the neuroendocrine system. Furthermore and due to the classification of nsc to different groups (according to their topography) and to different types (according to their stainability) it was also theoretically believed that juvenoids variably affect the development of adult structures through their effects on some groups (or even cells) of the nsc. However, the experiments represented here (which clearly show that development and metamorphosis in the flesh-fly *Sarcophaga crassipalpis* Macquart has occurred in absence of endogenous metamorphosis hormones. This may throw some doubts on the previously mentioned suggestions; at least in such cases.

On the basis of some other work on the neuroendocrine system by the same author that will be published separately later, the present author is in full accordance with the old statement of Williams (1942). He stated that "... at least in these cases, hormones are the servants rather than the master of development the ultimate result is determined by the ability of the tissues to react". The same conclusion have reached by Okasha (1965).

With regards to the mode of action of juvenoids in higher Diptera, it seems tempting to suggest that these active compounds act directly on all adult structures (both the external and internal; equally on the neuroendocrine system). Thus (somehow, most probably by inhibition of the synthesis of specific proteins or/ and synthesis of RNA) they cause either partial or complete inhibition of their development. This suggestion is supported by the fact that juvenoids act at a very low subcellular level (Sláma et. al., 1974). Oberlander et. al., (1965, 1966) detected slightly enhanced rate of RNA synthesis after application of juvenoids.



From the previous work (concerned with the effects of juvenoids on the external structures as well as in the internal ones Abou-Halawa (in print) and on the basis of the results described in this investigation, it can be safely stated that the internal organs are more sensitive and more seriously affected than the external structures. In the extremely defected insects they look as a typical adult with drastically defected internal organs. This (as it was suggested in the above mentioned paper) should be due to the time difference in their development. It is common knowledge that the imaginal buds of the external organs are present and could be easily seen during larval life. These structures begin their differentiation very early and at a very high rate at the end of the last larval instar. However, the internal organs of adult insects differentiate after complete degeneration of the corresponding larval structures very late during metamorphosis stages. It has been found that juvenoids affect the development of these structures according to the rate of their morphogenesis; the earlier in development are the less affected and vice versa. The same conclusion was reached by Srivastava et al., (1969) and Sláma et al., (1974).

On the basis of the present work it remains, however, a question for further research to find why the Cyclorrhaphous Diptera react to juvenoids in a completely different way than the other insect groups.

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The figures 1–2, 4–8 will be found at the end of this issue.

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**COMPARATIVE STUDY OF DAPHNIA ATKINSONI AND DAPHNIA ULOMSKYI  
(CRUSTACEA, CLADOCERA)**

Igor HUDEC

Received March 19, 1980

**Abstract:** Author describes distribution, variability and biology of *Daphnia atkinsoni* Baird, 1859 in Slovakia. The study is focused on the differentiation of *Daphnia atkinsoni* and *Daphnia ulomskyi* Behning, 1941. Following characters were studied using the populations from Slovakia and Jugoslavia: dorsal ridge, antennules and rostrum, antennae, shell-spine, number of setae on endopodites, postabdomen.

**INTRODUCTION**

While working on Cladocera in Slovakia we observed a large variability of *Daphnia atkinsoni*. The variability covered many characters. Our samples had either typical characteristic features of *Daphnia atkinsoni* or their characters reminded *Daphnia ulomskyi*.

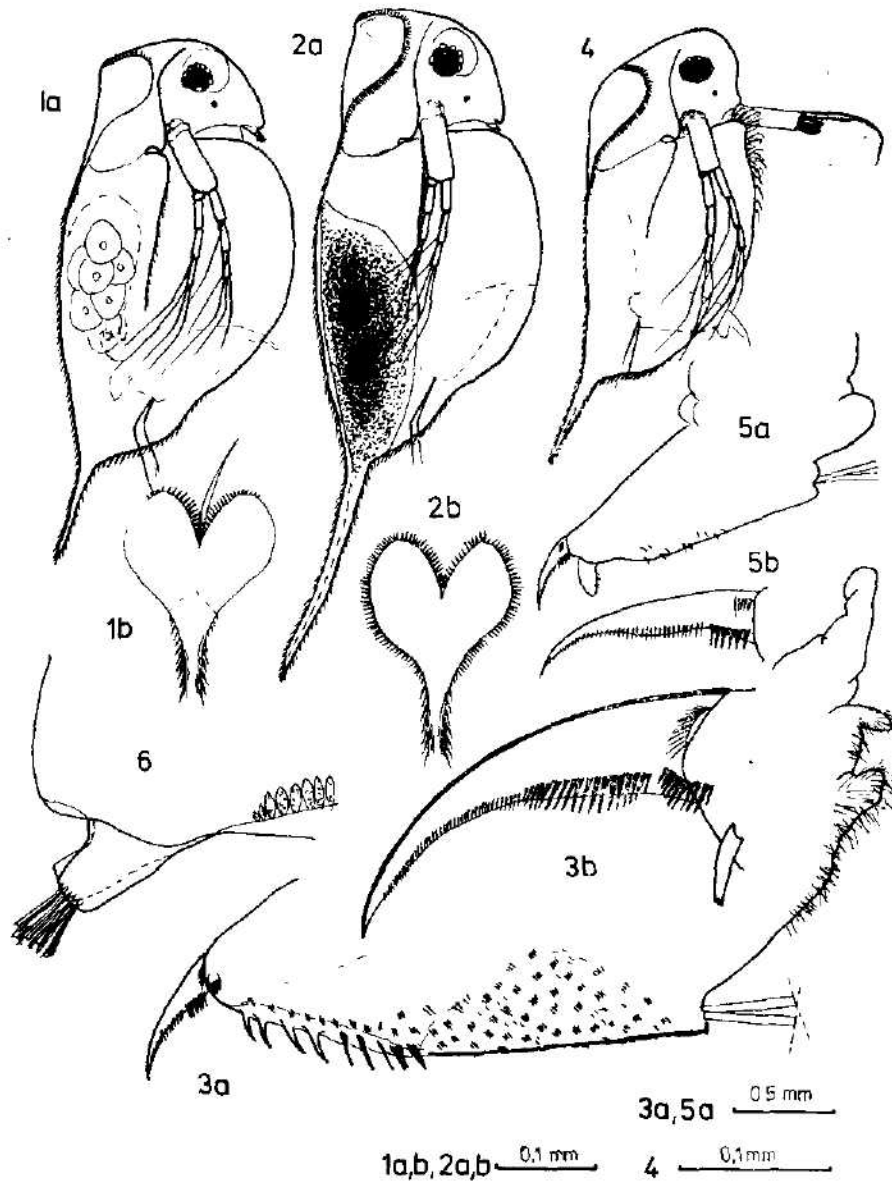
The variability of *Daphnia atkinsoni* is known for a long time (Wagler, 1936, Johnson, 1952a, Brooks, 1957). According to literature *Daphnia atkinsoni* occurs more or less in all Europe, except its northernmost regions with the exception of Iceland (Hrbáček, 1978). Outside Europe it occurs in N. Africa, S. E. Asia. Less commonly it is found east to central Asia and Siberia (Johnson, 1952b).

The geographical distribution of *Daphnia ulomskyi* is more limited. Its occurrence is confirmed only in Transkaukaz, Krym (Behning, 1941, Manujlova, 1964) and Macedonia (Petkovski, 1970). More information about biology and taxonomy of *Daphnia ulomskyi* is given by Petkovski (1970), but the variability of this species has not been studied yet.

**MATERIALS AND METHODS**

Slovakia: Mužla, shallow-pools in field, 16. 4. 1956., Palárikovo - Selice, shallow-pools on a pasture near a road, 17. 4. 1956., Pastovce - Bielovce, pool on a plough, 15. 4. 1956., Dolný Bar, shallow-pool on a pasture near a village, 8. 5. 1953., Malé Leváre, pool near a village, 23. 4. 1955., Malé Čiky (near Šurany village, little shallow pool on a pasture near a well, 17. 4. 1956., Sikenička-natron pool near a field, 14. 5. 1956., Topolníky, a rural shallow-pool in a field, 5. 4. 1955., Príbeta, wide ditch near a road, 29. 4. 1956., Čilistov, shallow-pool near a flood barrage, 25. 4. 1956., Tekovské Lužany, deep ditch in a field, 12. 4. 1954., Vlkaš, shallow pool on a meadow in a flood region of the river Žitava, 21. 4. 1969., Šurany - Palárikovo, large shallow-pool on a plough, 22. 4. 1969., Šurany - Tvrdošovce, ditch in a field under willow trees, 22. 4. 1969., Palárikovo, ditch near a willage with quit watter, 22. 4. 1969., Palárikovo, wide ditch near a willage joining a large shallow rural pool, 22. 4. 1969., et 14. 5. 1970., Nové Zámky - Komoča, periodical swamp full of *Carex* sp. situated under willow trees with rotting leaves on its bottom, 23. 4. 1969., Dulovce, rural shallow-pool, 24. 4. 1969., Chotín, shallow-pool with a mire-sandy bottom, 24. 4. 1969., Marcelová, rural shallow-pool, 24. 4. 1969., Búč, rural shallow-pool, plantless with a sandy bottom, 24. 4. 1969., Čenkov - Mužla, large grassy shallow-pool on a pasture near a road, 24. 4. 1969., Iža, shallow-pool, 15. 4. 1970., Iža - Komárno, little shallow-pool on a plough, 15. 4. 1970.

Chotín, shallow-pool on a field path, 15. 4. 1970., Zelený Háj, (near Hurbanovo), shallow pool on plough, 15. 4. 1970., Martinovce, shallow-pool on plough, 15. 4. 1970., Jarovce, a little shallow rural pool. 17. 4. 1970., Láb, shallow-pool on a field, 18. 7. 1970., Vajnory, shallow-pool on a field, 19. 4. 1970., Senec - Sládkovičovo, flooded ditches, 20. 4. 1970., Palárikovo, wide ditch



Figs. 1-6 *Daphnia atkinsoni* 1a - female from Okoč, 1b - dorsal plate, 2a - female from Palárikovo, 2b - dorsal plate, 3a - postabdomen of female from Okoč, 3b - terminal claw, 4 - male from Okoč, 5a - postabdomen of male from Okoč, 5b - terminal claw of male, 6 - rostrum of female from Okoč.

Table 1. Measurements of *D. atkinsoni*

♀♀	Okoč X ± s <sub>x</sub>	Polárikovo	Mralino- -Skopje	Nové Zámky
Total body length (mm)	2.25 ± 0.49	2.05 ± 0.23	2.20 ± 0.20	2.13 ± 0.35
Length of spine (mm)	0.42 ± 0.07	0.96 ± 0.22	0.31 ± 0.09	0.34 ± 0.11
Total carapace height (mm)	1.15 ± 0.28	1.15 ± 0.14	1.49 ± 0.29	1.22 ± 0.13
Length of head (mm)	0.453 ± 0.13	0.487 ± 0.085	0.336 ± 0.043	0.386 ± 0.108
Length of rostrum (mm)	0.0096 ± 0.001	0.0115 ± 0.003	0.0088 ± 0.003	0.0069 ± 0.001

near a village joining a large shallow-pool, 13. 5. 1970., Palárikovo, shallow-pool thinly covered with *Carex* sp., 13. 5. 1970., Palárikovo - Selice, a large shallow-pool in a field, 13. 5. 1970., Rastislavice, large shallow-pool in a field, 13. 5. 1970., Salka, shallow-pool, 17. 5. 1979., Drahňov, large shallow-pool with plantless bottom in a field, 2. 6. 1970., Hurbanovo, shallow-pool near a village, 14. 4. 1967., Nové Zámky, shallow-pool, 17. 4. 1967. (fig. 18)

The material from the following localities was analysed in more detail:

Okoč, May 6. 1955 — there occurred individuals of *Daphnia atkinsoni* with a well-developed dorsal ridge but we have also found many transitions of forms towards *Daphnia ulomskyi* with less or very little developed dorsal ridge.

Palárikovo, May 13. 1970 — all the individuals we examined were very similar to *Daphnia atkinsoni* var. *bolivari* (Richard, 1896) as found only in South America. All the individuals have relatively high head with a well-developed dorsal ridge as well as more strongly developed spina.

Nové Zámky, April 14. 1967 — the individuals found had features very similar to those of *Daphnia ulomskyi*.

Jugoslavia: Mralino - Skopje, April 2. 1970 — individuals described as *Daphnia ulomskyi* (Petkovski, 1970).

The study of variability is based on the following characters: body dimension (measured according to Šrámek-Hušek, 1962), dorsal ridge, antennules and rostrum, antennae, shell-spine, number of setae on endopodites, postabdomen, bionomy. The number of measured individuals of each sample was 13.

#### RESULTS AND DISCUSSION

The description of *Daphnia atkinsoni* is not given because it agrees with that given in literature (Johnson, 1956b).

The form of the head and dorsal ridge (Figs. 1, 2, 7—9).

The form of head in all females (with summer eggs as well as with ephippium) depends on the size of the dorsal shell ridge and plate. If the plate is well developed then the head is like in *Daphnia atkinsoni* (Okoč, Palárikovo). If denticles on the plate are not developed, the head shape resembles that of *Daphnia ulomskyi* (in most specimens from Slovakia).

Altogether we have found two types of the dorsal ridge:

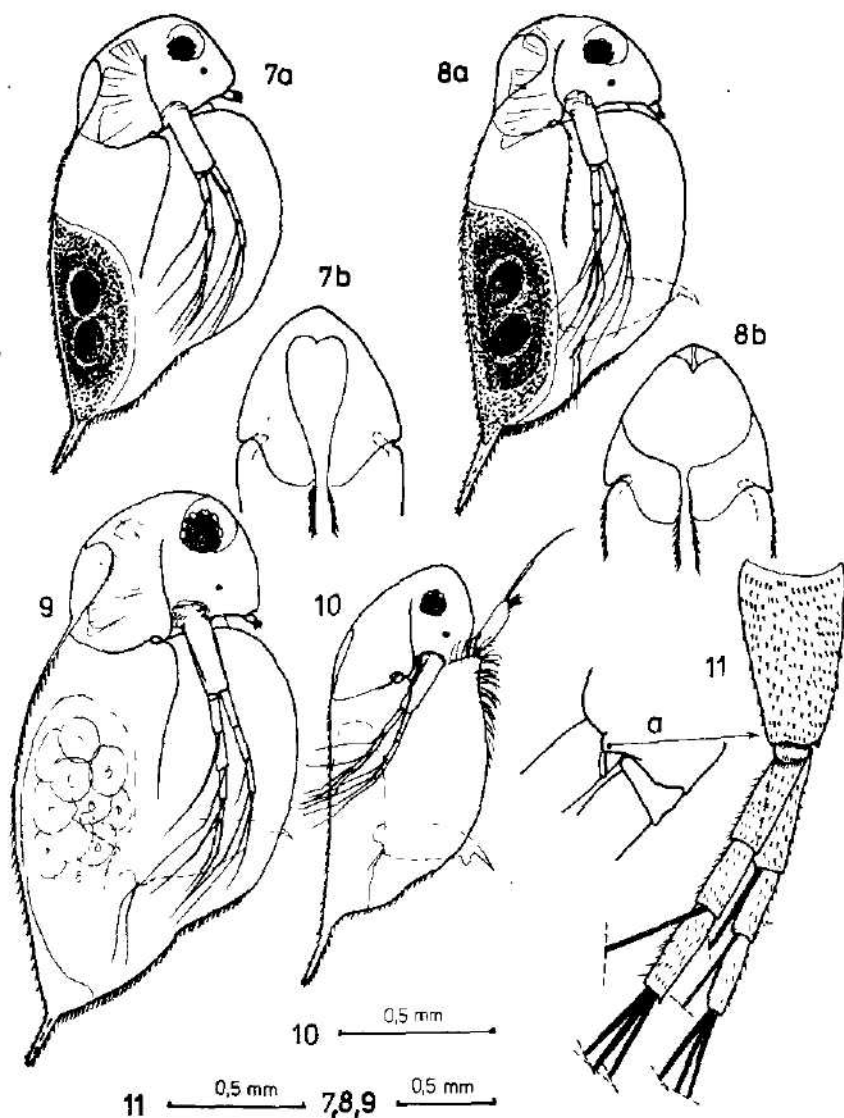
A) with well-developed dorsal plate — as it is with the typical individuals of *Daphnia atkinsoni*. This dorsal plate often reaches up to 1/3 of the head width and it is lined with denticles. The thickness of the denticulation changes from case to case and is often interrupted. (Figs. 1, 2, 8)

Table 2. The number of setae on endopodites

Trunk limbs of pairs	Mralino-Skopje	Polárikovo	Okoč
2 <sup>nd</sup>	12—15	15—18	11—15
3 <sup>rd</sup>	47—59	48—59	45—60
4 <sup>th</sup>	37—43	38—45	33—40

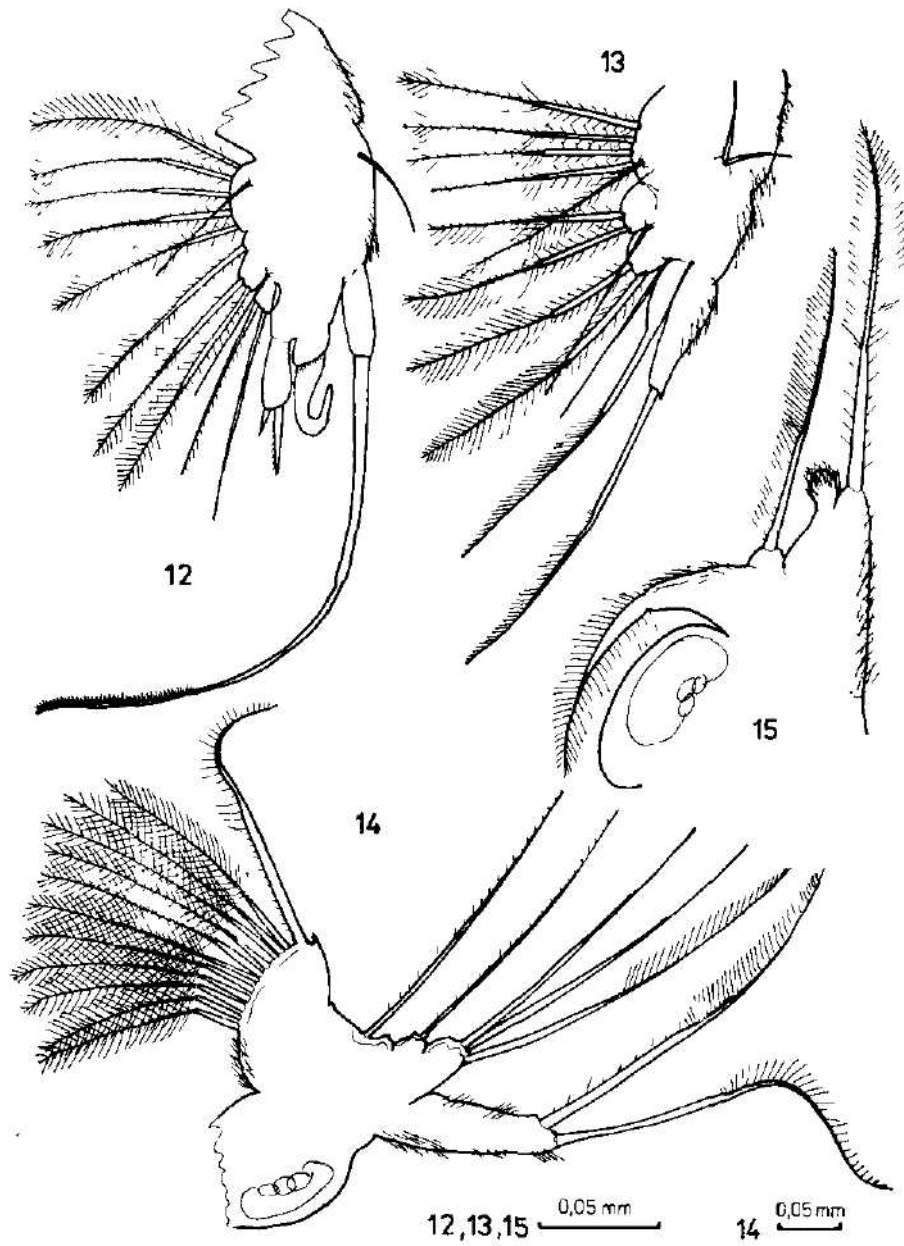
B) with the dorsal plate typical for *Daphnia ulomskyi* — the plate is very narrow and inconspicuous. It is reticulated polygonally (Nové Zámky, Mralino-Skopje). Always without denticles (Figs. 7a,b).

There exists a series of transitions between both the types of the plate. The thickness of one branch of the plate varies from  $1/3$  (*Daphnia atkinsoni*) to  $1/8$  (*Daphnia ulomskyi*) of width of the head. The same also applies to variability of the male dorsal plate.



Figs. 7-11. *Daphnia atkinsoni*. 7a — female from Mralino - Skopje, 7b — dorsal plate, 8a — female from Okoč, 8b — dorsal plate, 9 — female from Okoč, 10 — male from Mralino - Skopje, 11 — antennae.

Antennules and rostrum — one of the distinctive features in the Manujlova's key (1964) is the shape of the rostrum and the position of antennules of both the species: „Rostrum points downwards, the antennules are distant from its end (*Daphnia*

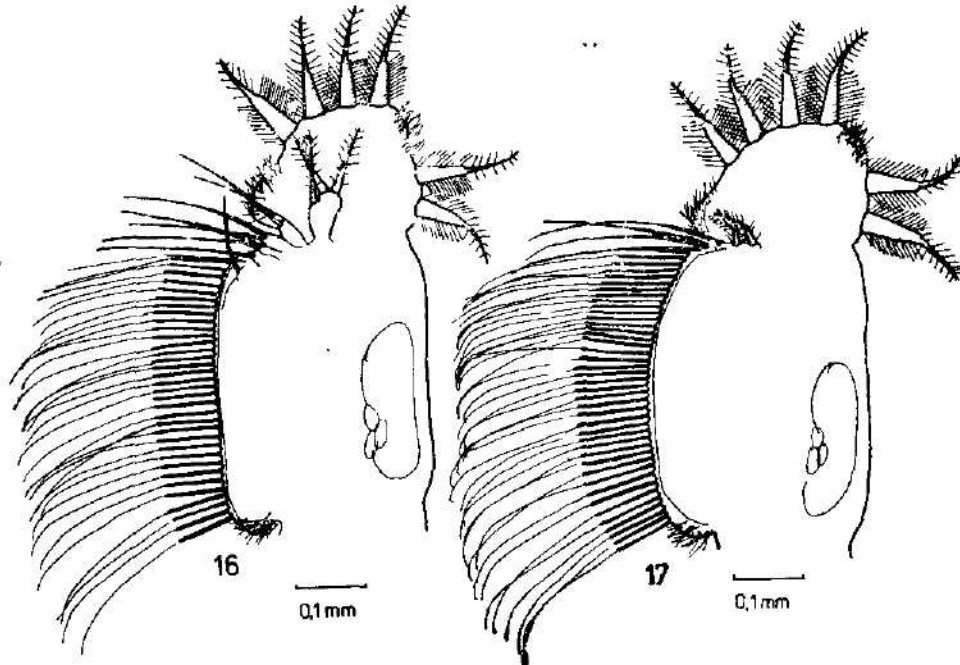


Figs. 12—15. *Daphnia atkinsoni*. 12 — 1<sup>st</sup> male trunk limb, 13 — 1<sup>st</sup> female trunk limb, 14 — 2<sup>nd</sup> female trunk limb, 15 — 5<sup>th</sup> female trunk limb.



*atkinsoni*; rostrum raised, the antennules are nearer to its end and they point forward (*Daphnia ulomskyi*)." (Fig. 6)

According to our measurements the distance of antennules from the end of rostrum cannot be used for the identification. The length of the rostrum of the ephippial females from Slovakia and Jugoslavia with sclerotinised carapace is more pointed than in parthenogenetic ones (Table 1.) The position of antennules depends on the length of the rostrum.



Figs. 16, 17. *Daphnia atkinsoni*. 16 — 3<sup>rd</sup> female trunk limb, 17 — 4<sup>th</sup> female trunk limb.

Antennae (Fig. 11) — small spinules covering antennae vary in thickness and in form within one population. Spinulation is not related to the development of the dorsal plate because it can also occur on the individuals with a very little developed plate. Therefore it has low taxonomic value.

Shell is denticulated along its margin. On its ventral side the spinules occur along 1/3 of the length (on the dorsal margin the spinules reach to the basis of the dorsal plate. Dorsal ridge carrying the keel with spinules on both its sides.

If the spinulation is well-developed also on the dorsal plate, they also occur on another ridge laterale along the shell (Fig. 2a).

Shell-spine — when compared with the rest of the body the spine of all the observed individuals is rather short and relatively thick at its basis. The populations from Slovakia and those from Jugoslavia (with poorly developed dorsal plate) have a similar shell-spine. On the other hand the populations with a well-developed dorsal plate have their shell-spine a bit larger but not as a rule.

It is the population from Palárikovo that serves as an exception. Their shell-spine resembles that of *Daphnia atkinsoni* var. *bolivari*. According to the illustration in the

Manujlova's key (1964) the shell-spine of the South American variety is straight while the individuals from Palárikovo have a bent shell-spine (Fig. 2a). The population from Palárikovo had its shell-spine twice as long than that of the other populations observed.

Trunk limbs (Figs. 12—17) — the 1<sup>st</sup> and 5<sup>th</sup> pairs of the limbs of females and males was observed (neither in their shape nor in the number of setae). Limbs of

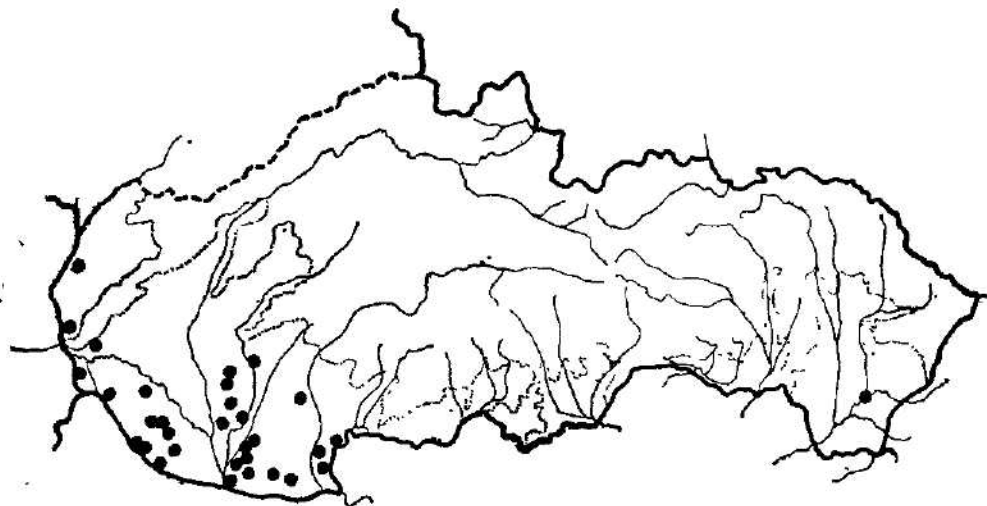


Fig. 18. Distribution of *Daphnia atkinsoni* in Slovakia.

2<sup>nd</sup>—4<sup>th</sup> pairs do not show any essential changes in their shape either (even in different localities). The number of setae on exopodites of 3<sup>rd</sup> and 4<sup>th</sup> pairs of the limbs is constant (6) but there are individual differences in the number of setae on endopodites (Table 2).

Postabdomen (Figs. 3a, 3b) — it is of the same build in all populations studied. The only difference is in the number of small spines on the distal line of postabdomen. The description of postabdomen is identical with those already published (Šrámek-Hušek, 1962; Herbst, 1962; Manujlova, 1964; Flössner, 1972; Behning, 1941, as well as in papers by Johnson, 1962b and Petkovski, 1970).

We also observed a cluster of fine bristles at the bases of the terminal claws of the individuals with a well-developed dorsal plate — the character that has only been stated with the *Daphnia ulomskyi* individuals up to the present.

Neither the postabdomen of the males showed any expressive variability — whether the male had a well-developed dorsal plate or not.

Colour — in individuals with a thick carapace above all those with ephippium this is bright yellow-brown.

Bionomy — all the individuals collected from the territory of Slovakia were found in the temporary shallow pools (puddles, ditches, shallow-pools on fields and meadows) between the beginning of April and the beginning of July. In the autumn they did not occur in our samples. According to our collections as well as data found in literature, they are typical representatives of temporary waters. They occurred

in the samples either as the only representatives of Cladocera, or most often accompanied by *Daphnia magna* and *Moina brachiata*. They occurred much more rarely with the following species: *Daphnia similis*, *Daphnia pulex*, *Daphnia curvirostris*, *Daphnia longispina*, *Ceriodaphnia reticulata*, *Ceriodaphnia laticaudata*, *Simocephalus expinosus*, *Scapholeberis aurita* and *Chydorus sphaericus*.

The distribution of the species is mainly restricted in Žitný ostrov, in the lowland parts of the rivers Váh, Nitra, Žitava, Hron and Ipel. We have also found this species in lowland of Záhorie, and once in the East Slovakia lowland.

#### DIFFERENTIATION FROM CLOSELY RELATED SPECIES

In the area of the distribution in Slovakia the species *Daphnia atkinsoni* can be misidentified with *Daphnia similis* and *Daphnia magna*.

The most distinctive features of morphology of *Daphnia atkinsoni* opposite to *Daphnia similis* are: 1) Dorsal ridge of the carapace and its extension into the head shield (these structures can be adequately investigated only in dorsal view). 2) distance of antennules from the end of the rostrum.

*Daphnia atkinsoni* — 1) The extension of the dorsal shell ridge into the head forms a dorsal plate. It may be wide 1/3 to 1/8 of width of the head. 2) Antennules are near the end of rostrum and sensory setae protrude over the rostrum by their whole length.

*Daphnia similis* — 1) The extension of the carapace into the head is either about as wide as the rest of dorsal shell ridge or narrower. 2) The distance of antennules from the end of rostrum is longer (2–3 length of antennules) and sensory setae never protrude over the rostrum by their whole length.

*Daphnia magna* is the next one of subgenus *Ctenodaphnia* which lives in Czechoslovakia. This species is easily distinguished by the shape of dorsal margin of its postabdomen.

#### SUMMARY

The study is centred on the comparison of *Daphnia atkinsoni* and *Daphnia ulomskyi*. Following characters were studied using the population from Slovakia and Jugoslavia: the dorsal plate (rostrum, position antennules in relation to rostrum, spinulation of antennae, the number of setae on endopodites, mainly on 3th and 4th pairs of limbs, postabdomen, cluster of hairs at the basis of the terminal claws.

It is apparent that *Daphnia atkinsoni* and *Daphnia ulomskyi* belong to the same species and according to the law of priority the name of *Daphnia atkinsoni* Band, 1859 should be used.

#### Acknowledgments

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**NOTE ON GROWTH OF THE BROWN TROUT (*SALMO TRUTTA M. FARIO*)**

Jaroslav POUPE

Received March 10, 1980

**Abstract:** 112 specimens of the brown trout, *Salmo trutta morpha fario*, angled in 13 localities in Bohemia, were studied with regard to growth. Scale method was used. Broad ranges in growth rate were observed both among individual localities and in specimens from the same part of the stream. Generally, the growth rate is evaluated as fast.

INTRODUCTION

The brown trout is planted very intensively in the Czech Socialist Republic. E. g., in 1976 only, according to fishery statistics of the Czech Anglers' Association, 1, 145, 612 specimens of yearlings and older specimens were artificially planted. The turn-out of the trout planted in that year ranged in various anglers' districts from 13 to 85%, the average was 26%. Better results for long-term periods have been noted in southern Moravia (56%); here it has been as much as 120% in some districts (Dyje 14). The smaller legal size here (23 cm of total length) plays certainly an important role. The smallest turn-out is observed in western Bohemia (13%), where apparently some limitations in angling influence (e. g. angling using only artificial fly on the river Otava). Statistical data do not differ among trouts reproduced by normal, natural spawning from those planted artificially. With regard to this fact the values of "returned" fish must be lower. In this contribution I wish to bring some material which could help increase the turn-out from trout streams.

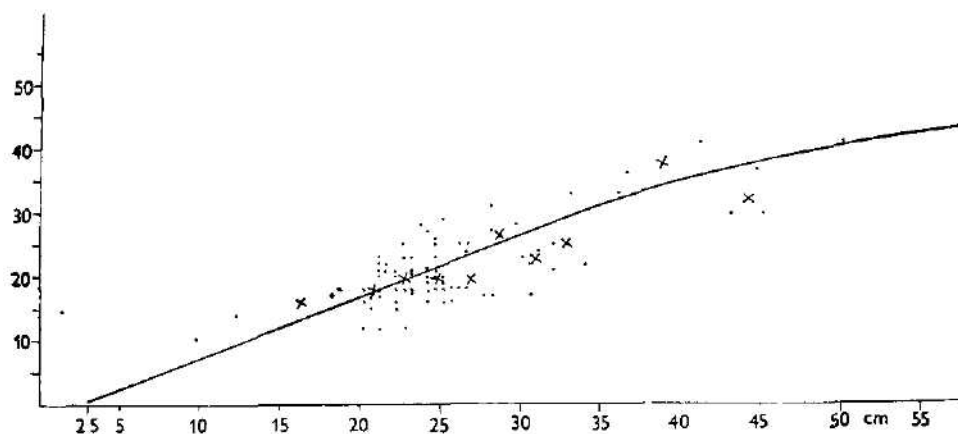


Fig. 1. Body/scale relationship at the time of scale formation. Dots — actual values, crosses — averages.

The growth of brown trout was studied in Czechoslovakia recently by many authors, e.g. Balon (1959), Kirka (1964), Libosvářský, Lusk, Krčál (1971), Leontovyč, Vostradovský (1974). From non-Czechoslovak authors the works of Hale and Smith (1955), Ball (1961), Fish (1963) should be mentioned.

#### MATERIAL AND METHODS

Scale samples were collected from 1967 up to 1977. Altogether 145 samples were obtained, for age determination scales from 112 specimens only were used. The rest represented regenerated scales. Localities were as follows: the brook Janovický potok, tributary of the river Sázava, district Benešov; the brook Jevanský potok, tributary of the Sázava, district Prague-East; the brook Kačák, tributary of the river Berounka, district Beroun; the rivulet Kocába, tributary of the Vltava, district Píbram; the brook Konopištský potok, tributary of the Sázava, distr. Benešov; the river Ohře below the riverine lake Nechranická přehrada, district Chomutov; the river Tichá Orlice, tributary of the Labe, district Ústí nad Orlicí; the brook Petroupinský potok, tributary of the Sázava, district Benešov; the brook Suchomastský potok, tributary of

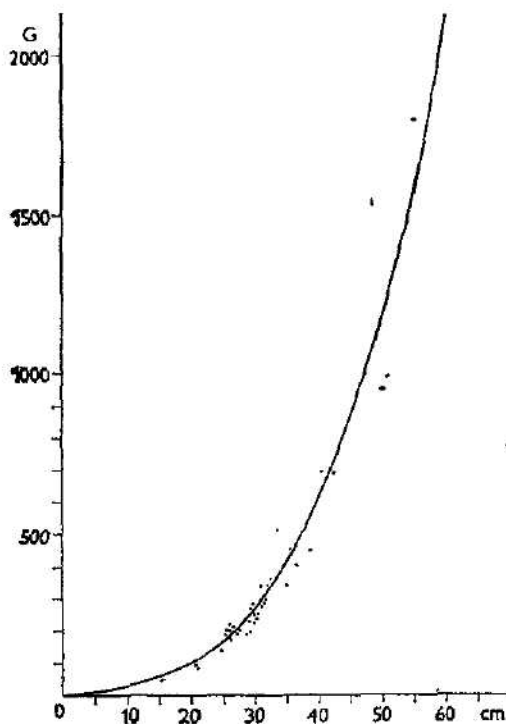


Fig. 2 Total length/weight relationship; dots — actual values.

the Berounka, district Beroun; the brook Štěpánovský potok, tributary of the Sázava, district Benešov; the riverine lake of the river Úhlava, district Klatovy; the brook Zahofanský potok, tributary of the Berounka, distr. Beroun; the river Vltava above Prague, district Prague West. These localities represent all kinds of waters inhabited by the trout in this country.

During angling I used lures — dead fish and artificial flies. Scales were removed following the method described by Leontovyč and Vostradovský (1974) and presented in envelopes; all necessary notes were made in the field. Scales were then studied in laboratory using Zeiss Lesengerat magnified 17.5 times. The annuli were noted on oral part of the scales the evaluation of back calculation or growth was made by use of Lee's method (Fig. 1); the relationship between SL (body or standard length) and TL (total length) and weight is demonstrated in Fig. 2 the relation-

ship between average growth and average increments in single age groups is shown in Fig. 3. Fultons condition index  $K = \frac{W \cdot 10^5}{L^3}$  was calculated for single age categories. Conversion factor for relationship between the total and standard length was calculated for all age categories and the average value determined.

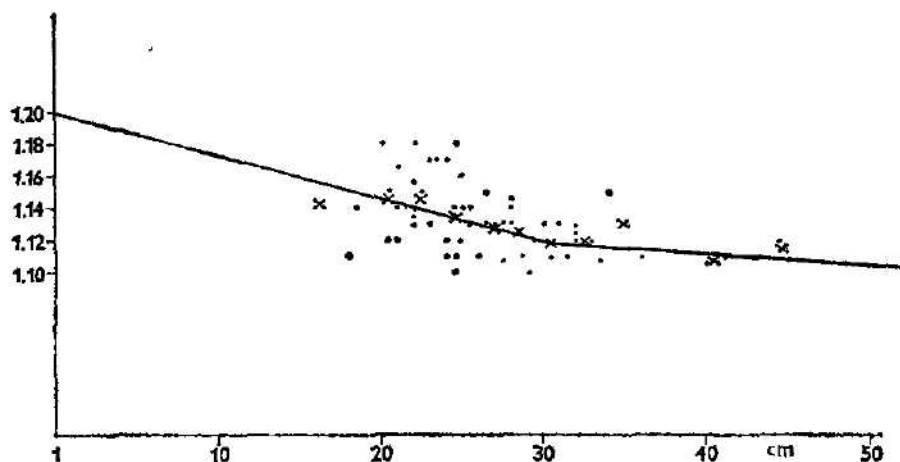


Fig. 3. Relationship of the total length to the standard length. Dots — actual values, crosses — averages.

#### RESULTS AND DISCUSSION

The body length at the time of scale formation was ascertained graphically as 25 mm. The correction factor body length /standard length ranges between 1.10—1.27, increasing in small fishes; the average value is 1.156. In 42 specimens cursory study of food was performed; the digestive tract contained small invertebrates, only in 7 cases fish rests were ascertained, and in one female (weight 1.8 kg) 3 voles and one gudgeon (*Gobio gobio*).

Concerning the body length at the time of scale formation there are considerable differences in the data given by various authorities (e. g. Frank 1959, Leontovyč-Vostradovský 1974 and others). Studying this problem by observing trout fry from hatcheries using 80 specimens I noted ranges between 16—35 mm. These ranges correspond also with the extreme values found graphically. The length/weight relationship was studied with regard to those of the body length/weight and the total length/weight. Graphical illustration seems to be better for quick calculation. The calculated weight average corresponds to sizes slightly overlapping the legal size of 25 cm (TL). A small number of specimens from single localities prevented me from reaching more precise conclusions concerning their growth. The fastest growth seemed to be manifested in trouts inhabiting the brook Janovický potok, a bad growth appeared in trouts from the brook Štěpanovský potok. These results coincide with those of Frank (1959), Kirka (1964), Leontovyč — Vostradovský (1974), Lohnický (1963). However, I cannot exclude that my results were influenced by the selectivity of the gear used. The growth of trouts under natural conditions was almost identical with trouts reared in special rearing "trout brooks". In some cases the legal size for angling was reached in the second year of life (according



to private communications of trout breeders, not verified by me personally). This refers to the brook Kosový potok (near the town of Tábor), the tributaries of the rivulet Chotýšanka (Benešov district), the brook Lomná near the town of Jablunkov (Moravia), the tributaries of the rivers Malše and Švarcava in southern Bohemia, the brook Ještědka, the tributary of the river Jizera (Liberec district).

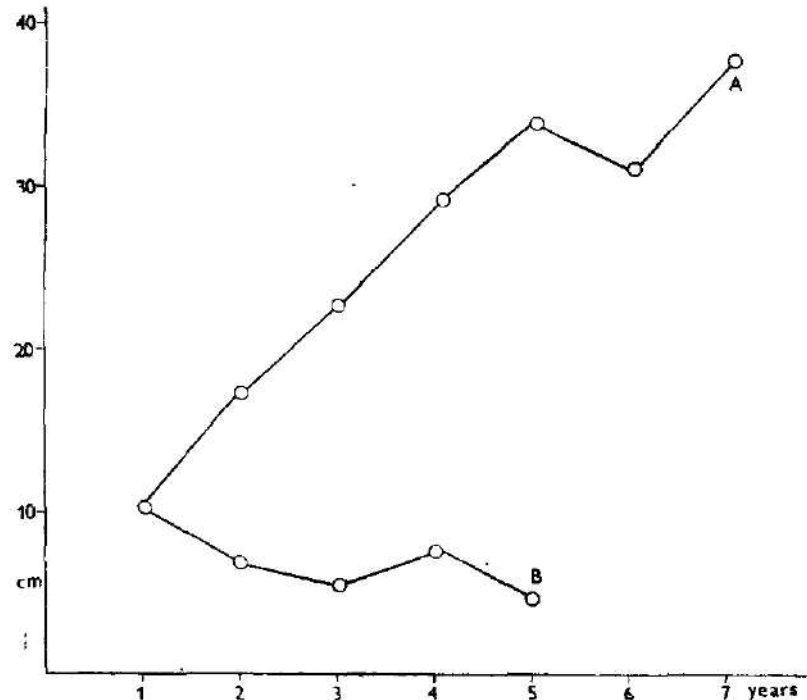


Fig. 4. Average annual increments. A — average calculated body length, B — average increments of body length. By dots represented calculated body lengths reached to the posterior margin of each annulus. All material summarized.

The growth of brown trout is strictly dependent on ecological condition of the given locality. Important factors are the number of specimens planted, the basic primeval population of the trout, the number of hiding places, the number of fish species which can represent either food, or competition for the trout, and the methods of fishing. The same results were demonstrated by Libosvářský (1973). Trout population in most places of its occurrence can be influenced by suitable use of fishing regulations. The lowering of legal size from 25 cm of TL to 23 cm of TL in south Moravian fishery district caused the apparently greater turn-out of trouts. Members of angling society in a given district wish to restrict angling with regard to the angling activities of other organizations that, in their opinion, reduces the number of fish in their district, and in this way they suppose to protect trout in their own angling district. It was really observed on some brooks often visited by anglers that the final number of trout caught by way of electrofishing in autumn for the rearing purposes is about 1/10 of the expected number. Anglers believe that this

Table 1. Summary of back-calculated growth and age class distribution in all examined trouts (112 sp.)

age	number of specimens	SL at the time of capture ranges below them ave.	TL at the time of capture ranges ave. all in mm	weight in g at the time of capture ranges, below the average	K	$l_1$	$l_2$	$l_3$	$l_4$	$l_5$	$l_6$	$l_7$	
II	3	155	184	160	1.49	117							
		120	140	—		90							
		220	250	—		158							
III	37	200	250	170	1.70	102	180						
		140	192	—		90	147						
		225	260	—		123	204						
IV	38	233	266	210	1.34	101	164	213					
		180	210	180		85	128	153					
		275	295	270		131	203	255					
V	27	300	338	360	1.45	110	176	242	284				
		230	260	190		77	125	170	214				
		570	610	1000		155	290	355	570				
VI	5	379	414	960	1.91	112	190	268	327	370			
		265	300	250		91	145	185	225	265			
		475	510	1430		131	231	365	415	454			
VII	1	265	300	250	1.33	72	132	175	202	248	265		
VIII	1	410	450	—	—	94	141	188	255	305	354	382	
		112	243	281	298	1.51	104	173	227	294	342	311	382
converted to the total length (TL) in mm						132	204	260	330	380	349	421	
calculated weights in g						44	87	155	364	522	422	650	

fact is caused by incomplete registration of the catches, but they do not take into account the normal fish mortality and mortality brought about by wounds caused by hooks in smaller individuals returned into water. Through angling only a part of normal trout production can be obtained (see Libosvářský et al. 1971).

In 1978 the water reservoir Větrkovice at Koprivnice (the angling district Lubina 3 A), 22 ha of the surface area, was opened for angling. In autumn 1977, about 8000 yearlings and two-year old brown trouts were planted there. In only two first days of the subsequent spring season (1978) more than 2000 specimens of brown trout were angled. No fish of under-legal size was registered. The angling pressure was demonstrated by over 500 anglers, who all captured 4 trouts, according to fishing rules.

This example is reported as a demonstration of the angling pressure on trout population, under special conditions.

Table 2. Comparison of own results with selected data from another localities

Locality and author	$l_1$ $L_1$	$l_2$ $L_2$	$l_3$ $L_3$	$l_4$ $L_4$	$l_5$ $L_5$	$l_6$ $L_6$	$l_7$ $L_7$
Hinec potok Kirka 1969	55 63	69 80	92 106	112 129	136 157		
Nebeská Rybná Lohnský 1963	62 71	120 139	153 177	174 201			
Biela Orava Holčík 1969	73 84	129 149	199 230	212 245			
Přimda Frank 1962	77 89	140 162	182 210				
Svratka Peňáz 1968	83 96	129 149	178 206	238 275	301 347		
Loučka Libosvářský 1968	91 105	153 177	177 204	195 225	223 257		
Hubenov-reservoir Vostradovský 1974	96 111	233 269	275 317				
Orava-reservoir Holčík-Bastl 1970	102 118	181 209	324 374	402 462	509 585	613 708	703 812
author	104 132	173 204	227 260	294 330	342 380	311 349	382 421
Klčava-reservoir Frank 1959	109 126	184 212	318 367	407 470	451 521		
Loučka-lower part Libosvářský 1968	112 129	159 183	184 212				

Libosvářský 1971, 1973 proofed angling can exploit only a part of available production from the trout stream. It seems necessary that some limitations concerning brown trout angling should be relieved within the limits of the present regulations. In this way the interest of anglers could be increased and the price of anglers' licenses lowered. As an example of a district where the angling pressure is low, because it is situated far from larger towns, is a part of the river Vltava near Kamýk (Vltava 15). Here during 1972—5 the considerable number of 56,000 specimens of various salmonids was artificially planted, and during the same period from 9,680 brown trouts only 160 specimens were captured. Altogether only 345 salmonid fishes were angled, nearly half the number being represented by the brown trout.

This part of the river Vltava situated among two dams of the neighbouring valley water reservoirs is visited only by a few anglers from the town of Příbram; most anglers here are not interested in trout angling. I suppose, that the trends to limit the number of angling persons and the number of fish angled and to increase the *minimum legal size of fish* are *hindering factors in the advance of angling*. As regards salmonids I recommend to permit to one angler more than four specimens during one excursion, to visit the trout brook more than 3 times per week, and last

but not least, that the minimum legal size be lowered from 25 cm of total length (TL) to 20–23 cm of TL.

When the brook Petroupimský potok was fished using electric current, from 560 trouts only 20 specimens overran the legal size and only one specimen was the "trophy fish". It is common in larger anglers' districts, such as are common on the river Moravice drainage or on the rivers Blanice Vodňanská, Orlice and Bečva, that during a one-day trip the angler catches, among 30 trouts, only 2-3 specimens having the legal size.

Recently most drainages were enriched by the planting of yearlings of the brown trout and, simultaneously, also by specimens two or three years old. Therefore the size of population is not dependent only on the number of native trouts in the brook. The trends to the artificial increase of the trout population have the opposite results — the lowering of catch resulting from the decreased growth of overfished trout streams due to the lack of food.

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#### SUMMARY

1. According to the structure of scales the growth of 112 brown trouts from 13 localities in the Czech Socialist Republic was ascertained.
2. The average body length at the time of scale formation was graphically determined to be 25 mm
3. The relationship coefficient between the body length (SL) and the total length (TL) is 1.156 for specimens over the legal size, (25 cm of TL), it decreases with the increasing growth.
4. The growth of the brown trout is very rapid, but considerable differences were found within one locality and among individual localities.
5. Every trout stream must be treated individually from the anglers point of view.
6. The minimum legal size of 25 cm TL seems not to be profitable from the anglers' point of view, and its lowering to 20-23 cm TL would be advisable.
7. Other limitations concerning the angling for the brown trout based on valid official regulations concerning the number of excursions permitted to one angler for fishing in brooks for brown trouts, the number of specimens caught, etc., must be used or relived according to the angling pressure and the actual status of trout population in a particular stream.

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**GYNANDROMORPHISM, INTERSEXUALITY AND TERATOLOGY OF EXTERNAL GENITALIA IN THE ORDER EPHEMEROPTERA**

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**Abstract:** Literary data and data obtained by the study of more than 20 specimens showing gynandromorphism, intersexuality or external genitalia teratology are summarized. While head and thorax show the bilateral type of gynandromorphism, abdomen exhibits a mosaic-like distribution of male and female portions; exceptions are described in detail. Genetically conditioned gynandromorphism is considered to be either spontaneous (early loss of an X chromosome) or connected with polyspermy and starting of parthenogenetic embryogenesis. Gynanders are most frequent in the families Baetidae, Heptageniidae and Leptophlebiidae (large number of species, high degree of sexual dimorphism). Intersexuality is caused by parasitic worms of the family Mermithidae. Parasitism is connected with the masculinization of females (10-40%) and at least partial castration (75-100%). Intersexes occur only in the family Baetidae. External genitalia teratology is conditioned either genetically (occurrence of supernumerary forceps on sternum VIII) or by a relatively very high ability to regenerate loss of genital or even 1-2 pregenital abdominal segments in larval stage.

Mayfly specimens (mostly adults or subimagos) having both male and female secondary sexual characters were first mentioned many years ago (Lestage, 1922; Bengtsson, 1928 and others). Since then several tens of such specimens have been described in 5 mayfly families. These individuals called "anomalous or monstrose specimens", "hermaphrodites", "intersexes", "sexual mosaics", "gynanders or gynandromorphs" etc. actually represent three categories of departures in the arrangement of secondary as well as primary sexual characters: true gynandromorphism (male and female parts of body normally developed, only exceptionally reduced in size, evenly or unevenly distributed), intersexuality (male and/or female parts of body intermedially developed, always unevenly distributed) and external genitalia teratology (deformations or unusual location of forceps and penis lobes).

Previous publications mostly represent descriptive morphological studies of these phenomena. Only little attention has been paid to factors causing gynandromorphism and intersexuality and to a relatively higher occurrence of these specimens in some families. In the following paragraphs morphological characteristics of these specimens are summarized and an attempt to analyze the nature, causes and distribution of these phenomena within the taxonomic groups is made.

**MATERIALS AND METHODS**

The following specimens showing atypical distribution of male and/or female secondary sexual characters or atypical arrangement of external genitalia were studied:

*Baetis alpinus* (Pictet), adult: Czechoslovakia, South Bohemia, Vltava riv., Ovesná, 23. x. 1953 leg. O. Winkler (specimen No. 1); *B. alpinus* (Pictet), adult: Czechoslovakia, North Bohemia, Teplá riv., Teplička, 12. vi. 1955 leg. V. Landa (No. 2); *B. fuscatus* (L.), adult: without any data, leg. M. Straškraba (No. 3); *B. fuscatus* (L.), adult: without any data, leg. M. Straškraba (No. 4); *B. fuscatus* (L.), adult: Czechoslovakia, South Bohemia, Lužnice riv., Bechyně, 4. viii. 1973

leg. T. Soldán (No. 5); *B. fuscatus* (L.), adult: Czechoslovakia, Central Bohemia, Sázava riv., Stříbrná Skalice, 25. ix. 1976 leg. T. Soldán (No. 6); *B. muticus* (L.), adult: Czechoslovakia, Central Bohemia, Bojovský brook, Měchenice, 23. v. 1960 leg. V. Landa (No. 7); *B. muticus* (L.), larva: Czechoslovakia, Central Bohemia, Zahořanský brook, Davle-Libřice, 5. xi. 1977 leg. T. Soldán (No. 8); *B. rhodani* (Pictet), adult: Czechoslovakia, South Moravia, brook, Chřibská Kamenice, 28. viii. 1957 leg. V. Landa (No. 9); *B. rhodani* (Pictet), 35 larvae: Czechoslovakia, Central Bohemia, Zahořanský brook, Davle-Libřice, 5. — 19. xi. 1977 leg. T. Soldán (No. 10); *B. rhodani* (Pictet), subimago, 2 adults, same data (No. 11); *B. vernus* (Curt.), subimago: Czechoslovakia, Central Bohemia, brook, Obořiště, 20. vi. 1960 leg. V. Landa (No. 12); *B. vernus* (Curt.), adult: Czechoslovakia, South Bohemia, Vydra riv., Turnerova chata, 17. viii. 1976 leg. V. Landa (No. 13); *Baetopus* sp., adult: Mongolia, Chovsgol, Tesimj gol riv., 14. viii. 1967 leg. Z. Kaszab (No. 14); *Centroptilum luteolum* (Müll.), adult: Czechoslovakia, Central Bohemia, Radotínský brook, Cí kánka, 10. vi. 1976 leg. Z. Pádr (No. 15); *Rhithrogena semicolorata* (Curtis), adult: Czechoslovakia, Central Slovakia, Solisková voda stream, Važec, 15. vii. 1973 leg. T. Soldán (No. 16); *Habroleptoides modesta* (Hagen), subimago: Czechoslovakia, South Bohemia, brook, Komárov, 21. iv. 1949 leg. V. Landa (No. 17); *Habrophlebia lauta* Etn, adult: Bulgaria, brook, Novo Pančarevo, 30. vi. 1978 leg. T. Soldán (No. 18); *Ephemerella* (*Ephemerella*) *ignita* (Poda), subimago: Czechoslovakia, South Bohemia, Lužnice riv., Tábor, 9. viii. 1975 leg. J. Vilimová (No. 19).

All the material studied is preserved in 75% alcohol and is deposited in collection of the Institute of Entomology, Czechoslovak Academy of Sciences, Praha. Legs, wings and genital segments of specimens dissected were transferred directly into Canada balsam with Cellosolve. Fresh material, when available (specimens No. 10, 11 and 18) was dissected in physiological saline, fixed with Bouin (Duboscque-Brasil modification) and embedded into Paraplast. Sections of thickness 4–6  $\mu$ m cut on a microtome (gonads) were stained with Mayer's haematoxylin-eosin.

Both control larvae of *Baetis rhodani* and larvae infected with parasitic worms were kept to the adult stage in normal aquarium at a temperature  $15 \pm 1^\circ$  C and 18 hours light day. Water was changed daily and occasionally aerated.

## RESULTS

### Morphological characteristics of gynandromorphs

The head of mayfly gynander is either male or female without the occurrence of the opposite sex characters, or male and female portions are bilaterally symmetrical. No case of mosaic-like distribution of characters has been reported so far. In the Baetidae male characters on head are usually conspicuously manifested by a normally developed turbinate eye. There is either left turbinate eye (Grandi, 1962; Berner, 1949; Landa 1949; specimens No. 2, 5, 7, 15 — this case seems to be more frequent) or right turbinate eye (Berner, 1949; Bugg, 1954) present. In gynanders of the family Leptophlebiidae there is also bilateral gynandromorphism in structure, colour and size of compound eyes (Daggy, 1944; specimens No. 17, 18). Of course, there are further differences in the arrangement of antennae, ocelli and in colour patterns of head apparent especially in the Baetidae (see detailed description by Landa, 1949). Rarely (specimens No. 5 — Figs. 1, 4) certain male structures (small, modified turbinate eye) occur on the female half of head. If the head shows bilateral gynandromorphism, the male and female portions are always clearly distinguishable, no head portion of unclear origin have been reported. The specimens with male head occur only in the Baetidae (males with ovaries — specimens No. 3, 4). This cases are probably extremely rare, no such individuals are mentioned in literature. On the contrary, specimens with solely female head were found in other families (Siphonuridae, Heptageniidae, Leptophlebiidae, Potamanthidae, and Ephemeridae). These specimens of course, have typical female eyes (Spieth & Ide, 1939; Bengtsson, 1928; Grimeland, 1963; Berner, 1957; No. 16). Some authors report the eyes of these gynanders "somewhat larger", e. g. Spieth & Ide (1939) for *Stenonema terminatum*.

Apart from several exceptions, the thorax of mayfly gynanders is mostly bilaterally symmetrical (including legs and wings) in the specimens of the Baetidae or predominantly female in other families where the gynanders occur. The tendency to mosaic-like



distribution is not so pronounced than that in abdomen although there are some cases indicating or resembling mosaics (No. 16). Bilateral distribution of characters and colour patterns (borders between male and female portions mid dorsal and mid ventral lines) is the most frequent case. Male portion of thorax can be either on the right hand or on the left hand (Bugg, 1954; Berner, 1949; Landa, 1969; Spieth & Ide, 1939; specimens No. 2.5). Bilateral symmetry on thorax occurs only in specimens with bilateral symmetry on head. Thorax symmetry can be of the opposite type than that in head. Male half of thorax on the right hand and male half of head on the left hand occur in specimens No. 2 (cf. Landa, 1949). Thorax symmetry is always longitudinal. Entirely female thorax was found by Grandi (1966) in *Baetis* and Spieth & Ide (1939) in *Potamanthus*, and in our specimens No. 1, 17, 18, 19. Also Bengtsson (1928) and Grimeland (1963) report female thorax in *Ameletus* gynanders. Entirely male thorax was found by Spieth & Ide (1939) in *Stenonema* and in our specimens No. 7, 15 (also specimens No. 3, 4 — males with ovaries-belong here). As far as the thorax of gynanders is concerned, there are two cases worth of our attention. In specimen No. 16 (*Rhithrogena semicolorata* — Figs. 6-9) there are male prothorax and fore legs while meso and metathorax with wings and middle and hind legs are not distinguishable from those of normal female. Judging from the colour patterns, the only case of mosaic-like distribution of male and female characters is known in *Hexagenia* (Berner, 1957). Although there are rests of bilateral symmetry in distribution of spots on the ventral side of thorax and on legs, mixture of male and female patterns indicates colour mosaic.

The pregenital abdominal segments of gynanders show mosaic-like distribution of characters in most specimens studied (Landa, 1949; Berner, 1949, 1957; Spieth & Ide, 1939; specimens No. 2, 5, 7, 15). No case of symmetry in distribution of secondary sexual characters has been described. Mosaic-like distribution of these characters is apparent only in species having sexual dimorphism in colour patterns since there is no dimorphism in shape of abdominal segments. In many specimens there are areas of unclear origin showing transitory types of colour patterns between males and females (cf. Landa, 1949; No. 5 — Figs. 1-5). No case of gynander with predominantly male characters was described. Either female segments or segment portions are prevailing (Berner, 1949, 1957; No. 15, 18) or male and female portions are approximately equally presented (Landa, 1949; Bugg, 1954; No. 5). The border between male and female portions of abdomen are usually not constituted according to abdominal segments, one segment can consist of both male and female portions. Mosaic-like distribution of characters occurs currently in the Baetidae, rarely in the Leptophlebiidae (cf. Spieth & Ide, 1939) and the Ephemeridae (cf. Berner, 1957). Entirely female pregenital abdominal segments in gynanders are referred by Bengtsson (1928) and Grimeland (1963) in *Ameletus* and by Grandi (1966) in *Baetis*. We found these conditions in specimens No. 16 and 19. Entirely male pregenital segments were found by Spieth & Ide (1939) in *Potamanthus* and in our specimens No. 3, 4.

Gynanders of mayflies, with some exceptions, always possess at least reduced forceps and/or penis lobes. Contrary to pregenital ones, the genital and postgenital segments often show a tendency to bilateral symmetry in arrangement of male and female characters. The following cases were observed as far as male external genitalia are concerned: (i) both gonopodes are normally developed (Landa, 1949; No. 15, 18), penis lobes present or absent; (ii) both gonopodes are present but reduced in length or in number of segments (Daggy, 1944; Bugg, 1954; No. 1, 3, 5, 16, 18, 19). Except for the Baetidae (penis absent), penis can be normally developed (Spieth & Ide,

Table 1 (continued)

Species	No. and stage of specimens	Collected in	Reference	Remarks
10. <i>Centroptilium luteolum</i> (Müll.)	1 adult	England	Bugg (1954)	gynandromorph (No. 15)
11. <i>C. luteolum</i> (Müll.)	1 adult	Czechoslovakia	present study	
12. <i>Closon simile</i> (Ent.)	1 adult	Finland	Tienasu (1937)	
13. <i>Heterocloen curiosum</i> (McDunn.)	1 adult	USA	Borner (1949)	typical gynandromorph
13. <i>Pseudocloen</i> sp.	1 adult	USA	Borner (1949)	
C. family Heptageniidae				
1. <i>Stenacron interpnucatum</i> (Say)	1 adult	USA	Needham, Traver & Hsu (1935)	
2. <i>Stenonema</i> <i>rubromaculatum</i>	1 adult	USA	Spioth & Ide (1939)	gynandromorph
3. <i>S. terminatum</i> (Walsh)	1 adult	USA	Spioth & Ide (1939)	
4. <i>Rhithrogena</i> <i>semicolorata</i> (Curt.)	1 adult	Czechoslovakia	present study	(No. 16)
D. family Leptophlebiidae				
1. <i>Habroleptoidea</i> <i>modesta</i> (Hag.)	1 subimago	Czechoslovakia	present study	gynandromorph (No. 17)
2. <i>Habroleptia lauta</i> (E.)	1 subimago	Bulgaria	present study	
3. <i>Leptophlebia cupida</i> (Say)	1 adult	USA	Daggy (1944)	gynandromorph (No. 18)
4. <i>L. nebulosa</i> (Say)	1 adult	USA	Daggy (1944)	
5. <i>Paraleptophlebia</i> <i>mollis</i> (E.)	1 adult	Canada	Spioth & Ide (1939)	
E. family Ephemerellidae				
1. <i>Ephemerella</i> <i>ignita</i> (Podia)	1 subimago	Czechoslovakia	present study	gynandromorph (No. 19)
F. family Ephemeridae				
1. <i>Hexagenia munda</i> <i>elegans</i> Traver	1 adult	USA	Borner (1957)	gynandromorph
G. family Potamanthidae				
1. <i>Potamanthus</i> <i>verticis</i> (Say)	1 adult	USA	Spioth & Ide (1939)	

Table 1. Gynandromorphs, intersexes and external genitalia teratology in Ephemeroptera

Species	No. and stage of specimens	Collected in	Reference	Remarks
<b>A. family Siphonuridae</b>				
1. <i>Ameletus inopinatus</i> Etn.				
<i>A. inopinatus</i> Etn.	1 adult	Norway	Bengtsson (1928)	
	1 adult		Grimeland (1963)	
<b>B. family Baetidae</b>				
1. <i>Baetis alpinus</i> (Pictet)				
<i>B. alpinus</i> (Pictet)	2 adults	Roumania	Codreanu & Codreanu (1938)	supernumerary forceps (No. 1-2)
<i>B. fuscatus</i> (L.)	2 adults	Czechoslovakia	present study	typical gynandromorph (No. 3-6)
<i>B. fuscatus</i> (L.)	1 adult	Czechoslovakia	Landa (1949, 1969)	
<i>B. fuscatus</i> (L.)	4 adults	Czechoslovakia	present study	
<i>B. muticus</i> (L.)	1 adult, 1 larva	Czechoslovakia	present study	(No. 7-8)
<i>B. rhodani</i> (Pictet)	1 adult	Belgium	Lestage (1922)	intersex
<i>B. rhodani</i> (Pictet)	4 adults, 5 larvae, 1 subimago	Roumania	Codreanu & Codreanu (1931)	probably intersexes
<i>B. rhodani</i> (Pictet)	1 adult, 1 subimago	France	Degrange (1960)	intersexes
<i>B. rhodani</i> (Pictet)	3 adults, 35 larvae, 1 subimago	Czechoslovakia	present study	intersexes (No. 9-12)
<i>B. scambus</i> Etn.	1 adult	Finland	Tiensuu (1937)	intersex
<i>B. vernus</i> (Curt.)	1 subimago	Czechoslovakia	present study	supernumerary forceps
<i>B. vernus</i> (Curt.)	1 adult	Czechoslovakia	present study	intersex
<i>Baetis</i> sp. (fuscatus?)	1 subimago	Finland	Tiensuu (1937)	intersex
<i>Baetis</i> sp.	1 adult	Italy	Grandi (1968)	
<i>Baetopus</i> sp.	1 adult	Mongolia	present study	(No. 13)

1939 — *Paraleptophlebia*; No. 19), reduced in size or completely absent (No. 16); (iii) bilateral symmetry occurs in male external genitalia: either left or right gonopode (reduced or normal) is present (Berner, 1949 — *Pseudocloeon*; Berner, 1957; Spieth & Ide, 1939 — *Stenonema*; No. 2, 4, 17). Penis (if present) is normally developed (Spieth & Ide, 1939) or one penis lobe is lacking (Berner, 1957) In the *Potamanthus* gynander only one penis lobe but both gonopodes are developed (Spieth & Ide, 1939). Reduced penis lobes in *Ameletus* gynander with forceps lacking are described by Grimeland (1963); (iv) all male external genitalia are lacking (Grandi, 1966; Berner, 1949 — *Heterocloeon*). Female external genitalia are either lacking or normally developed in gynanders with female pregenital segments (cf. Grimeland, 1963). We found reduced female openings also in specimens No. 3, 4 where pregenital segments were entirely male. Reduced openings (posterior margin of sternum VII not produced) were observed in specimens No. 16. Vestibulum was considerably reduced as well.

The postgenital segments (tergum X, paraprocti, epiproct and cerci with paracercus) always show bilateral symmetry (cf. Landa, 1949; No. 5) or they are entirely male (cf. Spieth & Ide, 1939; No. 3, 4) or entirely female (cf. Grandi, 1966, No. 16, 19).

#### Gonads of gynandromorphs

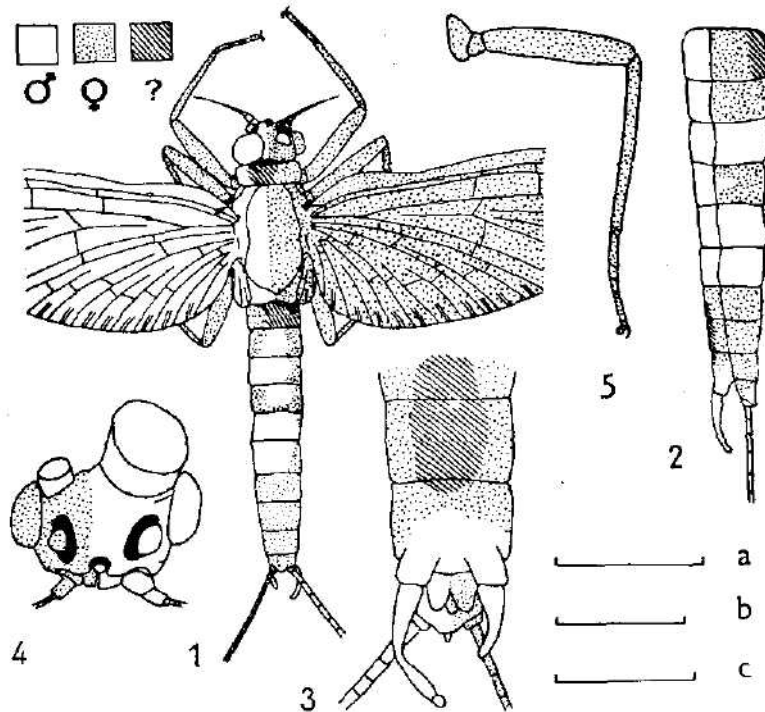
Since no true gynander was studied in the larval stage, gonads are described only in adults where testes are atrophied and empty and dilated oviducts are filled up with the eggs. In all specimens studied at least reduced gonads are present. As with the external characters, femal features prevail in internal organs as well — ovaries or their rests were found in most specimens. We found fully developed ovaries only in specimens No. 3 and 7. In remaining specimens with eggs in the abdominal cavity there were only reduced oviducts and reduced number of eggs present (No. 1, 4, 7, 16, 18, 19). However, previous oviposition cannot be excluded in specimens with normally developed openings. On the other hand, dilated oviduct usually reach only to abdominal segments II or III (No. 4, 7, 18) so that ovaries are apparently reduced. Also Spieth & Ide (1939), Berner (1949) and Grimeland (1963) found eggs in the abdominal cavity. In these specimens male ducts are sometimes present (No. 3, 4, 7, 16, 19) but they represent only ductus ejaculatorius and slight posterior portion of was deferens. Seminal vesicle and rests of testicular follicles were never found (cf. Landa, 1949). No spermatozoa were observed on sections (No. 7, 16). Similar conditions were found also in specimens without eggs in abdomen. Reduced seminal vesicles were observed in specimens No. 1 and 15 but their content could not be studied because of poor preservation.

Codreanu & Codreanu (1931) described larva with both functional testes nad ovaries: “.gonades formées de follicules produisant des spermatozoides en quantité massive et communiquant toutefois avec des oviductes typiques...”. Judging from external characters, this specimen might belong rather to intersexes, despite absence of parasites. We studied similar specimen of *Baetopus* (No. 14). Although the ovaries were normally developed and male ducts present we failed to find seminal vesicles and spermatozoa or rests of testicular follicles.

#### Morphological characteristics of intersexes induced [by mermithid parasitism

Contrary to gynanders, the individuals showing intersexual arrangement of somatic characters represent predominantly females with intermediately developed

male characters. As far as the intersexes are concerned, no case of symmetrical arrangement of characters was observed in our material. The occurrence of male characters is restricted to head and last abdominal segments (especially sternum IX). In typical intersexes, the thorax including wings and legs and abdominal segments I-VIII is always of the female character. The below description concerns intersexes induced by a mermithid parasitization.



Figs. 1-5: Gynandromorphism and intersexuality in the Ephemeroptera. Gynander of *Baetis fuscatus* (L.), specimen No. 5. 1 - whole specimen, dorsal view. 2 - abdomen, lateral view. 3 - last abdominal segments, ventral view. 4 - head, frontal view. 5 - fore leg. Scale A (Fig. 1): 2.5 mm. Scale B (Fig. 2): 3.4 mm. Scale C (Figs. 3-5): 1.7 mm.

Intersexual individuals usually possess a pair of turbinate eyes between normally developed female eyes. These turbinate eyes are by  $1/2-2/3$  smaller than normally developed ones in males. Although they are of the same colour as those in males, they are differently shaped, usually much more rounded. Light ring, present in some *Baetis* species is always lacking. In our material we found these conditions in most *Baetis* intersexes studied (specimens No. 6, 11, 12, 13). Male turbinate eyes of intersexes are usually of the same size (No. 13, 14) but sometimes one eye is larger than remaining one (No. 11). Also Codreanu & Codreanu (1931) and Tiensuu (1937) described similar cases. Development of one reduced turbinate eye is probably very rare; we found only three female larvae (No. 10) having the analgen of either only left (2 cases) or only right (1 case) male eye developed. Contrary to reduced male genitalia, which can be studied solely in adults, growing turbinate eyes are well visible under the cuticle of older larvae.

Intersexual individuals are characterized also by considerably modified forceps present on the posterior margin of abdominal sternum IX. Similarly to those of some gynanders, the forceps are often only one-segmented and much shorter than forceps of normal males (No. 11, 13). The same case is mentioned by Tiensuu (1937). In one specimen of our material (No. 6) the forceps are remarkably reduced and only forceps base resembles that of normal male.

#### Gonads of intersexes and infected specimens

As it has been mentioned above, the occurrence of intersexes in populations of some *Baetis* species is evidently connected with infection of larvae by larvae of parasitic worms from the family Mermithidae. In order to study the effects of parasitization on host gonads we dissected several hundreds of larvae of *Baetis rhodani* of which 163 larvae were parasited (mermithid larva present in body cavity of host larva). Of these, there were 151 female larvae (92.64%) and only 12 male larvae (7.36%).

The dissections of male larvae revealed that all the larvae were castrated (none of them with intersexual characters on head or abdomen). These larvae had died before the subimaginal moulting started. No rests of testes were found. Among 151 infected female larvae (the mortality in laboratory less than 10%), there were 35 larvae (23.2%) showing intersexual characters. These individuals exhibited full castration again. Histological treatment of last abdominal segments (VII-IX) enabled to recognize rests of oviducts not distinguishable during dissections. No ovaries were found in abdominal cavity of any larvae filled up with coiled mermithid larva. Rests of oviducts completely disappear in adults (No. 6, 11) so that castration caused by mermithid larvae in larval stage results in complete sterility of adults.

Infected larvae, which do not possess intersexual characters, represent various degrees of reduction of gonads. Some ovarioles and even those forming previtellarium were found in several specimens while in the others they are heavily damaged. In these cases germinal and follicular cells are indistinguishable, ovarioles are filled with degenerating tissues containing lysed oocytes with pyenotic nuclei and they do not form any egg chambers. In most specimens infected the vitellogenesis does not start at all, vitellarium as well as previtellarium are disintegrated before starting of yolk secretion.

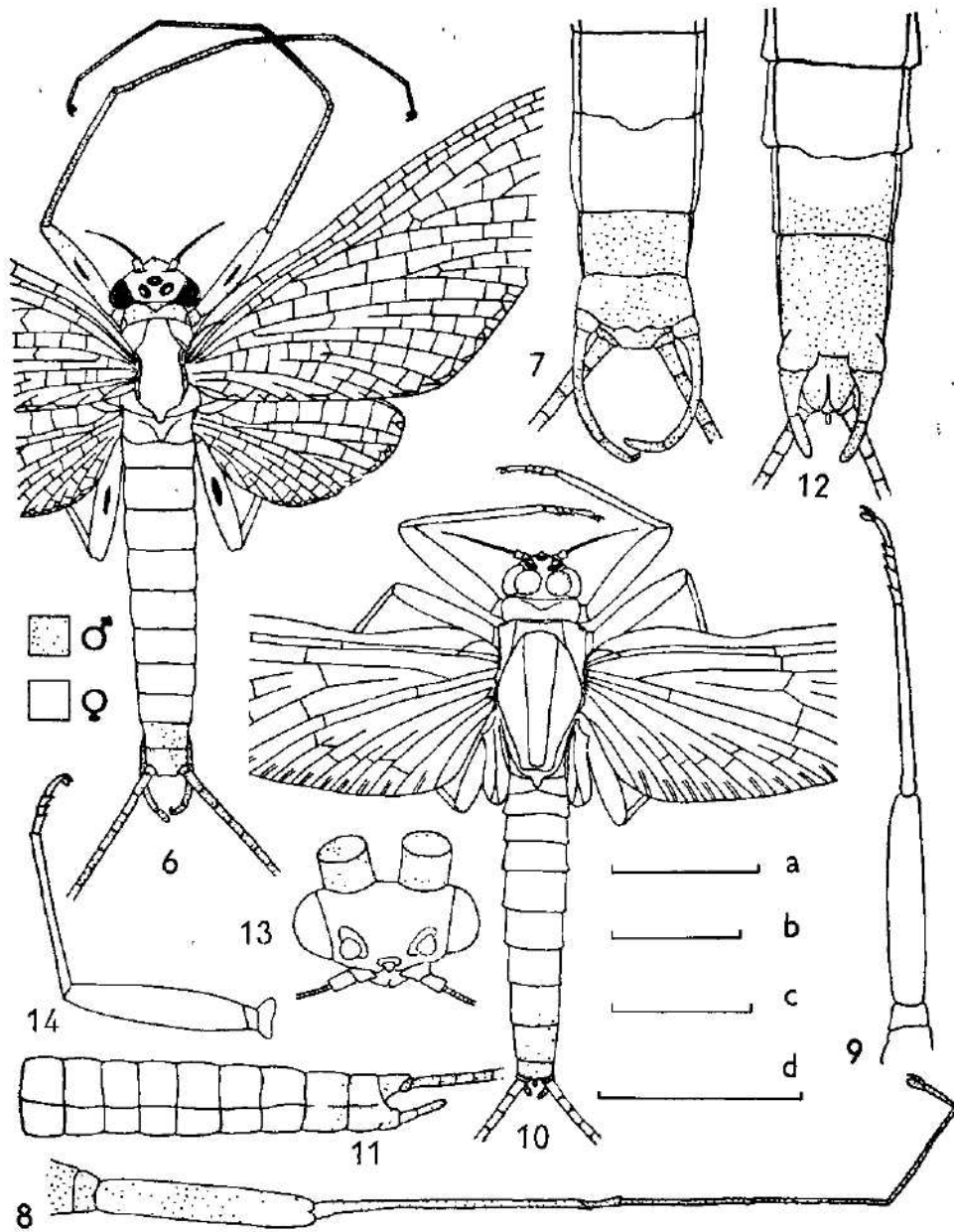
The ovarioles number cannot be usually stated because of resorption of ovary as a whole but it is undoubtedly strongly reduced. Some ovarioles of some specimens infected can probably give rise to several eggs, despite resorption of rest of ovary. The eggs are then present in abdominal segments of adult females without intersexual characters. In spite of the occurrence of some eggs, these individuals are practically sterile because the total fecundity is reduced to 0.5—1.0% in comparison with control females fecundity. In six adults, which have undergone mermithid infection in larval stage, 13, 29, 36, 41 and 68 eggs respectively were found.

After the mermithid larva leaves the body of host mayfly larva, the mortality of mayfly larvae will remarkably increase. We managed to rear to the subimaginal and imaginal stages only 14 larvae of which 4 were intersexes. Remaining larvae quickly died probably of a secondary infection.

#### Teratology of external genitalia

Apart from teratology of external male genitalia described in many specimens of gynanders and intersexes and discussed in respective paragraphs, there are some cases of atypical arrangement of forceps which are evidently not connected with atypical arrangement of secondary sexual characters. These cases are mentioned





Figs. 6-14: Gynandromorphism and intersexuality in the Ephemeroptera. Gynander ♂ of *Rhithrogena semicolorata* (Curt.), specimen No. 16 (Figs. 6, 7, 8, 9); intersex of *Baetis vernus* (Curt.), specimen No. 13 (Figs. 10, 11, 12, 13, 14). 6, 10 - whole specimen, dorsal view. 7, 12 - last abdominal segments, ventral view. 8, 14 - fore leg. 9 - hind leg. 11 - abdomen, lateral view. 13 - head, frontal view. Scale A (Fig. 6): 3.3 mm. Scale B (Figs. 7-9, 12-14) 1.6 mm. Scale C (Fig. 10) 2.5 mm. Scale D (Fig. 11) 3.0 mm.



in literature only in males, no cases are known as far as relatively less known female external genitalia are concerned. There are two distinct types of teratology in male external genitalia: supernumerary forceps and deformed forceps on the hind margin of sternum IX (in normal position).

Supernumerary forceps were observed posterolaterally on hind margin of abdominal sternum VIII which may be arranged similarly to tergum IX including a pair of sclerites near the basis of forceps. In addition to supernumerary forceps normal forceps on sternum IX are present. Codreanu & Codreanu (1938) describe two specimens of *Baetis alpinus* (Table I) having supernumerary forceps: there is either a pair of gonopodes or only right gonopode on sternum VIII. All supernumerary forceps are of the same length as normal ones and normally segmented. We observed a specimen of *Baetis vernus* (No. 12) having a reduced left gonopode on sternum VIII. This gonopode is by 1/2 shorter than the normal one on sternum IX and its basis is not modified at all.

We found several cases where deformed or reduced forceps were present in the genera *Baetis* and *Cloeon* (family Baetidae). Forceps are usually only one- or two-segmented and always differently shaped. Basal segment, which is characteristic in normal males, is never discernible in these individuals. Forceps reach only 1/3—2/3 of the normal length. In all the cases investigated the whole segments IX and X with paraprocts, epiproct and cerci are smaller and less sclerotized than in normal males. In all these cases both gonopodes, although of different shape, are present.

Teratology of male external genitalia has been observed only in the family Baetidae so far. That is why we have no data concerning the teratology of penis. The openings of ducts in cases studied are usually unaffected, openings are present only on the hind margin of segment IX (specimens No. 12). In specimens with deformed forceps the duct openings are only slightly modified (more membranous) and never interrupted. Gonads (testes) of specimens investigated were always normal.

#### Habits of gynandromorphs and intersexes

There are only several data concerning the habits of gynanders and intersexes during the emergence and mating flight. These specimens are mostly identified in fixed material so that the habits and nature of gynandromorphs and intersexes can be only indirectly deduced.

The typical gynander of *Heterocloeon curiosus* described by Berner (1949) was collected in the female swarming (about 50 specimens collected) from 1.45—3.30 p. m. where no males were present. Females flew over the swiftest part of the river occasionally dropping down to the water. The second gynander described by Berner (1949) was caught together with males and females but at the time of collecting the specimens were not flying in swarms but individually with males rising and falling in the manner typical for the Baetidae.

The specimens No. 5 and 18 were behaving as males when collected. They were present in male swarms containing about 1000 (No. 5) and 100 (No. 18) males respectively. Also the gynandromorph of *Rhithrogena semicolorata* (No. 16) was collected together with about 50 males in swarm which was individually entered by unfertilized females. Landa (1949) reports his specimens behaving as males as well. On the other hand the gynander of *Centroptilum luteolum* (No. 15) was caught together with about 10 females during the compensatory flight before oviposition.

Masculinized females, which have undergone a mermithid parasitism, were always behaving as typical females when collected. They were usually caught in the female swarm (No. 13 and others). Completely sterile intersexes are present in female

swarms as well (e. g. No. 11). The intersex of *Baetis fuscatus* (No. 6) was found even ovipositing on submerged stones together with normal females. With the exception of higher sensitivity of the latter to temperature and oxygen content no differences between habits of normal and masculinized larvae of *Baetis rhodani* (No. 10) were observed. Infected larvae mostly do not molt and exhibit much higher mortality than those in controls. Specimens showing teratology in male external genitalia always behave as typical males.

#### DISCUSSION

As it is apparent from the above paragraphs, there are three distinct categories of deviations in the arrangement of secondary sexual characters and copulatory organs in the Ephemeroptera. However, the distinction between these individual categories (gynanders, intersexes, external genitalia teratology) seems to be rather arbitrary. In classifying our material we followed these principles: (a) specimens with both male and female parts of body mostly normally developed were considered as gynanders; (b) specimens showing predominantly female characters with fundamentals of turbinate eyes and reduced forceps, and especially those where previous parasitism could be detected, were considered as intersexes — masculinized females; (c) specimens with only male (female) somatic characters normally developed and copulatory organs differently developed were called "teratology of external genitalia". Although there are undoubtedly some difficulties in applying these principles, e. g. apparent gynanders sometimes possess "intersexually" developed characters or reduced forceps, this classification enables to separate true intersexes and gynanders. Agnew (1979) believes that genetically conditioned intersexuality does not exist and that "sometimes the gynanders have been erroneously referred to as 'intersexes'". If such cases do exist within the Ephemeroptera, they are indistinguishable from gynanders having some characters intermediately developed. On the other hand, masculinization of *Baetis* females caused by parasitism represents true intersexuality and at least this type of intersexuality is proved in mayflies. Some earlier authors regarded also these individuals incorrectly as "gynandromorphs" (cf. Agnew, 1979).

As it is obvious from Tables I and II, both quantitative and qualitative presentation of gynanders, intersexes and external genitalia teratology are irregular within the mayfly families. If these phenomena are analyzed, we can find several remarkable aspects:

(i) The occurrence of gynanders and intersexes is restricted only to Europe and North America with the exception of one specimen (No. 14) from Mongolia. This phenomenon can be simply explained by the fact that detailed treatments of mayfly fauna have been made only in these Holarctic regions. Faunistic study is always connected with sampling of great numbers of specimens where the probability of gynandromorphism or intersexuality detection is much higher. Apart from some individual findings, gynanders were always caught among several hundreds of specimens (cf. Berner, 1949, 1957; Landa, 1949, and others). We found the specimens No. 5, 16, 18 among numerous normal individuals in swarms as well. There is no doubt that gynandromorphism is not restricted geographically and further specimens will be found also in the remaining biogeographical regions. However, the occurrence of intersexes depends on the distribution of parasites causing masculinization of infected females (worms from the family Mermithidae).

(ii) Gynanders are numerous in families containing a large number of species (see Table II). There is direct correlation between the number of known gynanders

Table 2. Occurrence of gynandromorphs, intersexes, and external genitalia teratology within the families

Family	No. of species reported		No. of specim. reported (adults only)		Total No. species in Europe and North America <sup>†</sup>	Degree of sexual dimorphism
	No.	%	No.	%		
A. Siphonuridae	1	3.8	2	4.3	12 + 81	+
B. Baetidae	13	50.0	33	70.2	56 + 128	+++
C. Heptageniidae	4	15.5	4	8.5	76 + 152	+
D. Leptophlebiidae	5	19.3	5	10.7	25 + 70	++
E. Ephemerellidae	1	3.8	1	2.1	10 + 85	++
F. Ephemeridae	1	3.8	1	2.1	6 + 13	+
G. Potamanthidae	1	3.8	1	2.1	1 + 8	+
<b>Total</b>	<b>26</b>	<b>100</b>	<b>47</b>	<b>100</b>	<b>186 + 537</b>	

<sup>†</sup>) calculated from Puthz (1978) and Edmunds (1978)

and the number of species included. The most numerous mayfly families — Baetidae, Heptageniidae and Leptophlebiidae — comprise more than 80% of known gynanders and 100% of intersexes while the occurrence of gynanders in families with smaller number of species (e. g. Ephemeridae and Potamanthidae) is very low. On the other hand, only three cases of gynandromorphism were detected in relatively numerous families Ephemerellidae and Siphonuridae. This phenomenon is probably due to the fact that species from numerous families are more frequently collected and by a higher probability of spontaneous gynandromorphism in these families. The same reasons cause the higher occurrence in widespread and abundant species. Species of the genus *Baetis* comprising most of gynanders studied belong to the most common species in Europe and North America.

(iii) Gynanders are mostly detected in mayfly groups with high degree of sexual dimorphism and nearly unknown in groups with sexual dimorphism only slightly developed. There is again direct correlation between occurrence of gynanders and degree of sexual dimorphism (see Table II). The highest degree of sexual dimorphism (turbinate eyes, legs, wings, colour patterns, cerci) occurs in the Baetidae (most of known gynanders), only slight dimorphism occurs in Ephemeridae and Potamanthidae (only two cases of gynandromorphism). The high degree of sexual dimorphism undoubtedly enables easy detection of gynanders and intersexes while in other families they can easily escape our attention. In the *Hexagenia* gynander described by Berner (1957) male and female body parts were distinguished only according to colour patterns, there were no somatic characters distinguishing males and females.

According to literary data and in our material we found three principal types of gynanders: bilateral gynanders, predominantly females and predominantly males. Bilateral gynandromorphism is apparent solely on head and thorax (cf. Berner, 1949; Landa, 1949; Bugg, 1954; Grandi, 1966), abdomen of these specimens always shows mosaic-like distribution of males and females characters. Gynanders with predominantly female characters usually possess male eyes and some of male terminalia (cf. Spieth & Ide, 1939; Daggy, 1944). Gynanders with predominantly male characters are described for the first time (No. 3, 4). There are only slightly modified external genitalia and eggs present in abdomen, no further female characters occur. As it noted by Agnew (1979) there are two remarkable points within the mayfly gynanders: male parts sometimes occur on both sides of symmetry and some body areas (e. g. colour patterns on abdomen) are atypical, neither female nor male.

Gonads of gynanders are always either male or female but both testes and ovaries are usually reduced in size and in ovarioles (eggs) number.

Although mayfly gynanders are known for more than 50 years and the origin of gynanders in general became explained at the beginning of this century in *Drosophila*, no attempts to explain this phenomenon in the Ephemeroptera have been made. Only Grimeland (1963) reports that it is caused by „disturbance of the XX·XY mechanism”. At present, when basic data concerning sex determination in the Ephemeroptera have been published (Katayama, 1939; Kiauta & Mol, 1977; Mol, 1978) the interpretation of mayfly gynandromorphism is presented by Agnew (1979): “Gynanders arise from XX female zygotes with early loss of an X in one cell line giving rise to subsequent male tissues (XO karyotype); there appears to be some mixing (more so than in *Drosophila*) of cleavage nuclei during the syncytial divisions because of the islands. While sex per se (as seen in gonads and secondary sex characters such as eyes, legs and genitalia) is autonomous, pigmentary phenotype is less so, probably because of diffusible substrates or products”. This explanation, although involving account for anomalous colour patterns, cannot be applied for species where another type of sex determination occurs (XX ♀♀/XY ♂♂), e. g. in *Ecdyonurus* or *Ephemerella* (cf. Mol, 1978). We believe that also further interpretation of gynandromorphism in mayflies might be used. Spontaneous frequency of mayfly gynanders seems to be relatively very high in comparison with that of other insects (1.2–3.0 in 10<sup>4</sup> in *Drosophila*). In some mayfly families this frequency is higher by at least an order than in *Drosophila*. The relatively higher frequency of gynanders in Ephemeroptera may be due to parthenogenesis and polyspermy. Gynanders of this origin have been experimentally evoked in some other insect orders. After starting parthenogenetic embryogenesis (cleavage) some nuclei can be fertilized anyway and can give rise to subsequent male tissues. The probability of fertilization of these nuclei is increased by poly- or dispermy. Presence of males in parthenogenetic population is necessary. With the exception of polyspermy, which has been discovered only in the genus *Baetis* so far (Bohle, 1969) all these phenomena (parthonegenesis, occurrence of males in parthenogenetic populations) are widespread within the Ephemeroptera. Diploid thelytoky was described in nearly 100 species (Degrange, 1960; Needham et al., 1935 and others), tycho-parthenogenesis is present probably in all species. Males are often found in apparently parthenogenetic populations (Needham et al., 1935; Landa, 1969). Moreover, diploidy in parthenogenetic eggs is reached probably after oviposition.

In comparison with causes of gynandromorphism, causes of intersexuality are more evident. Masculinized females have been found only in the genus *Baetis*, in individuals infected with worms from the family Mermithidae (Nematoda, Enoplida). Parasited larvae of several *Baetis* species are currently found (Murphy, 1922; Degrange, 1960; Benech, 1972; Sukop, 1973) but only some specimens (10–40 are masculinized and may give rise to intersexual adults. Although mermithids were found in other genera (e. g. *Callibaetis* — Peters & Arvy, 1979) of Baetidae and in other families (e. g. Heptageniidae — Muttkowski, 1929; Caenidae — Arvy & Peters, 1979) no cases of intersexuality have been reported. Rubtsov (1977) reports further 8 families of aquatic nematods parasiting in the mayfly larvae but masculinization of mayflies and other aquatic insects (aquatic Diptera and Heteroptera) is caused only by species of the family Mermithidae.

Contrary to gynanders, development of male secondary sexual organs is restricted only to turbinate eyes and external genitalia forceps. Although the masculinization of larvae is relatively abundant in infected population, the quantitative representation



of these intersexes in adults is low because of high larval mortality. Our results concerning the mortality of infected male larvae (100%) fully agree with those obtained by Degrange (1960). He believes that male larvae do not represent a sufficient food supply for the parasite larva so that the larva of mermithid destroys also remaining necessary organs (gut, central nervous system) which results in the death of the host larva. The same might be applied in the case of infection of younger larvae. Older female larvae are able to provide mermithid parasite with sufficient amount of food (developed ovaries and large fat body are resorped). This explanation could be accepted in the case of mayflies only. In other insects, e. g. in Homoptera-Delphacidae, feminization of males was described after mermithid parasitization. Although no data concerning changes in neurosecretory organs of specimens infected are available, the hormonal interaction between host and parasite and damage of host CA and neurosecretory cells in brain can be supposed. Moreover, there are considerable irregularities in moulting cycles or their suppression in host larvae infected. On the other hand, selective mortality, which is sexually determined, cannot be explained by this way (sexual hormones are not present in insects and their absence is supposed to be evidenced just by the existence of gynanders and, intersexes). The adult intersexes, apart from complete or nearly complete sterility are always behaving as typical females. Otherwise the behaviour of gynanders does not probably depend on morphologically prevailing secondary sexual characters. Destruction of gonads of intersexes and infected mayfly larvae shows typical characters of developing progressive sterility. Contrary to gynanders, gonads are gradually resorped and histological changes of both germinal and follicular cells can be compared with those caused by radiation or chemosterilization (diffusing of nuclei and oocyte ooplasm, pycnoses, break-down of follicular epithelium etc.). Contrary to some other insects infected with larvae of mermithids, infected mayfly females are nearly always sterile, only exceptionally several eggs are developed. In some other insects (e. g. bark-beetles) the fecundity of females is only slightly reduced or unaffected.

As far as the teratology of external genitalia is concerned, there are two distinct types of teratology in male copulatory organs; in females no cases have been described so far. The occurrence of supernumerary forceps is undoubtedly caused in embryogenesis and probably conditioned genetically (different segmentation of last abdominal segments and their appendages). Supernumerary forceps can be either normal in shape and length (Codreanu & Codreanu, 1938) or smaller and deformed (specimen No. 12). On the other hand, deformed forceps in normal position are most probably due to a regeneration of lost appendages and respective segments during larval development. Similar shape deformations can be observed on regenerated legs, gills and mouthparts. Oppenheim (1908) and Schmidt (1955) found that regeneration of abdominal segment X or segments IX and X with respective appendages was usual after experimental amputation in *Cloeon dipterum*. Apart from appendages and pseudocuticle, respective internal organs (tracheae, alimentary canal and probably also terminal portion of vas deferens and vas efferens) are regenerated. This regeneration occurs in other genera of the family Baetidae and in other genera as well.

As it is apparent from the foregoing paragraphs, the study of gynandromorphism, intersexuality and external genitalia teratology in the Ephemeroptera can elucidate not only special but also some general problems. Especially genetic analyses of wild specimens, attempts of experimental induction of gynanders in connection with parthenogenesis and hormonal interactions host-parasite in intersexes are worth of our attention.

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**OCURRENCE OF LEIOBUNUM GLABRUM IN CZECHOSLOVAKIA  
(ARACH., OPILIONIDEA)**

Vladimír ŠILHAVÝ

Received October 2, 1979

**Abstract:** The author has accomplished a revision of *Leiobunum rupestre* (Herbst) found in Czechoslovakia up to now and of some specimens from adjoining countries (Poland, Rumania, Hungary, West Germany) considered as *L. rupestre*. He has found out that *L. rupestre* lives in the western part of Czechoslovakia and West Germany, whilst in the Carpathian part of the territory, as well as in Poland, Rumania and Hungary occurs *L. glabrum* L. Koch, which is an older synonym of *Nelima glabra* (L. Koch) and *Leiobunum tisciae* Avram. Some ecological data and differential diagnosis of *L. rupestre* and *L. glabrum* are presented

In 1799 J. F. W. Herbst described a species of opilionids from central Europe, *Opilio rupestris*, which was in 1839 classed in the genus *Leiobunum* by L. Koch. Roewer in 1923 noticed that the specimens from Siebenburgen/Rumania/differ somewhat from the other specimens in the armature as well in the colour patterns. Due to this variability, there were formerly even some synonyms described (*L. gracile*, *L. laeve*, *L. norvegicum* — following Tullgren 1906).

In 1896 L. Koch described *Leiobunum glabrum* from Tirol (Meran, 1♀ only). The deposit of the type remains unknown. In 1910 Roewer separated this species as well as other representatives of the genus *Leiobunum* which are characterized by the absence or rows of tubercles on the coxae, in the independent genus *Nelima*: in 1923 this author gives following grounds of "*Nelima glabra*": Meran, Siebenbürgen: Eisenstein, Venusberg; Schwäbischer Jura: Urach.

On the basis of research on some young specimens of Leiobunidae from Triglav (Jugoslavia), Hadži in 1931 assumed that the *Nelima glabra* was a synonym of young specimens of *Leiobunum rupestre*. Later some authors (Šilhavý 1956, 1971, Staręga 1976, Martens 1978) accepted this opinion. When preparing my book "Fauna ČSR-Opilionidea" I had at my disposal mostly only the young or badly prepared specimens of "*L. rupestre*" from Slovakia. In figures 422 and 447 (p. 177 of cited work) a young specimen from east Slovakia (Vihorlat mountains) is drawn which I have designated as "*Leiobunum rupestre-Nelima glabra*".

Kolosváry mentioned long ago the species *Nelima glabra* currently from Hungary: Menyháza (Körös Fluss-Gegend) 1939: nördlicher Tiszataal, Dombrád 601—605 Flkm 1965; Lónya, Tiszamogyorós, Mátyus Endes-Pusztá, Gergelyugornya 660—698 Flkm Tiszataal 1967; Innundationsraume der Theiss 1955—1960: Dombrád-Komoró (Theiss) 1966. Kolosváry names this species also from Jugoslavia (Plitvitzaer Seen, 1939) and Rumania (Transilvania, reg. Crisana, r. Gurahont, sat. Moneasa, 1963) — localities cited following the author

In 1968 Avram described *Leiobunum tisciae* from the upper flow of Tisza (Hungary). In the original description, the figure of male holotype is badly reproduced



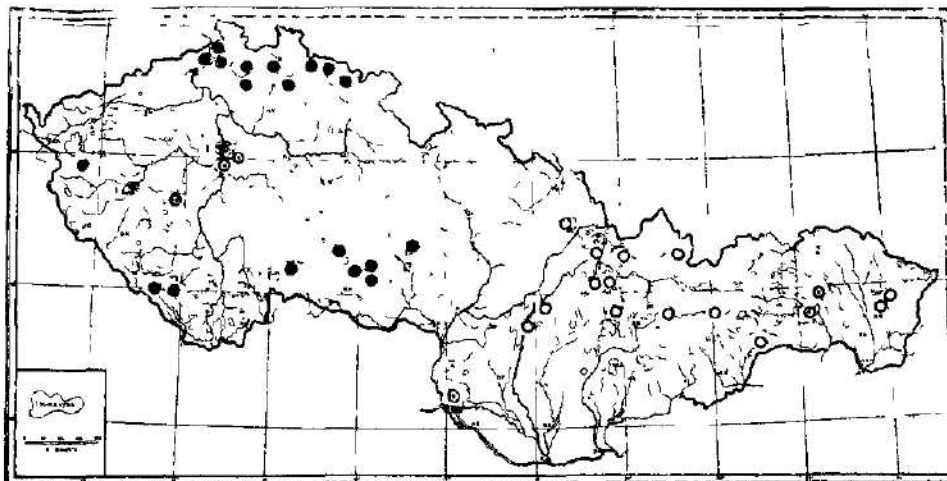


Fig. 1. Repartition of *Leiodunum rupestre* and *L. glabrum* in Czechoslovakia

● *L. rupestre*: Mariánské Lázně, Kvilda, Boubín, Pravčická brána (Hřensko), Tiské skály (Děčín), Klášky (Nový Bor), Máchovo jezero (Doksy), Ještěd, Hrubá Skála, Rokytnice n. Jiz., Špindlerův Mlýn, Rýchory, Holná, Olší (Jindř. Hradec), Horní Smrčné, Koněšín, Mohelno (Třebíč), Vlčí kopec, Lamberk (Náměšť n. Osl.), Moravský kras. ○ Findings not reviewed: Trenšín (Rožmitál), Jevany, Krč, Kunratice, Pajštún (Bratislava) — Bartoš. Košice, Prešov (Kratohvil).  
○ *L. glabrum*: Nové Město n. Váhom, Trenčianske Teplice, Súlov, Vrátna dolina (Žilina), Ráj. Teplice, Štub. Teplice, Roháče, Dobroč (Brezno n. Hronom), Červená skala (Dobšiná), Gombasek (Rožnava), Vihorlat, Kamenica n. Cír

that the colour pattern of the dorsal surface of body does not fully correspond with the reality. I had the possibility to compare the paratypes through the courtesy of Dr. S. Avram. The exact description and the figures of the genital morphology make the diagnose quite clear.

Martens (1978) in his notice about the affinities of the *Leiodunum rupestre* (p. 410) writes: "Moglicherweise verbergen sich hinter "rupestre" 2 Arten" and holds the view that it is necessary to investigate further into this question. Nevertheless he admits the independence of species *L. tisciae*.

All these differences and discrepancies made me revise all specimens accessible to me of *L. rupestre* which have been found on the territory of Czechoslovakia up to the present. There are some specimens at my disposal determined as *L. rupestre* from Poland, Rumania, West Germany and mentioned paratypes of *L. tisciae* from Hungary.

From Czechoslovakia I have 256 specimens altogether: 187 from Bohemia and Moravia and 69 from Slovakia.

The results of my revision are the following:

1. Two independent species of the "*Leiodunum rupestre*" group live in our country. In the western part of the territory, Bohemia and Moravia, lives mostly *Leiodunum rupestre* (Herbst), in the eastern territory, Slovakia and eastern Moravia mountains *Leiodunum glabrum* L. Koch.
2. *Nelima glabra* is a younger synonym of *Leiodunum glabrum* L. Koch.
3. *Leiodunum tisciae* Avram is a synonym of *Leiodunum glabrum* L. Koch.

Ad 1. On the territory of Czechoslovakia five species of *Leiobunum* were found: *L. rotundum* (Latreille) — on the whole territory, *L. limbatum* L. Koch — only in the western mountains of Bohemia, *L. blackwalli* Meade in the western part of Bohemia (the Vltava river forms roughly the eastern boundary of its Bohemian area), *L. rupestre* (Herbst) which has been found, up to now, only in Bohemia and Moravia and

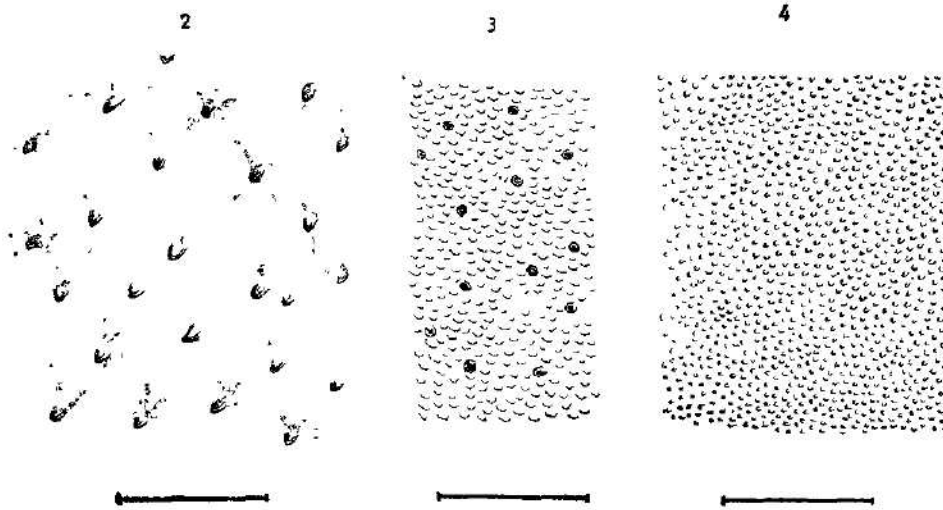


Fig. 2 *Leiobunum glabrum*, surface of the dorsal portion of cuticula on the tergites II—III. — Fig. 3. *Leiobunum glabrum*, surface of cuticula on the tergites II—III, lateral portion. — Fig. 4. *Leiobunum rupestre*, surface of cuticula on the tergites II—III, dorsal portion. Scales = 0.1 mm.

finally *L. glabrum* L. Koch, of which, on the contrary, most findings are from Slovakia (it was found only once in the Beskydy mountains — not far from the Slovak frontier). The natural boundary between Slovakia and Moravia are the western Carpathian mountains).

Ad 2. In 1968 I pointed out that the rows of tubercles on the coxae of *Leiobunidae*, especially in the genus *Leiobunum*, develop only when the animals mature, in the last instar. That is why we cannot distinguish the generical appurtenance of *Leiobunum* or *Nelima* before the last ecdysis. It seems probable that Roewer in 1910, on the occasion of separating the *L. glabrum* in the genus *Nelima* worked with not quite mature specimens or a specimen with few tubercles which he overlooked. This view is supported by the work of Avram, when describing *L. tisciae*, demonstrated a large variability in the number of tubercles on the margins of coxae: in her Fig. 2-A, there are only two tubercles on the posterior margin of coxae IV, all other coxae are without tubercles!

Ad 3. On the basis of all those data (descriptions, figures, repartition and comparative research) I suppose that *Leiobunum tisciae* Avram is a younger synonym of *Leiobunum glabrum* L. Koch.

From all other species of *Leiobunum* living in our country the two species — *L. rupestre* and *L. glabrum* — differ in the colour of trochanters which are nearly the same as those of coxae while the trochanters of *L. rotundum*, *L. blackwalli* and

*L. limbatum* are black or brown so that their colour sharply contrasts with the light colour of distal parts of coxae.

The main differences between *L. rupestre* and *L. glabrum* are the following: constant and very specific characterization of both species is a quite different structure of the dorsal surface of the abdominal cuticula of adults. In *L. rupestre* the surface is corrugated by very fine round granulations in the number about 150 on 0,01 mm<sup>2</sup>. On the cuticula of *L. glabrum* there are relatively greater tubercles (some of them are subpointed) in the number of 5–6 on 0,01 mm<sup>2</sup>. These tubercles are extended at the basis in 3–6 radial keels which give to them a star-shaped appearance. The structure of cuticula mentioned is only on the dorsal surface, the lateral parts are finely granulated with greater round tubercles (see Figs. 2–4).

The penes of *L. rupestre* are robust, the apical wings from the dorsal aspect on their basal portion are widest. The penes of *L. glabrum* are relatively slim, the wings are widest on their apical portion. Both the jointed ampullae of receptacula seminis of *L. rupestre* are oval, the praedistal ampullae of *L. glabrum* are nearly spheroidal.

The colour of adult specimens of both species, if they are dark-pigmented (mainly of the males) is nearly the same and at first glance we can easily confuse them. In the females and in young specimens of *L. glabrum* there are two characteristic darker flecks on the fourth abdominal tergite extended laterally over the lateral boundaries of the not very distinct saddle. In the middle of the dorsal pattern of most specimens of *L. glabrum* there is a pair of lighter round spots on each area, which are situated on the fourth tergite medially of the romboidal flecks mentioned. In the species *L. rupestre* these small spots are only exceptionally present in some females.

From other countries of Central Europe I studied the specimens of *L. rupestre* which I found in West Germany (Schwarzwald, Stubach) in 1966. All reviewed specimens are identical with the specimens of Bohemia and Moravia. I have at my disposal also some specimens from Poland sent to me through the generosity of Dr. Starega (from Kazimierz Polny, distr. Pulawy) and Dr. Sanocka (Krakow, Cęstochova). All specimens are *L. glabrum*. Similarly the specimens offered kindly to me from Dr. D. Dumitrescu from Rumania (Monts Cosial-Valée de Cerna) are *L. glabrum*. For this reason it seems necessary to revise all founds of *L. rupestre*, mainly in the eastern territory of Europe.

The biotopes of *L. rupestre* and *L. glabrum* are nearly similar: moist, shady localities, very often the rocks in old forests. While *L. rupestre* seems to prefer the highlands, *L. glabrum* lives also in the low-lying biotopes (f. i. the areas of inundation of Tisza-river). In 1968 I observed an enormous number of juvenile *L. rupestre* in the rocks of northern Bohemia (Tiské skály, Pravčická brána, Prachovské skály).

The localities of the two species see the map.

The occurrence of *L. glabrum* in England (Martens 1978 sub *L. tisciae*) shows that the territory of this, for a longer time omitted species, is much larger than we have thought.

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**SOME ASPECT OF INCUBATION IN THE DOMESTICATED ROCK PIGEON  
(COLUMBA LIVIA F. DOMESTICA)**

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**Abstract:** Eggs of Moravian Strasser Gelb were followed up for weight loss during natural incubation. The weight loss dynamics was evaluated separately for normally hatching eggs, eggs with dead embryo and unfertilized eggs. Correlations between total weight loss and certain characteristics of eggs were calculated.

INTRODUCTION

The object of this study was to evaluate the course of natural incubation in the domestic pigeon by means of measurement of egg weight loss.

The weight loss in eggs is almost entirely due to diffusion of water through the shell (Romanoff and Romanoff, 1949). Drent (1974) described the relationship between total water loss and hatchability. At the same time he indicates the following three critical factors which influence optimum for embryonic development; the gaseous environment ( $O_2$ ,  $CO_2$ ,  $H_2O$ ), the thermal environment, and the position of the eggs in a nest.

In ornithological practice, estimates of the stage of egg incubation are based on measuring air cell size at candling (Otryganjev, 1953, Veselovský, 1954, Pikula, 1969).

The present paper describes these methods in their application to the domestic pigeon.

MATERIAL AND METHODS

Egg weight loss and some candled egg characteristics were studied during the natural incubation of clutches of 10 Moravian Strasser Gelb pairs, average age 2.5 years, in the course of a reproductive season. A total of 130 eggs were laid; the fertilization and hatching rates were 84.21 and 63.16%, respectively. Nest temperature during incubation varied in the range of 34–39° C. Levi (1974) gives values of 36.1–36.6° C as the temperature optimum for artificial hatching of pigeon eggs.

On the days of being laid the eggs were weighed with an accuracy of 0.05 g and measured with a sliding caliper. Egg shape was expressed in term of the index  $\frac{\text{width}}{\text{length}} \times 100$  and egg surface area was estimated according to the formula for the general ellipsoid area,  $\frac{\text{length}}{2} \cdot \frac{\text{width}}{2} \cdot \pi$ .

During incubation the eggs were weighed daily between 6 and 7 p.m.. The air cell size was determined with a sliding caliper as the circumferential diameter at ooscopy.

In addition to the above parameters, the post-hatching weight (prior to first feeding) was taken in 21 squabs. The ratio of this value to the weight of the freshly laid egg constitutes the coefficient of egg content utilization by squabs.

Observation throughout the incubation period was completed in 76 eggs, which were divided into three basic groups: (a) 48 normally hatching eggs; (b) 16 eggs with embryo dying during incubation, and (c) 12 unfertilized eggs. For some purposes, the first group was subdivided into

Table 1. Values of basic indices in first-laid and second-laid eggs

	Weight (g)		Surface area (cm <sup>2</sup> )		Shape (%)	
	first	second	first	second	first	second
n	68	62	68	62	68	62
$\bar{x}$	21.88	23.28	10.17	10.61	73.67	72.97
s	1.502	1.489	0.494	0.459	2.400	1.943
$s_x$	0.128	0.186	0.059	0.058	0.291	0.246
v	6.86	6.30	4.85	4.32	3.26	2.66
P	< 0.01		< 0.01		> 0.05	

two: one of 31 eggs with normally viable embryos and another of 17 eggs with nonviable squabs, i. e. dying within a few days of hatching.

All data obtained were analysed statistically. Differences were tested by variance analysis and t-test. The size of the basic sample of 48 eggs is (with respect to the total egg weight loss by the 17th incubation day) representative enough to allow basic statistical values to be determined. The assessments were made by estimating the least number of cases.

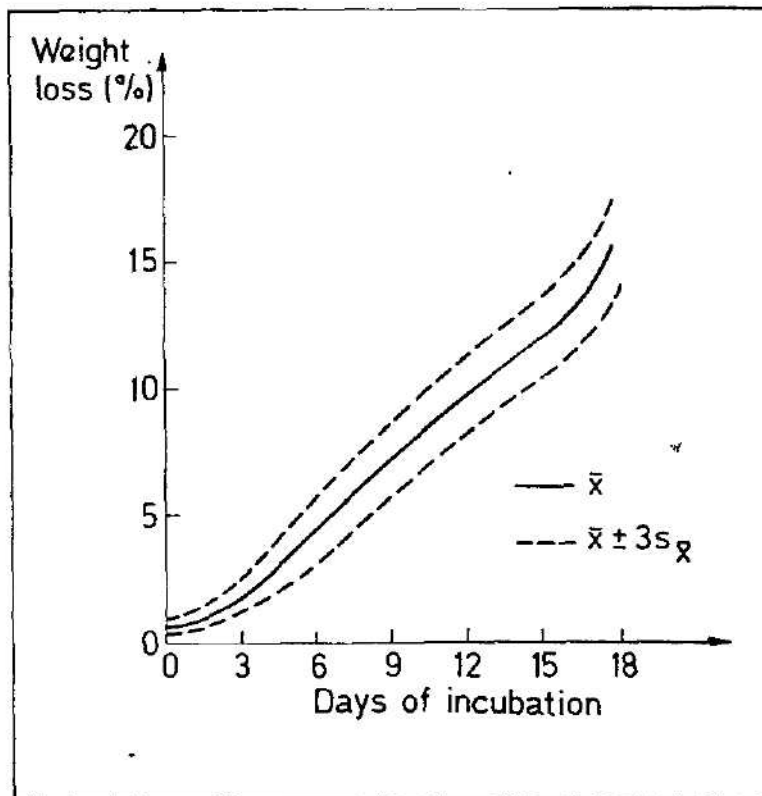


Fig. 1. Dynamics of weight loss in 27 normally hatching eggs (27 eggs with 100% hatchability)

Table 2. Values of basic indices in individual egg groups

Group of eggs	No. of cases	Weight (g)				Surface area (cm <sup>2</sup> )				Shape (%)			
		$\bar{x}$	s	$s_x$	v	$\bar{x}$	s	$s_x$	v	$\bar{x}$	r	$s_x$	v
normally hatching	43	22.86	1.532	0.221	6.70	10.45	0.467	0.067	4.47	73.01	2.082	0.304	2.86
with embryo dying during incubation	16	22.68	1.607	0.376	6.65	10.48	0.466	0.116	4.46	73.12	1.309	0.325	1.79
unfertilized	12	21.35	2.197	0.634	10.29	9.99	0.754	0.217	7.55	74.11	4.273	1.237	5.77
with viable embryo	31	23.10	1.646	0.296	7.13	10.49	0.507	0.091	4.84	73.16	2.269	0.410	3.10
with nonviable embryo	17	22.43	1.228	0.298	5.48	10.37	0.365	0.088	3.52	72.72	1.713	0.410	2.36



Table 3. Mean values of egg weight decrease on consecutive incubation days (%)

Eggs	normally hatching*			with	unfertilized***
	Day	$\bar{x}$	s	dead embryo**	$\bar{x}$
1	0.54	0.607	0.139	0.32	0.56
2	1.09	0.808	0.190	0.88	1.73
3	2.02	0.889	0.204	1.75	1.29
4	2.87	0.825	0.198	2.32	3.31
5	3.71	1.008	0.658	3.42	4.12
6	4.21	1.141	0.316	4.11	4.47
7	5.24	1.109	0.268	4.54	6.36
8	6.23	1.455	0.364	5.66	8.43
9	6.77	1.437	0.338	6.30	10.11
10	8.01	1.738	0.506	7.56	10.27
11	8.84	1.803	0.481	7.61	12.50
12	10.13	1.892	0.488	8.88	12.12
13	10.26	2.210	0.553	9.57	11.72
14	11.51	2.068	0.451	10.19	15.77
15	12.31	2.210	0.536	10.60	13.83
16	12.95	2.509	0.535	10.34	15.95
17	13.63	2.442	0.509	14.02	14.93
18	15.85	2.625	0.618	12.50	16.36

\* 27 eggs; the per-day number of eggs varied from 12 to 23

\*\* 13 eggs; n in the range of 4-12

\*\*\* 4 eggs; n in the range of 1-4

### RESULTS

The basic index values for all the eggs laid are given in Table 1. As the mean values indicate, second-laid eggs are larger than first-laid eggs ( $P < 0.01$ ) but do not differ in shape ( $P > 0.05$ ). The individual egg groups are characterized in Table 2.

Normally hatching eggs displayed a striking acceleration of the otherwise steadily progressing weight decrease on the last day of incubation, which corresponded with the incipient cracking of egg-shell and consequent higher evaporation (see Fig. 1). This rather abrupt loss of weight was not observed in the other egg groups. The total weight loss was therefore taken as represented by the 17th day value. As Table 3 indicates, the highest weight loss during incubation was recorded in unfertilized eggs (four in number). In 27 normally hatching eggs and 13 eggs with dead embryo the weight loss values were lower and mutually comparable. On most incubation days the inter-group differences in weight loss were not significant ( $P > 0.05$ ). The limited numbers of eggs in the individual groups are due to the fact that only eggs that had been weighed on each consecutive incubation day were used for these comparisons.

Evaluations of total egg weight loss (day 17 of incubation) disclosed no difference among egg groups incubated by individual parent pairs ( $F = 0.46$ ;  $P > 0.05$ ). Seasonal (spring, summer, autumn) influence was not significant either ( $F = 1.75$ ;  $P > 0.05$ ). Total weight loss was practically the same in eggs giving viable squabs ( $\bar{x} = 15.57 \pm 3 \times 0.336\%$ ) and those whose squabs died shortly after hatching ( $\bar{x} = 15.58 \pm 3 \times 0.603\%$ ).

The only statistically highly significant difference ( $P < 0.01$ ) was found between the total weight loss in first-laid eggs ( $\bar{x} = 16.39 \pm 3 \times 0.488\%$ ) and second eggs ( $\bar{x} = 14.76 \pm 3 \times 0.285\%$ ). This difference is attributable, possibly besides other factors, to the following two causes: (1) first eggs are on the average lighter and smaller than second eggs and (2) first eggs are laid two days in advance of second

Table 4. Statistical correlation values

Characteristics correlated		No. of cases	Correlation coefficient values	Proability P	Regression coefficient values	Regression linear equation
x	y	n	$r \pm 3s_r$		$b_{xy}$ $b_{yx}$	$y/x'$
egg weight on laying	total loss of egg weight	48	$-0.8483 \pm 3 \times 0.1123$	< 0.01	-0.4709 -0.8927	$y' = 35.9825 - 0.8927 x$ $x' = 30.1971 - 0.4709 y$
egg surface area	total loss of egg weight	48	$-0.4013 \pm 3 \times 0.1350$	< 0.01	-0.0892 -1.8049	$y' = 34.4372 - 1.8049 x$ $x' = 11.8416 - 0.0892 y$
total loss of egg weight	air cell diameter on day 17	27	$+0.2164 \pm 3 \times 0.1953$	> 0.05	+0.4110 +0.1140	$y' = 26.1103 + 0.1140 x$ $x' = 2.7147 + 0.4110 y$
coefficient of egg contents utilization	total loss of egg weight	21	$-0.5963 \pm 3 \times 0.1842$	< 0.01	-1.0339 -0.3439	$y' = 39.2387 - 0.3439 x$ $x' = 85.7969 - 1.0339 y$

eggs and consequently lose about 0.5 % of their weight prior to commencement of the incubation proper (laying of second egg). In rare instances the parents incubate already their first egg, which may account for the greater weight loss variability found among first than among second eggs in clutches.

For the basic group of 48 normally hatching eggs the total weight loss was expressed also in relation to certain other properties of incubated eggs. The correlation coefficient value  $r = -0.65$  represents a negative dependence of the total weight decrease on the weight of the freshly laid egg. The dependence of total weight decrease on egg size (approximate surface area) is characterized by the correlation coefficient value  $r = -0.40$ . The correlation with air cell size is low ( $r = +0.22$ ) and statistically not significant. The values of this correlation coefficient is influenced by the variable size and shape of the eggs, which to a certain degree determine the size of the air cell.

Evidence of a highly negative correlation between total weight loss and the coefficient of egg contents utilization by squab is provided by the coefficient value  $r = -0.60$ . Thus a high weight loss is characteristic of a low degree of egg contents utilization by squab. This fact will probably also reflect squab viability. The mean values of the egg contents utilization coefficient for 10 eggs with normal embryo viability ( $\bar{x} = 72.52 \pm 3 \times 0.968\%$ ) and 11 eggs with embryo nonviability ( $\bar{x} = 67.95 \pm 3 \times 0.854\%$ ) differed significantly ( $P < 0.01$ ). This finding confirms that the coefficient of contents utilization by squab is an indication of the biological value of eggs and progeny.

The other statistical data characterizing the above relationships are presented in Table 4.

#### DISCUSSION

Common principles and problems on incubation of avian eggs were summarized by Drent (1975), who studied the influence of environmental dimensions upon embryonic development.

In the domestic pigeon studied, egg weight loss during incubation amounted to 15.57 %. The weight loss value for eggs from which viable pigeons hatched varied within the range of 12.35 to 18.35 %. In domestic fowls, Otryganjev (1953) found a variation range of 8–18% (mean value between 10 and 11%) on the 18th day; he also noticed that the extremely high weight loss values were associated with chick nonviability. A similar observation was made by Cade (1977) and the finding is also confirmed by the present results. Cade (1977) gives a mean value of 16 % at defined temperature and relation humidity for *Falco peregrinus*. Drent (1975) takes as optimum total water loss commonly 10–12% of the initial egg weight.

Differences (if present) in weight decrease between unequal species may be due to the different relationship between egg weight, shell thickness, water conductance, and total functional pore area (Ar et al., 1974).

Egg weight loss may be variable even between closely related species. For some species of the *Falco* genus this is explained by Schwartz ex Cade (1977) by a different submicroscopic structure of the egg shell dependent on ecological factors extant in the respective habitat regions.

A higher weight loss by smaller eggs associated with their relatively greater surface area (Romanoff and Romanoff, 1949) and some relationship between weight decrease and certain egg characteristics are indicated by the correlation values calculated. However, these values are somewhat biased by the different weight loss in first and second eggs in clutches.

Another current method used for evaluating the course of incubation is candling, which is applied not only to biological control of poultry hatching (Otryganjev, 1953) but is also used in ornithological practice for determining air cell size in order to estimate the stage of egg incubation (Pikula, 1969). The methods based on identifying the stage of embryonic development via breaking one of the eggs in the clutch, which have been developed to perfection by Mc Cabe and Hawkins (1946), Veselovský (1954) and Motl (1964), are not very suitable for application to nidicolous birds laying only few eggs per clutch. For this reason a description of the characteristic changes of eggs during natural incubation may be helpful.

#### SUMMARY

1. The average weight loss in eggs from which viable and nonviable squabs hatched was the same, amounting to 15.57%. The limited material could no more suggest a difference in the egg content utilization coefficient between viable ( $\bar{x} = 72.53\%$ ) and nonviable squabs ( $\bar{x} = 67.95\%$ ) ( $P < 0.01$ ).

2. The total weight loss differed significantly between first-laid ( $\bar{x} = 16.39\%$ ) and second-laid eggs (14.76%) in clutches ( $P < 0.01$ ).

3. Correlation values for total egg weight loss during incubation, on the one hand, and weight at hatching, egg surface area, or coefficient of egg content utilization by squab, on the other hand, were  $r = -0.65$ ,  $-0.40$  and  $-0.60$ , respectively.

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**MOST IMPORTANT FACTORS INFLUENCING THE LARVAL DEVELOPMENT OF CESTODES OF THE FAMILY HYMENOLEPIDIDAE IN CRUSTACEANS (OSTRACODA)**

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**Abstract:** Effect of the temperature, intensity of infection and size of intermediate host (Ostracoda) on the larval development of six cestode species of the family Hymenolepididae Fuhrmann, 1907 parasitic in water birds were studied experimentally. The temperature and intensity of infection influence the length of larval development and size of cysticercoids. The intensity of infection is also related with the temperature. No relationship was observed between the size of the intermediate host and the development of larvae.

The effects of the temperature, intensity of infection and size of intermediate host (Ostracoda) on the larval development of cestodes were experimentally studied in 1967–1972 using the following species: *Dicranotaenia coronula* (Dujardin, 1845), *Diorchis inflata* (Rudolphi, 1819), *D. nyrocae* Yumaguti, 1935, *D. ransomi* Schultz, 1940, *Fimbriaria fasciolaris* (Pallas, 1781) and *Sobolevicanthus gracilis* (Zeder, 1803). The present study follows a previous one dealing with the effects of the same factors on the larval development of 11 cestode species of the family Hymenolepididae in Copepoda (Valkounová 1980).

**MATERIAL AND METHODS**

The ostracods *Dolerocypris fasciata* (O. F. Müller), *Heterocypris incongruens* (Ramdohr) and *Notodromas monacha* (O. F. Müller) have been used in our experiments (Table 1). They have been found to serve as the only intermediate hosts of the class Ostracoda for the studied cestode species both under natural conditions of water biotopes in southern Bohemia and southern Moravia and under experimental conditions.

The breeding of crustaceans, cultivation of cestode eggs and course of the experiments were described in a previous paper (Valkounová 1980). The experiments were performed at the temperatures of 8–10° C, 12–14° C, 18–20° C, 24–26° C and 28–30° C.

A total of 180 experiments were carried out, of them 20 experiments with eggs of one cestode species and one intermediate host species, i. e., four experiments at each of the temperature

Table 1. Survey of cestodes and their intermediate hosts in our material

Cestode	Intermediate host
<i>D. coronula</i>	<i>D. fasciata</i>
	<i>H. incongruens</i>
	<i>N. monacha</i>
<i>D. inflata</i>	<i>H. incongruens</i>
	<i>D. fasciata</i>
<i>D. nyrocae</i>	<i>N. monacha</i>
	<i>D. fasciata</i>
<i>D. ransomi</i>	<i>D. fasciata</i>
<i>F. fasciolaris</i>	<i>D. fasciata</i>
<i>S. gracilis</i>	<i>D. fasciata</i>

Table 2. Effect of temperature on intensity of infection

Cestode	Temperature (°C)	Intensity of infection	
		Oncospheres	Cysticeroids
<i>D. coronula</i>	12-14	2-4 2	1-2 1
	18-20	3-7 5	1-4 2
	24-26	3-16 9	1-5 4
<i>D. inflata</i>	12-14	1-5 3	1-2 1
	18-20	2-9 5	1-3 2
	24-26	2-12 7	1-4 3
<i>D. nyrocae</i>	12-14	3-8 5	1-3 2
	18-20	1-10 8	1-4 3
	24-26	2-13 9	1-6 5
<i>D. ransomi</i>	12-14	1-4 3	1-2 1
	18-20	3-9 6	1-3 2
	24-26	3-12 10	1-4 3
<i>F. fasciolaris</i>	12-14	1-7 5	1-4 3
	18-20	1-11 9	1-6 3
	24-26	1-15 11	1-8 5
<i>S. gracilis</i>	12-14	2-4 2	1-2 1
	18-20	1-6 3	1-3 2
	24-26	1-9 5	1-3 2

Fraction: numerator = minimum -- maximum value  
denominator = average value in round numbers

scopes. One hundred crustaceans were used in each experiment. They were put in 1-litre aquarium containing the eggs of the studied cestode species (50 eggs per one crustacean on an average). Care was taken to keep as many eggs as possible in the proglottids of cestodes, to prevent swelling of their envelopes and their dispersion in various heights of water column, since the ostracods live at the bottom of water reservoirs and feed on animal and plant remnants. Twelve hours after the beginning of the experiment the crustaceans were transferred to 6-litre aquaria (enlargement of the living environment, prevention of reinfections) where they were kept during the whole experiment. During the development of the oncosphere into the cysticeroid the crustaceans were examined microscopically first after 1, 2, 3, 4, 5, 6, 7, 9 and 12 hours and later when necessary, but at least once a day. The observation of larvae inside the crustaceans was difficult due to a poor transparency of their shells. A description of the larval development was published in the paper by Neradová-Valkounová (1971).

The results summarized in the tables include only the experiments carried out at the temperatures of 12-14° C, 18-20° C and 24-26° C, i. e., 108 experiments, since at the temperatures of 8-10° C and 28-30° C many of the crustaceans and cestode larvae died (40-60%). Of the total number of 100 crustaceans used at the temperatures of 12-14° C, 18-20° C and 24-26° C,

Table 3. Effect of temperature on length of larval development

Cestode	Temperature (°C)	Length of larval development (in days)
<i>D. coronula</i>	12-14	26-31
	18-20	17-21
	24-26	11-15
<i>D. inflata</i>	12-14	25-32
	18-20	13-17
	24-26	9-11
<i>D. nyrocae</i>	12-14	27-31
	18-20	15-19
	24-26	12-17
<i>D. ransomi</i>	12-14	29-33
	18-20	19-23
	24-26	12-16
<i>F. fasciolaris</i>	12-14	24-32
	18-20	15-20
	24-26	14-17
<i>S. gracilis</i>	12-14	30-32
	18-20	17-21
	24-26	13-16

1-15% died (17% and 19% only in one case each). Of the dead crustaceans, 1-11% were positive and 1-4% negative to cestode larvae. Of the surviving crustaceans, 2-5% were negative to cestode larvae. The tables include the crustaceans which survived and were infected with cestode larvae, i. e., 80% specimens from each experiment.

## RESULTS

Of the studied factors, the temperature and intensity of infection at certain temperatures were found to influence the length of larval development and the size of the cysticercoids. These relationships concerned all six species of cestodes, be it in a single intermediate host species or in all intermediate host species simultaneously. The size of the intermediate host did not influence the development of larvae.

### 1. Temperature

#### 1.a. Effects of the temperature on the intensity of infection

The intensity of infection was directly related with the temperature (Table 2). The intensity of infection with oncospheres and cysticercoids increased gradually

Table 4. Effect of temperature on length of larval development of *D. coronula* in various species of Ostracods

Intermediate host	Temperature (°C)	Length of larval development (in days)
<i>D. fasciata</i>	12-14	26-28
	18-20	18-21
	24-26	12-14
<i>H. incongruens</i>	12-14	27-30
	18-20	16-19
	24-26	11-14
<i>N. monacha</i>	12-14	28-31
	18-20	19-20
	24-26	11-13



Table 5. Effect of intensity of infection on length of larval development at a given temperature

Cestode	Intermediate host	12–14° C		18–20° C		24–26° C	
		I	L	I	L	I	L
<i>D. coronula</i>	<i>D. fasciata</i>	1	26–27	1	16–17	1	11
				2	18	2	11–12
				3	20	3	12
				4	21	4	13
	<i>H. incongruens</i>	1	28–29	1	16	1	12
		2	30–31	2	17–18	2	13
				3	20	3	13
						4	14
	<i>N. monacha</i>	1	27–30	1	17	1	11
		2	31	2	18	2	12
				3	19	3	
				4	20	4	14
<i>D. nyrocae</i>	<i>D. fasciata</i>	1	27	1	15–16	1	12
		2	29	2	17	2	13
		3	30	3	18	3	14
				4	19	4	15
	<i>N. monacha</i>	1	29–30	1	17–18	1	12–13
		2	30	2	19	2	12–13
		3	31	3	19	3	14
						4	15
						5	16
						6	17

I — Intensity of infection (cysticercoids)

L — Length of larval development (in days)

with increasing temperature from 12 °C. The infection with oncospheres was more intensive than the infection with cysticercoids since the number of swallowed eggs was always higher than the number of larvae capable of completing their development (reduction of the number of oncospheres — see Valkounová 1980). The influence of the number of eggs and the length of their contact with intermediate hosts were not considered due to standard conditions of the experiments (see Material and Methods). At the temperatures of 8–10 °C the initial intensity of infection was 1–2 oncospheres or one cysticercoid per host. At the temperatures of 28–30 °C the intensity of infection distinctly decreased as compared to the temperatures of 24–26 °C, maximum intensity being five oncospheres (two oncospheres on the average) per host. The cysticercoids occurred either single or, rarely, two cysticercoids per crustacean.

#### 1.b. Effect of the temperature on the length of larval development

The length of the larval development was indirectly related with the water temperature. With increasing temperature from 12 °C to 26 °C the time necessary for the development of the cysticercoid gradually decreased from 33 to 9 days (Tables 3 and 4). At the temperatures of 8–10 °C the larvae developed for 52–61 days, at 28–30 °C for 30–35 days.

#### 1.c. Effect of the temperature on the size of cysticercoids

The size of the cysticercoids was directly proportional to the used temperatures of 12–26 °C. At the temperatures of 18–20 °C the cysticercoids were by 50–70 µm

Table 6. Effect of intensity of infection on the size of cysticercoids at the temperature of 24–26° C

Intensity of infection	Cysticercoids of <i>D. coronula</i> in <i>N. monacha</i> (μm)	Cysticercoids of <i>D. nyrocae</i> in <i>N. monacha</i> (μm)	Cysticercoids of <i>F. fasciolaris</i> in <i>D. fasciata</i> (μm)
1	219–239	314–332	140–169
2	184–193	280–295	144–157
3	158–171	240–259	143–155
4	135–150	199–219	143–154
5		181–199	141–152
6		158–174	140–150
7			139–148
8			138–147

larger than those developing at the temperatures of 12–14° C; at 24–26° C they were by 30–50 μm larger than at 18–20° C. At 8–10° C they were of almost the size as at 12–14° C and at 28–30° C they were approximately of the same size as at 18–20° C.

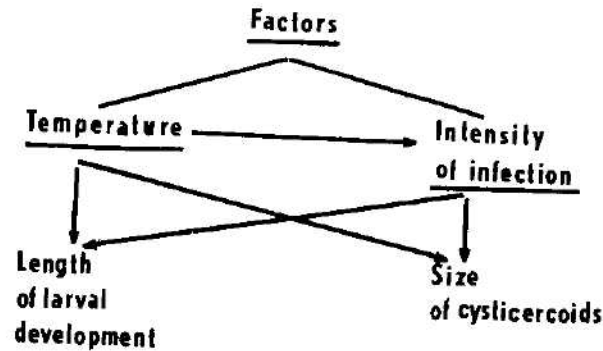
## 2. Intensity of infection

### 2.a. Effect of the intensity of infection on the length of larval development at a given temperature

The length of larval development at the temperatures of 12–26° C was directly proportional to the intensity of infection. With increasing intensity of infection the time necessary for the development of larvae became longer (Table 5). At the temperatures of 8–10° C and 28–30° C the intensity of infection was most often one cysticercoid per crustacean, therefore this relationship could not be evaluated.

### 2.b. Effect of the intensity of infection on the size of cysticercoids at a certain temperature

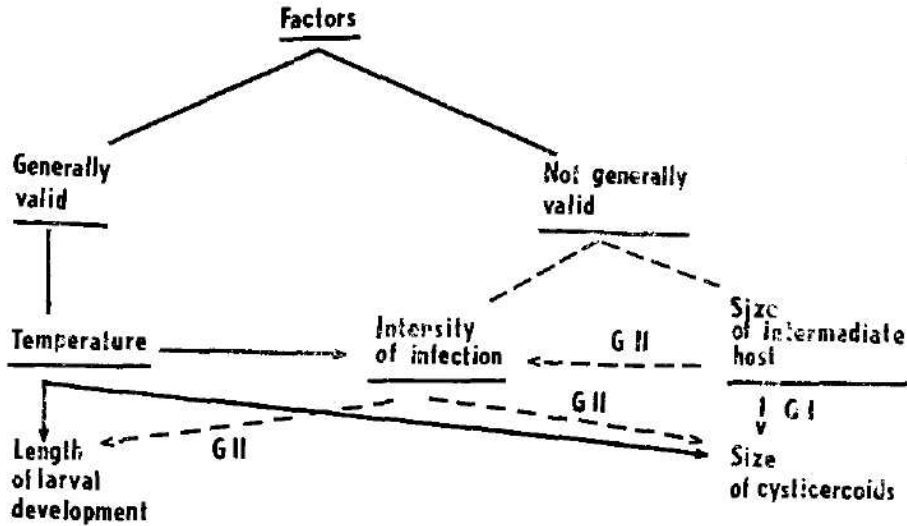
The intensity of infection was found to be indirectly proportional to the size of cysticercoids. At the temperatures of 12–26° C and increasing intensity of infection the size of the cysticercoids decreased (Table 6). This relationship could not be evaluated at the temperatures of 8–10° C and 28–30° C, since the intensity of infection was one and, rarely, two cysticercoids per crustacean.



## CONCLUSION AND DISCUSSION

In Ostracoda, the length of the larval development and the size of cysticercoids of the six cestode species investigated are influenced by the temperature and intensity of infection (Scheme 1), the intensity of infection being dependent on the temperature.

The effect of the intensity of infection on the length of larval development of *D. ransomi* in the ostracod *Cypridopsis vidua* (O. F. Müller) was dealt with in the



- Relationship generally valid for all studied cestode species
- - - - -→ Relationship valid for Group I or Group II separately

paper by Rybicka (1957). According to this author, at the intensity of infection 1–18 larvae the length of larval development was not influenced (maximum intensity of infection described by the author was 21 cysticercoids, in one case 45 cysticercoids). In our experiments, the length of the larval development was influenced already by the intensity of 3 cysticercoids (maximum intensity of infection 8 cysticercoids); at the intensity of 1–2 cysticercoids this relationship was not always distinct. Like in our results, the author observed a relationship between the size of the cysticercoids and intensity of infection. However, the results of both papers cannot be compared, because Rybicka gives only the length of the contact of ostracods with cestode eggs (1–18 hours) and not the number of eggs used for the infection, neither the temperature at which the experiments were performed.

The relationships between the studied factors and the course of the larval development of cestodes in Copepoda are much more complicated (Valkounová 1980). The effects of the temperature, intensity of infection and size of the intermediate host on the larval development in eight species of Copepoda were studied using eleven cestode species. These were divided into two groups according to their intensity of infection: Group I (maximum intensity of infection 4 cysticercoids) — *D. inflata*, *D. ransomi*, *Microsomacanthus compressa* (Linton, 1782), *M. paracompressa* (Czapliński, 1956), *M. paramicrosoma* (Gasowska, 1931), *S. gracilis*, *S. krabbeella*

(Hughes, 1940), *S. octacantha* (Krabbe, 1896); Group II (maximum intensity of infection higher than 4 cysticercoids) — *D. coronula*, *D. nyrocae*, *F. fasciolaris*. Maximum intensity of infection with cestodes belonging to Group I (4 cysticercoids) was found both in experimental and natural conditions. This phenomenon was mentioned only by Dobrokhotova (1971) in *Bisaccanthus bisaccata* (Fuhrmann, 1906). The effect of individual factors on the course of larval development is valid either generally for all eleven cestode species or for Group I or Group II separately (Scheme 2). The temperature and intensity of infection affect the length of larval development and size of cysticercoids, whereas the size of the intermediate host influences only the size of the cysticercoids. The intensity of infection is dependent on the temperature and size of the intermediate host (Scheme 2).

The results obtained can be summarized as follows:

- a. The temperature is the most important factor influencing the intensity of infection, length of larval development and size of cysticercoids of all studied cestode species in Copepoda and Ostracoda. The larval development takes place in Copepoda at the temperatures of 8–30° C and in Ostracoda at the temperatures of 12–26° C. At the temperatures higher or lower than the given values the larval development is distinctly prolonged or even stopped and the larvae die at a higher rate (40–60%). However, the optimum temperature for the development of cestode larvae in Copepoda and Ostracoda is 24–26° C. At the temperatures of 28–30° C the development of cestode larvae in Copepoda is more rapid (9–17 days as compared to 11–19 days at 24–26° C), but the larvae die at a higher rate (9–11% during each experiment).
- b. The intensity of infection influences the length of the larval development and the size of cysticercoids in Copepoda in the cestodes of Group II and in Ostracoda in all the six studied cestode species. The maximum intensity of infection with cysticercoids in *F. fasciolaris* was 37 cysticercoids at 24–26° C and 32 cysticercoids at 18–20° C in Copepoda, and 8 cysticercoids at 24–26° C and 6 cysticercoids at 18–20° C in Ostracoda. The intensity of infection is influenced by the temperature in all studied cestode species in Copepoda and Ostracoda and by the size of the intermediate host in Copepoda and cestodes of the Group II.
- c. The size of the intermediate host influences the larval development of cestodes only in Copepoda. In cestodes of the Group I it affects the size of cysticercoids and in cestodes of the Group II the intensity of infection.

The studied factors are not the only criteria producing an effect on the course of the development of cestode larvae, particularly in nature where many other mutually related factors (Valkounová 1980) are involved. Nevertheless, the temperature, intensity of infection and size of the intermediate host remain the most important ones. The effects of these factors observed under experimental conditions are quite the same as in nature, only the average rate of the intensity of infection is always lower than in the laboratory (the cestode eggs are more dispersed) and the length of larval development may vary with great changes of the temperature within a short period, or sometimes the development may temporarily cease.

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**GROWTH AND AGE COMPOSITION OF THE POPULATION OF THE BREAM *ABRAMIS BRAMA* (PISCES, CYPRINIFORMES) IN THE VALLEY LAKE ORLÍK AND IN THE MINING POOLS IN THE VICINITY OF TEPLICE (BOHEMIA)**

Josef ZÁVĚTA

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**Abstract:** The growth of the bream (*Abramis brama*) in the valley lake Orlík (Bohemia) in 1974 and 1976 was studied using structure of scales from 566 specimens. In the mining pools in the vicinity of Teplice (Northern Bohemia), the growth of the bream was studied on 244 specimens. The growth of the bream, studied by other authors in 1972 and by the author of the present paper in 1974 and 1976 (the total number of specimens 1,355) is evaluated. No changes concerning the length and weight growth have been found in the valley lake Orlík in the 1972—76 period. The bream grows more slowly here than in other valley lakes in Bohemia.

INTRODUCTION

The bream *Abramis brama* (Linnaeus, 1758) is an important component of the Czechoslovak ichthyofauna. It is the typical fish species of the lower parts of streams, backwaters and pools in inundation areas. In our valley lakes it reproduces frequently and belongs to very plentiful fish species. With regard to economic and angling points of view this species deserves our attention. In the catches of anglers in 1965—76 it represents, on the average, 14.7% of all fish (Tab. 1).

In this study I examined the growth of the bream in the valley lake Orlík in 1974 and 1976. I evaluated also its growth from the year 1972 till 1976. Besides, the growth of the bream was investigated into in two mining pools in the vicinity of the town of Teplice, for which no data had been available. Naiksata (1974) and Matěnová (1975) were the first to investigate into the growth of the bream in the valley lake Orlík. The growth of the bream here was compared with its growth in the valley lake Slapy, which is also situated on the river Vltava. From there, data on the growth of the bream (Čihař and Oliva, 1960; Poupč, 1971) are based on large numbers of specimens examined. In the latter papers contributions of other Czechoslovak authors are also mentioned, who had less numerous materials at their disposal, as well as several papers by foreign authors.

General data on the fishing employment of mining pools are presented, e. g., by Schubert (1931), Tejčka (1946), Václavík (1955), Flasar and Flasarová (1975).

MATERIAL AND METHODS

The material of the bream examined was collected from the lower part of the Orlík reservoir near the village of Štědronín, where the river Otava flows into the Vltava. The utility area of the Orlík riverine lake is 2,400 ha. For further details of the locality see Naiksata (1974).

The other part of the material comes from the mining pools in the vicinity of Teplice, named "Kateřina" and "Modlany".

The mining pool Modlany has the average annual flow of 13.2 l/sec., the minimum flow being 4.2 l/sec. Both data have been calculated. The crest of the dam is situated 197 m above the sea

Table 1. Data of catches of some fish species in the valley lake Orlik during years 1965—76

years	carp	bream	Angling (specimens/kg)		fishing	altogether
			pike	white fish		
1965	5910/11604	5723/ 2553	1498/3291	78649/17900	23400	44600
1966	619/14000	9748/ 3286	1360/3149	75719/18152	25207	48300
1970	6795/17066	26713/13500	901/2579	12645/ 7280	8000	55900
1971	6722/13814	27462/12441	1846/4799	19830/ 8092	6600	63700
1972	5629/11707	14983/ 8504	675/1919	11650/ 4392	6400	57400
1973	10867/20806	9399/ 6101	703/2180	48413/ 9334	7600	80000
1974	8073/14252	28774/ 8946	1251/3196	22691/ 4896	6820	71100
1975	9959/17714	44142/13495	938/2478	16011/ 3593	5730	62767
1976	9145/18323	49950/15068	946/2521	28936/ 5399	13533	87284

level. The maximal surface level is 196.4 m, the minimal level 195 m above the sea level. The minimal inundated area is 39.5 ha. The average inundated surface is 60.4 ha.

The crest of the maximal level of the mining pool Kateřina is 194 m above the sea level, the minimal level is 192 m above the sea level. The minimal inundated area is 56 ha. (These data were furnished by the District National Committee of Teplice, Department of the Woods and Water Economy, Mr Groger).

The numerous material from the valley lake Orlik was gained from the day's and night's seining between the last third of June and the second third of September of the year 1976, another part of the material was acquired in June, 1974. The catch was performed using bag nets and it was carried out by the Czech Anglers' Association as a part of regulation and economical exploitation of fish population in this riverine lake.

In the mining pool Kateřina breams were collected on July 28th and 29th, 1976, into gill nets by the staff of the Department of Systematic Zoology, Charles University. The length of gill nets was 30 m, depth 4 m, size of meshes  $3 \times 3$  cm. The material was immediately conserved in a 4% solution of formalin. Scales from this material were taken on October, 20th, 1977. The breams in the mining pool Modlany were collected using gill nets of the same dimensions on October 20th, and 21st, 1977. Gill nets were set in different places along banks and in free water. Specimens caught here were measured, scales were taken and afterwards they were returned into the pool.

In all specimens the body length (*longitudo corporis*) was measured, in some specimens also the total length (*longitudo totalis*). Specimens were measured and weighed by means of the methods mentioned by Oliva (1959). Collected scales (after Oliva, 1958) were examined using reading apparatus Dokumator DL II, product of the firm VEB Carl Zeiss Jena, using magnification 17.5 (Peňáz and Libosvářský, 1961). The sex and weight of the specimens from the mining pools were not ascertained. For determination of age growth R. Lee's (1920) method was used with the correction to the body length at the time of scale formation, using E. Lea's monogram. For back calculation of weight the method of Rounsefell and Everhart (1960) was used. The condition coefficient was calculated using Fulton's formula. Growth characteristics (Vasňáček, 1934) from relative growth coefficients were used.

## RESULTS

### 1. The age composition

The valley lake Orlik. 119 breams caught in 1974 were analysed; 5 specimens (4.22%) had regenerated scales. Length group 201—210 mm (32 specimens) had been pre-viously represented. Specimens examined included the IIIrd—VIIth age groups. The Vth age group was most frequent (48 specimens). The frequency distribution of particular age groups in the material from the valley lake Orlik is demonstrated in Fig. 1 (the material from 1974 white column). The sample from the year 1976 included 483 specimens. The growth analysis could not be carried out in 31 specimens (6.4% of the total number). The sample included specimens from the 1st — IXth age groups. The Vth age group (111 specimens) was the most numerous. The frequency distribution see Fig. 1. The largest was the 221—230 mm length group (81 specimens).



From the year 1974, 14 specimens from the catch were weighed. The average weight of a single bream at the time of the catch was 190 g. The bream 240 mm from the VIth age group had the maximal weight 245 g. The bream 190 mm from the IIIrd age group had the minimal weight 140 g. 87 specimens from the catches in the year 1976 were weighed. The average weight at the time of the catch was 179 g. The bream 310 mm from the VIIth age group weighed 680 g. The bream 100 mm from the IInd age group had the minimal weight 15 g

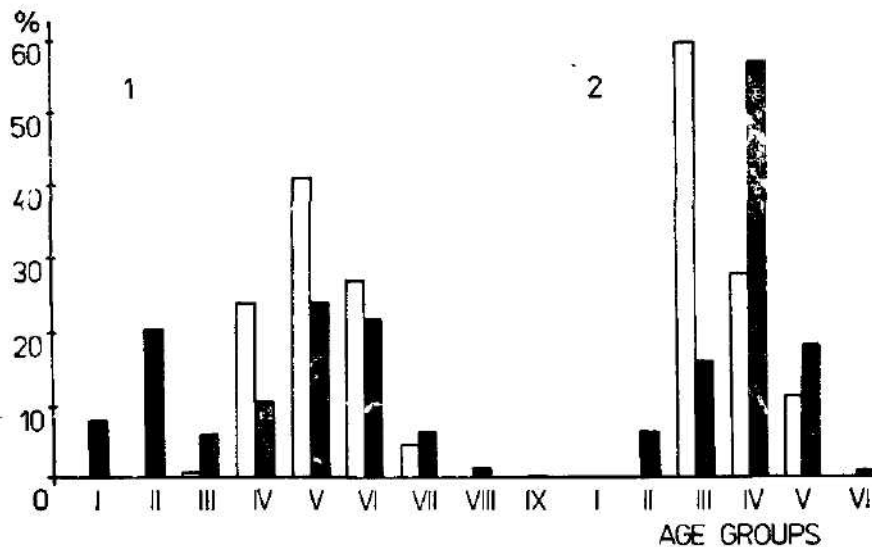


Fig. 1: The frequency composition of age groups in the catch from the valley lake Orlik in 1974 (white) in 1976 (black) in % of the total number.

Fig. 2: The frequency composition of age groups in the catch from the mining pools Kateřina (black) and Modlany (white) in % of the total number.

The mining pool Kateřina. The growth analysis was performed in 184 specimens from the total number of 189 specimens. 2.6% of scales from this number were regenerated or damaged therefore they were not used. From catches in the mining pool Kateřina the length group 140–150 mm (61 breams) was most frequent. The sample included the IInd–VIth age groups, the IVth group (105 specimens) was the most numerous. The abundance of particular age groups in % of the total abundance is demonstrated in Fig. 2 (black columns).

The mining pool Modlany. 62 specimens in total had been acquired, the scales of two breams were damaged and regenerated (3.2%). The catch from the mining pool Modlany included the IIIrd–Vth age groups. The IIIrd age group was most frequently represented (36 specimens). The numbers in particular age groups see Fig. 2 (white columns). The length group 180–190 mm (15 specimens) was most frequent. The above mentioned distribution of specimens into age groups does not correspond with the actual status, similarly as their numeric representation. The size of specimens in the catch was certainly influenced by catching methods used (gill nets, mesh size in seines).

Table 2 Length growth of the bream in the valley lake Orlik in the year 1974

Age group	n	body lengths at the time of the capture average	Back calculated body lengths in mm								
			l <sub>1</sub>	l <sub>2</sub>	l <sub>3</sub>	l <sub>4</sub>	l <sub>5</sub>	l <sub>6</sub>	l <sub>7</sub>		
III	2	193	190-195	43 42-44	81 78-84	136 120-151					
IV	28	194	160-220	45 36-62	80 62-102	133 102-157	174 102-192				
V	48	207	165-235	46 37-59	83 63-122	127 83-178	166 130-207	189 133-224			
VI	31	218	160-240	48 40-72	86 67-138	129 95-177	163 132-195	186 143-221	204 154-234		
VII	5	228	210-240	48 42-55	87 83-90	128 113-138	166 151-181	183 179-196	202 189-214	215 198-225	
	114		average	46 36-72	83 62-138	131 83-178	167 102-207	186 143-224	203 154-234	215 198-225	
The average year increments				46	37	48	36	19	17	12	

Table 3. Length growth of the bream in the valley lake Orlik in the year 1976

Age group	n	Body lengths at the time of the capture		Back calculated body lengths in mm														
		average	ranges	l <sub>1</sub>	l <sub>2</sub>	l <sub>3</sub>	l <sub>4</sub>	l <sub>5</sub>	l <sub>6</sub>	l <sub>7</sub>	l <sub>8</sub>	l <sub>9</sub>						
I	37	104	96-110	71	-	-	-	-	-	-	-	-	-	-	-	-	-	-
				57-92														
II	94	116	95-155	71	95	-	-	-	-	-	-	-	-	-	-	-	-	-
				45-89	80-123													
III	27	154	120-195	55	93	127	-	-	-	-	-	-	-	-	-	-	-	-
				48-65	79-109	101-162												
IV	49	182	135-230	55	86	126	164	-	-	-	-	-	-	-	-	-	-	-
				42-71	66-107	99-163	120-205											
V	111	219	180-250	55	89	130	169	198	-	-	-	-	-	-	-	-	-	-
				46-74	62-114	89-180	134-212	157-232										
VI	97	223	185-290	54	90	127	160	186	206	-	-	-	-	-	-	-	-	-
				42-70	60-132	94-169	119-209	124-239	162-270									
VII	30	240	195-310	52	89	124	153	182	207	228	-	-	-	-	-	-	-	-
				47-70	74-133	89-178	112-211	143-248	167-279	163-297								
VIII	5	247	235-270	55	86	117	141	168	193	216	237	-	-	-	-	-	-	-
				52-65	69-108	92-136	117-164	149-189	176-208	207-238	235-260							
IX	2	255	240-270	59	102	132	157	181	199	214	230	246	-	-	-	-	-	-
				63-65	94-109	127-136	148-166	174-188	198-200	205-222	219-240	236-257						
	452		average	59	91	126	157	183	201	219	233	246	-	-	-	-	-	-
				42-92	60-133	89-180	112-212	124-248	162-279	183-297	219-260	239-257						
The average year increments				59	32	35	31	26	18	18	14	13						

Table 4. The comparison of weight growth (in g) of the bream in the valley lake Orlik

year	w <sub>1</sub>	w <sub>2</sub>	w <sub>3</sub>	w <sub>4</sub>	w <sub>5</sub>	w <sub>6</sub>	w <sub>7</sub>	w <sub>8</sub>	w <sub>9</sub>
1973	4.7	20	49	84	127	170	205	245	271
1974	3.2	15	51	98	131	166	193	—	—
1976	4.8	17	44	83	129	170	219	263	305
average	4.2	17	48	88	129	167	206	254	288

## 2. The length and weight growth of the bream

For age determination, the scale structure was used. The correction was determined from the linear relationship between the actual particular values of diagonal radius of the scale and body length. For the material from the valley lake Orlik sampled in the year 1974, this correction value represents 50 mm, but it was not used (see discussion). For the material caught in 1976 the correction value was determined as 25 mm. The results of the length growth from the catch from 1974 are demonstrated in Tab. 2., the results of the length growth from the catch from 1976 are demonstrated in Tab. 3.

The weights of breams in the past years of life were calculated from the length-weight relationship. Values from the year 1974 and 1976 are demonstrated in Fig. 3.

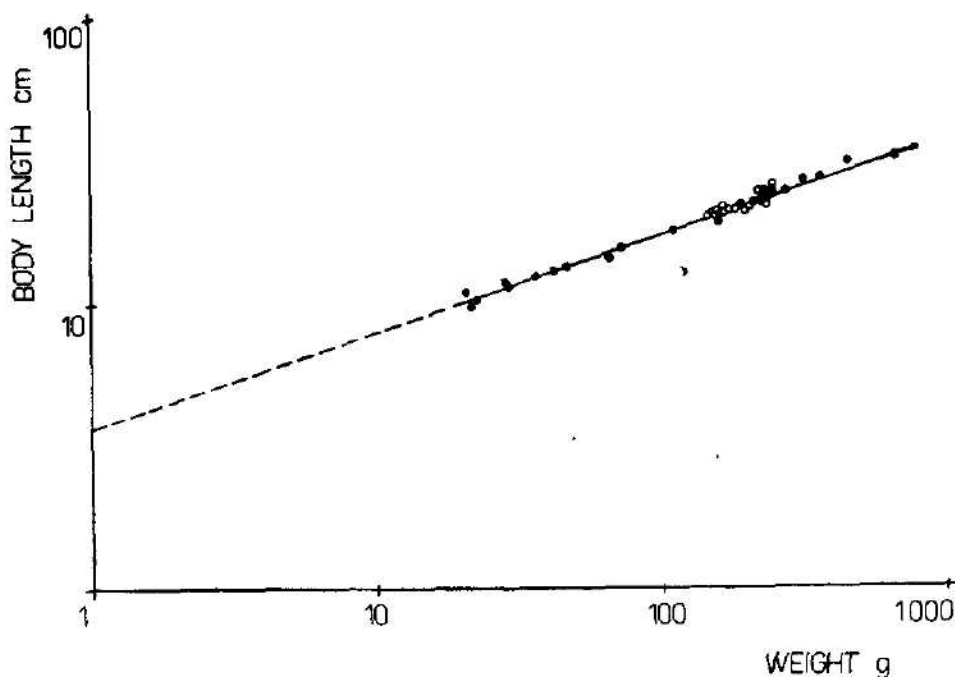


Fig. 3: The relationship between the weight and the body length on the logarithmic scale. The valley lake Orlik-the year 1974 (white), the year 1976 (black). The value 35 mm on the axis representing the body length corresponds to the weight of 1 g.

Table 6. Length growth of the bream in the running pool Modlany

Age group	n	Body length at the time of the capture average	Body length at the time of the capture ranges	Back calculated body lengths in mm					
				l <sub>1</sub>	l <sub>2</sub>	l <sub>3</sub>	l <sub>4</sub>	l <sub>5</sub>	l <sub>6</sub>
III	36	167	120--190	49 38--77	104 64--143	136 89--173	—	—	—
IV	17	191	120--210	48 37--70	90 57--121	134 89--155	168 102--188	—	—
V	7	220	195--260	48 42--56	94 70--140	148 122--183	184 151--230	204 177--248	—
	<b>60</b>		average	48 37--77	96 57--143	139 89--183	178 102--230	204 177--248	—
The average years increments				48	48	43	37	28	—

Table 5: Length growth of the bream in the mining pool Katerina

Age group	n	Body length at the time of the capture		Back calculated body lengths in mm						
		average	ranges	l <sub>1</sub>	l <sub>2</sub>	l <sub>3</sub>	l <sub>4</sub>	l <sub>5</sub>	l <sub>6</sub>	
II	12	139	90-180	47 40-52	102 80-111	-	-	-	-	-
III	30	143	135-150	61 39-71	97 85-121	124 109-139	-	-	-	-
IV	105	156	145-180	53 35-64	88 61-109	118 96-141	139 122-162	-	-	-
V	34	164	156-190	41 33-55	79 58-100	107 94-131	132 106-156	149 118-177	-	-
VI	3	186	160-190	38 34-38	69 63-80	93 87-101	117 116-120	133 132-135	151 148-153	-
	184		average	46 33-71	87 58-121	111 87-141	129 106-162	141 118-169	151 148-153	-
The average years increments				46	41	24	18	12	10	

The value on the axis representing the body length corresponding to the weight of 1 g is 35 mm. Values of the weight's growth are demonstrated in Tab. 4. The results of the length growth of the bream from the mining pool Kateřina are demonstrated in Tab. 5. Results of the length growth of the bream from the mining pool Modlany are demonstrated in Tab. 6.

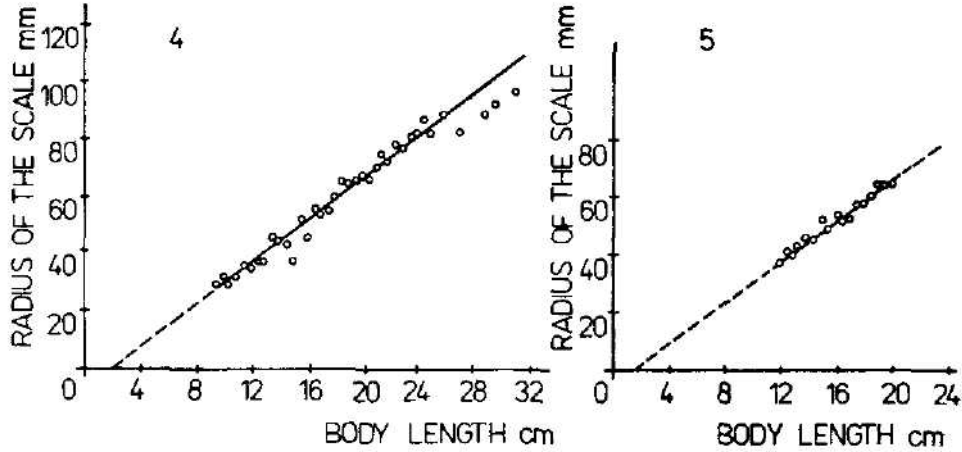


Fig. 4: The relationship between the diagonal radius of the scale (magn. 17.5) and the body length ( $l_c$ ) in mm. The valley lake Orlik in 1976. Correction 25 mm.

Fig. 5: The relationship between the diagonal radius of the scale (magn. 17.5) and the body length ( $l_c$ ) in mm. Mining pools Kateřina and Modlany. Correction 17 mm.

#### DISCUSSION

The Lee's correction used for back calculation of linear growth was determined from the above mentioned body/scale relationship. This relationship is linear, as it is apparent from Fig. 4. The value of the correction from the material from the valley lake Orlik in 1972 was 30 mm (Naiksata, 1974). Matěnová (1975) found this value to be 19 mm in 1973. In my material I found the correction value 50 mm collected in 1974, while for the sample from 1976 it was 25 mm. For the combined material from the mining pools Kateřina and Modlany the correction value is 17 mm (Fig. 5). For the bream from backwaters of the Labe in Central Bohemia, Oliva (1958) found the correction 21 mm, Segerstrale (1932) for his Finnish material 16–18 mm. The correction 19 mm was used for our material from the year 1974,

Table 7. Length growth of the bream in the valley lake Orlik during years 1972–1976

year	author	$l_1$	$l_2$	$l_3$	$l_4$	$l_5$	$l_6$	$l_7$	$l_8$	$l_9$
1972	Naiksata(1974)	57	93	127	161	187	212	—	—	—
1973	Matěnová (1975)	54	93	129	158	184	205	220	235	244
1974	author	46	83	131	167	186	203	215	—	—
1976	author	59	91	126	157	183	201	219	233	246
1972 to 1976	average	54	90	128	161	185	205	218	234	245



Table 8. The comparison of values of the index of the condition in the valley lake Orlík in years 1973–1976

years	1	2	3	4	5	6	7	8	9
1973	—	—	2.21	2.17	1.95	2.03	2.05	1.99	1.93
1974	—	—	1.99	2.24	2.17	1.93	2.48	—	—
1976	2.0	2.09	2.29	2.43	2.05	1.99	2.25	1.35	—

the value used also by Matěnová (1975) for her calculations from 1973. The high value of the correction (50 mm) was obtained for a small number of breams of lower age groups. Neither the values of correction 8 mm found in the body/scale relationship of breams living in the mining pools in Northern Bohemia could be used for the calculation of body lengths in the past years. The latter values do not agree with the body length in the time of scale formation, as it was documented by Segerstrale (1932) who studied this problem directly on the bream fry. Consequently, the bream material from the mining pools was studied as a whole the mean values of the diagonal radii of scales were determined, and the correction 17 mm was used. For the analysis of the less numerous material it appears as more suitable to use such a value of correction that was found on the same or neighbouring locality by another author and that is supported by numerous scale material. In other cases it seems profitable to use a correction value acquired experimentally. The length growth of the bream in the observed period is given in Tab. 7. From the values cited it is evident that the growth of the bream showed no serious variation. In the year 1974, the growth of the bream accelerated in the third year of life. This may be due to a different type of food relations, represented by the shift to the bentic food (Havelka, Roud, Vostradovský, 1967). The results of the growth of the bream from the valley lake Orlík are based on numerous scale material from the whole period of observance 1972–76 (in total 1,355 specimens). According to my results, the growth of the bream is stabilized. This is evidently supported by catches using angling and netting, which both until lately limited the overpopulation of the bream. The weight of all fishes inhabiting the reservoir Orlík as calculated on hectar per year is increasing; in the year 1968 it was 19.3; 1969: 26.2; 1970: 23.2; 1971: 26.5; 1972: 22.7; 1973: 27.0; 1974: 24.0; 1975: 26.1; 1976: 36.3 (all in  $\text{kg}\cdot\text{ha}^{-1}$ ). From the results concerning the weight growth of the bream it is evident that it does not show any greater changes over the whole period observed. The values of the index of condition for the observed period are demonstrated in Tab. 8. It is commonly known that the value of Fulton's index of condition changes in dependence on the size and age of the fish specimen. With increasing age the fish grows relatively more in the weight than in the length. Index of condition changes in the course of the year and its larger value shows a better condition of the specimen. I can confirm these results. From the growth characteristics, which are demonstrated in Tab. 9, it is possible to determine the period of the growth and its intensity (Vasněcov, 1934). According to the growth charac-

Table 9. Characteristics of the growth in valley lake Orlík in years 1973–1976

years	1	2	3	4	5	6	7	8	9
1973	29.3	30.4	26.1	24.0	19.9	14.4	14.3	8.7	—
1974	27.1	37.8	31.8	17.9	16.2	11.6	—	—	—
1976	26.2	29.6	27.7	24.0	17.0	17.2	13.5	12.6	—

Table 10. Characteristics of the growth in mining pools of the vicinity of the town Teplice in North Bohemia

Locality	years	1	2	3	4	5	6
Modlany		33.5	35.5	32.8	25.9	—	
Kateřina		29.3	21.2	16.7	11.5	9.7	

teristics it is possible to state that there were no changes in the growth of the bream in the course of the period of observation in the valley lake Orlik. The growth of the bream in the above mentioned mining pools in Northern Bohemia is different. From the values cited it is evident that the growth in the pool Kateřina is slower than in the pool Modlany. This is evident also from the growth characteristics (Tab. 10). The Modlany mining pool is still enlarging due to the overflowing of new areas which presents new possibilities of food for the fish. My results of the growth show that the bream has not yet overpopulated here. On the other hand the mining pool Kateřina is older and does not enlarge now spontaneously, its banks being stabilized, and there are no overflows into new areas. The slow growth of the bream shows that the pool may be overpopulated. The slow growth of the bream is demonstrated also in the growth characteristics. The comparison of the growth of the bream in my localities, i. e. the valley lake Orlik and both the mining pools, with some other Czechoslovak localities and localities abroad shows that the growth of the bream in the valley lake Orlik is slower as compared with other valley lakes (Tab. 11). Only under the Scandinavian, climatically worsen, conditions the growth of the bream is slower (Segerstrale, 1933). As an example of localities with a rapid growth the bream from the Caspian Sea could be mentioned (Berg, 1949). Comparing the growth of the bream in backwaters, the growth in the mining pool Kateřina was found slower than in the Labe backwater Poltruba (Oliva, 1958). On the contrary, in the pool Modlany the growth of the bream is better than in the Poltruba backwater and in the backwater Žofín (inundation area of the Dunaj, Naiksatam, 1973) (Tab. 12).

In our country, the bream is economically of importance only in the valley lakes, and at present it is being caught using angling and netting, regardless to its size and quantity.

Table 11. The comparison of the growth of the bream in some valley lakes

Locality	Number of specimens	1 <sub>1</sub>	1 <sub>2</sub>	1 <sub>3</sub>	1 <sub>4</sub>	1 <sub>5</sub>	1 <sub>6</sub>	1 <sub>7</sub>	1 <sub>8</sub>	1 <sub>9</sub>	1 <sub>10</sub>	1 <sub>11</sub>
Orlik												
average 1972-76	1355	54	90	128	161	185	205	218	234	245	—	—
Slapy —												
Poupě (1964)	303	85	135	179	219	249	289	320	370	404	425	445
Slapy — Čihár and Oliva (1960)	463	80	126	165	196	216	242	303	340	383	412	—
Lipno —												
Poupě (1971)	403	76	112	152	186	210	233	264	322	331	346	357
Caspian Sea —												
Berg (1949)	—	73	162	253	295	332	360	393	405	421	431	437
Haika Fjörd Borga Finland-Segerstrale (1933)	—	34	70	103	129	149	166	184	203	223	239	261

Table 12. The survey of the growth of the bream in stagnant waters

Locality	Number of specimens	1 <sub>1</sub>	1 <sub>2</sub>	1 <sub>3</sub>	1 <sub>4</sub>	1 <sub>5</sub>	1 <sub>6</sub>	1 <sub>7</sub>	1 <sub>8</sub>
<b>Mining pools</b>									
Modlany — author	60	48	96	139	176	204	—	—	—
Kateřina — author	184	46	87	111	129	141	151	—	—
<b>Poltruba-backwater</b>									
Oliva (1958)	157	55	77	115	153	181	213	269	335
<b>Danube-backwater</b>									
Žofin	999	57	92	115	162	187	215	250	273
Naiksatam (1973)									

The bream has big utility value which is higher than that of the carp (*Cyprinus carpio*) and tench (*Tinca tinca*) — see Pokorný (1965).

The content of the fat in the flesh is larger than in other species. The bream can be used also as human food. Smaller specimens can be utilized industrially as food in fur farms, in trout hatcheries, in zoological gardens, and for the production of the feeding flour (Havelka, Roud. Vostradovský, 1967). The utilization of the bream for fishery in the mining pools should not be underestimated. Besides our valley lakes they are the most extensive stagnant waters in Northern Bohemia, having the estimated total area of about 1,8000–2,000 ha (Václavík, 1955).

#### SUMMARY

1. In 1974 the author examined the growth rate in 114 specimens, and in 1976, in 452 specimens of the bream, *Abramis brama*, from the valley lake Orlik. From the mining pool Modlany 60 specimens and from the mining pool Kateřina 184 specimens of the bream were studied.
2. From the valley lake Orlik growth data of other authors from years 1972–73 are known, based on 789 specimens.
3. From the growth of altogether 1,355 breams in the valley lake Orlik it is evident that their growth is stabilized. The growth of the bream is slower here than in other localities and deviations were observed in the period studied.
4. From the growth analysis of 244 breams from the mining pools Modlany and Kateřina, a bad growth was ascertained in the pool Kateřina, while in the pool Modlany the growth was found to be better.
5. With regard to the above-mentioned results it is possible to recommend the catch of the bream in the valley lake Orlik regardless of the size and number, while controlling simultaneously the age structure of the population.
6. The results of the growth of the bream in the mining pool Kateřina support the necessity of influencing the dynamics of the fish population through intensive catching using all methods regardless of the size of fish and their number. As to the mining pool Modlany, only the control of the growth of the population can be recommended without any intensive interference of anglers and fishermen.

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REVIEWS — RECENZE

Harrison, G.: *Mosquitoes, Malaria and Man: A History of the Hostilities since 1880*. Nakl. John Murray, Londýn, 1978, 314 str., 8,5 L.

Loňského roku tomu bylo sto let, co francouzský, v Alžiru působící lékař Alphonse Laveran, poprvé spatřil v krvi původce malárie. Nebyl první, kdo jej tam hledal, ale pozornost jeho předchůdců odlákal vždy nápadnější malariický pigment. Jeho objev byl vodou na mlýn posmívanému skotskému lékaři Patricku Mansonovi, který stále „pošetile“ tvrdil, že komáři roznášejí některá lidská onemocnění. Na jeho myšlenky se mu podařilo nalákat jen mladého anglického lékaře Ronalda Rosse, díky tomu, že duševní rozpětí tohoto muže mezi básníkem a matematikem mu dovolilo takové věci pochopit a pro ně se nadchnout. Ross přenos ptačí malárie komáři skutečně objevil. Do věci se zapojil italský Battista Grassi, jehož větší vnitřní křídla mu dovolila provést řadu soustavných a úspěšných pokusů s malárií lidskou. Nakonec mezi těmito muži vznikl nesoulad a jediný Ross vyšel z toho s Nobelovou cenou. Do bádání se připojil Robert Koch a mnoho dalších. Toto vyprávění zaujímá velkou část knihy. Je to příběh známý již odjnuď, ale tu pojatý mnohem širěji; s kořeny ze kterých vyrostl, s okolnostmi, které jej doprovázely a které jej dokreslují. Poučný příklad toho, jak komplikované se rodí lidské poznání, kolik prosazujících se myšlených a kolik podceňovaných správných myšlenek stojí na počátku odhalení pravdy a zároveň příklad toho, jak pravda již poznána se těžko dera napovrch přes nedůvěru i horší vlastnosti.

Knihou tím nekončí. Líčí nám pozdější protikomáří akce a konečné vyřešení toho, kam záhadně mizí malaričtí sporozoiti po vpichnutí do lidského těla komáři. To již v období po 2. světové válce, kdy hlavními postavami tehdy byly dosud žijící angličtí protozoologové Percy Garnham a Henry Shortt. Závěr knihy nás zavádí do Indie a Srí Lanky, kde se poválečné milionové počty případů malárie podařilo snížit pomocí DDT, na oněch 29(!) v r. 1964 ve Srí Lance. Narůstající rezistence komárů proti chlorovaným uhlovodíkům i omezování v používání DDT začaly však vracet křivku zase směrem vzhůru.

Je to zajímavé čtení, doplněné ve zvláštní části poznámkami o pramenech s dalšími detaily a ilustracemi. Pokud je recenzentovi známo, není tato kniha v žádné naší veřejné knihovně. Stěží v rukách soukromých.

J. Chalupský

Kean, B. H. — Mott, K. E. — Russell, A. J., *Tropical Medicine and Parasitology, Classic Investigations, Volumes I and II*, Cornell University Press, Ithaca and London 1978, 677 p., 50 \$.

Every specialist in the field of zoology sometimes needs or simply wishes to read communications in original versions. However, it may be very difficult to locate them, and quite often the energy employed is totally wasted. In addition, language barriers may complicate things. As regards parasitology, the publication of the above mentioned book has solved these problems. All important papers on discoveries in parasitic protozoa, helminths and their vectors are now available in one publication at the reader's fingertips. It contains communications by 200 authors from the period 1650—1950, all in English (translated where necessary). Several classic articles by Czech authors — Lambi's on today's *Giardia (Lambia)* (1859), Janků's on the first case of human toxoplasmosis (1923) and Drbohlav's (with Boeck as the first author) on the cultivation of *Entamoeba histolytica* (1925) are included. This is a very useful book, both informing and inspiring.

J. Chalupský

Rozkošný R. (ed.): *Clíč vodních larev hmyzu (Bestimmungsschlüssel der Wasserlarven der Insekten*. 524 pp., 143 Taf., Academia, Praha, 1980'. Preis 95 Kčs (tschechisch).

Der Bestimmungsschlüssel der Wasserlarven der Insekten stellt das erste Buch in unserer Literatur vor, in dem die Bestimmungsschlüssel fast aller, aus dem Gebiet der Tschechoslovakei bekannten im Wasser lebenden Insektenlarven, enthalten sind.

Es entstand als Resultat der Arbeit von 15 Autoren, die meistens als Spezialisten über die betreffenden Insektengruppen bekannt sind. Insgesamt wurden die Schlüssel für die im Wasser lebenden Larven von 9 Insektenordnungen verfasst: Ephemeroptera (15 Familien), Odonata

(9 Familien), Plecoptera (7 Familien), Heteroptera (11 Familien) Megaloptera (1 Familie), Planipennia (2 Familien), Coleoptera (12 Familien). Das Kapitel über die Ordnung Hymenoptera ist auf die Bemerkungen über die Pupal- und Larvalparasiten beschränkt.

Einzelne Ordnungen wurden nach einem einheitlichen Schema bearbeitet: kurze Beschreibung der Ordnung, Bemerkungen über die Morphologie der Larven, Puppen und Eier, Biologie der Larven, Schlüssel der Familien, Schlüssel der Arten. Jedes Kapitel ist mit dem Verzeichnis der Hauptliteratur versehen. Grosse Aufmerksamkeit wurde auch dem allgemeinen Teil des Buches gewidmet. Man findet hier ausführliche Auskünfte über die Morphologie der Entwicklungsstadien der Wasserinsekten, über die Klassifizierung der aquatilen Ökosysteme, über die Nahrungsbeziehungen der Larven und über die praktische Bedeutung der im Wasser lebenden Insektenlarven. Auch der Sammlungstechnik, der Präparationstechnik und der Aufbewahrung des Materials ist genug Platz gewidmet. Ein Schlüssel am Anfang des speziellen Teiles des Buches ermöglicht die Bestimmung der Larven und Puppen in die Ordnungen. Am Ende der Publikation fehlen selbstverständlich nicht die Register der tschechischen und wissenschaftlichen Namen.

Die meisten Bestimmungsschlüssel ermöglichen die Bestimmung der Larven bis in die einzelnen Arten oder Artengruppen (Fam. Chironomidae). Das Buch ist reich illustriert (143 Tafeln mit 2319 Abbildungen). Obwohl die Mehrheit der Bilder von anderen Autoren übernommen wurde und der Stil der Zeichnungen deshalb nicht einheitlich ist, wurden alle Illustrationen gut gewählt und dokumentieren ausreichend die Unterscheidungsmerkmale einzelner Arten. Die Qualität des Nachdrucks ist bis auf die Tafel 45 auf der Seite 147 sehr gut.

Als gewisser Nachteil dieser Publikation kann man ansehen, dass neben den Schlüsseln die auf Grund eigener Forschungen der Autoren, die dann auch meistens mit Originalzeichnungen versehen sind z.B. Trichoptera, Culicidae, Chironomidae, u. a., sind bei manchen anderen Gruppen die Schlüssel kompilationsweise auf Grund der Literaturangaben, die nicht immer dem heutigen Zustand der Kenntnisse entsprechen müssen, verfasst. Bei der Ordnung Ephemeroptera gelang es leider nicht, die in der letzten Zeit veröffentlichten Funde der für die Tschechoslowakei neuen Eintagsfliegenarten, in die Schlüssel einzureihen.

Diese Nachteile vermindern aber keineswegs die Bedeutung dieser Publikation, die sich zweifellos als ein modernes Hilfsmittel, sowohl für die Spezialisten — Hydrobiologen und Entomologen als auch für die Studenten und Laien, erweisen wird. Nach mehr als 25 Jahren vom Erscheinen des H. Bertrands Werkes über die europäischen Wasserinsekten steht jetzt zur Verfügung ein modernes Bestimmungsschlüssel beinahe aller mitteleuropäischen im Wasser lebenden Insektenlarven. Eine neue Ausgabe in der englischen, deutschen oder russischen Sprache würde von den ausländischen Biologen sicher sehr begrüsst.

*M. Tonner*



## POKYNY PRO AUTORY

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

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

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

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

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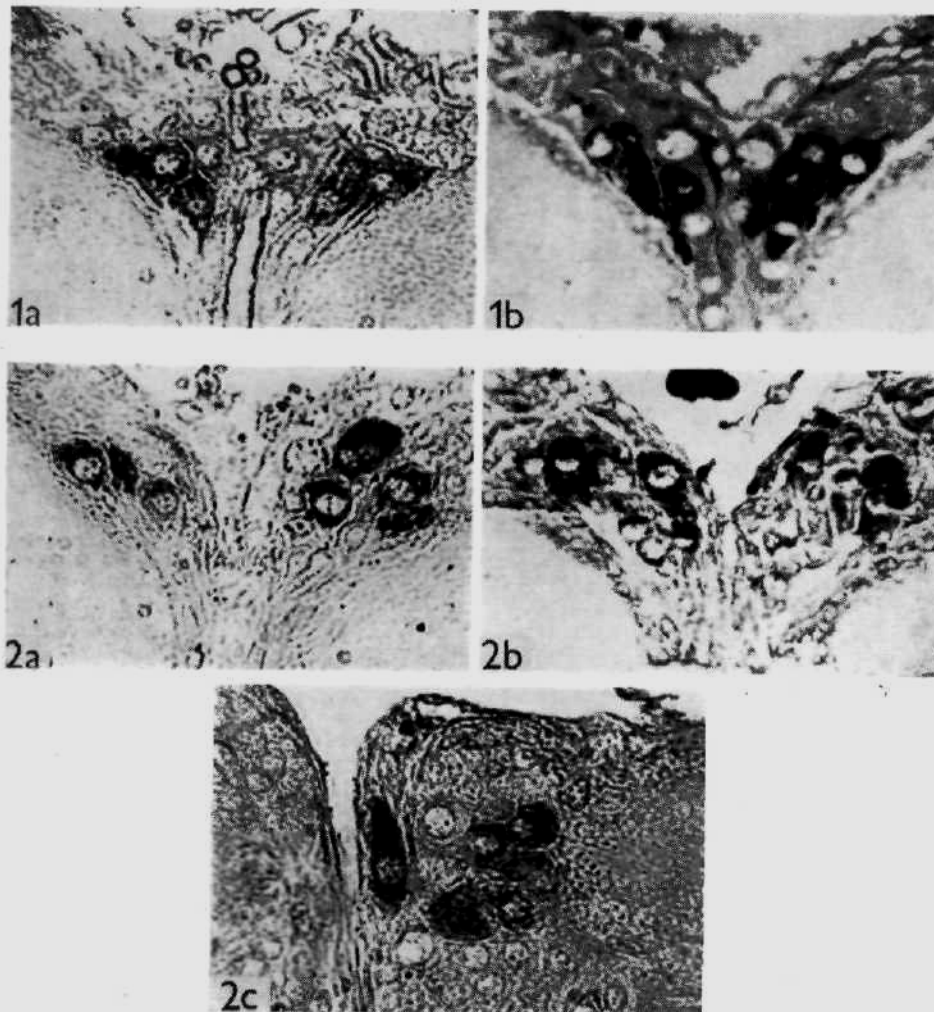


Fig. 1 a) Parts of sections in the pars intercerebralis to show the mnsc in defected insects (belong to the first category) (640 $\times$ ) b) In the normal newly formed adult (640 $\times$ ).  
Fig. 2 a) Parts of sections in the pars intercerebralis to show the mnsc in defected insects (second category). (640 $\times$ ), b) In normal newly formed pupae, c) In defected insects (third category). (640 $\times$ ).

Abou-Halawa S. M. A.: Effects of juvenoids on the neuroendocrine system of the flesh fly *Sarcophaga crassipalpis*

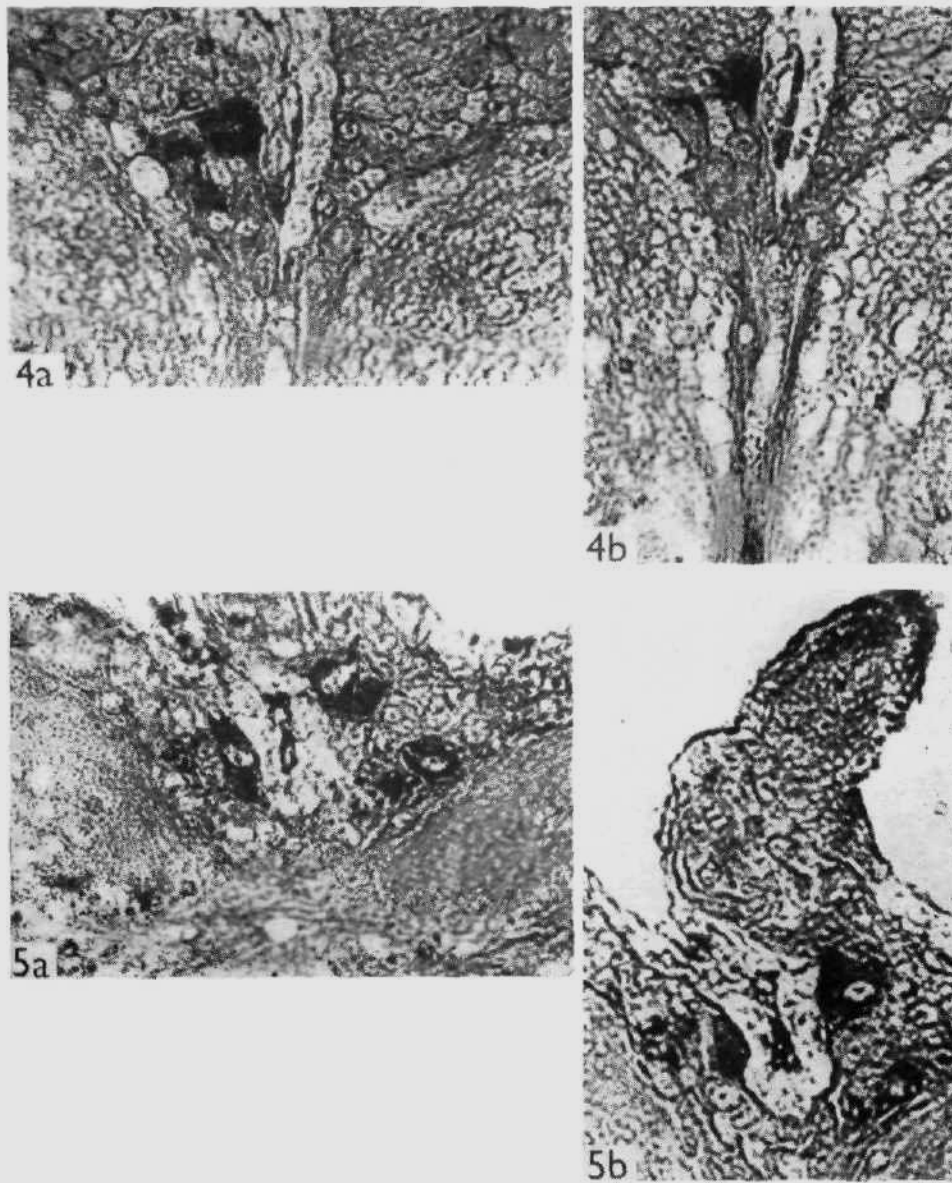


Fig. 4 a) Parts of sections in the brains of defected insects (640 $\times$ ), b) The proceeding section to show the median bundle with ns-material.

Fig. 5 a) Parts of section in the defected brains belong to the fourth category (640 $\times$ ), b) In the proceeding section to show the abnormal growth of the ocellar nerve.

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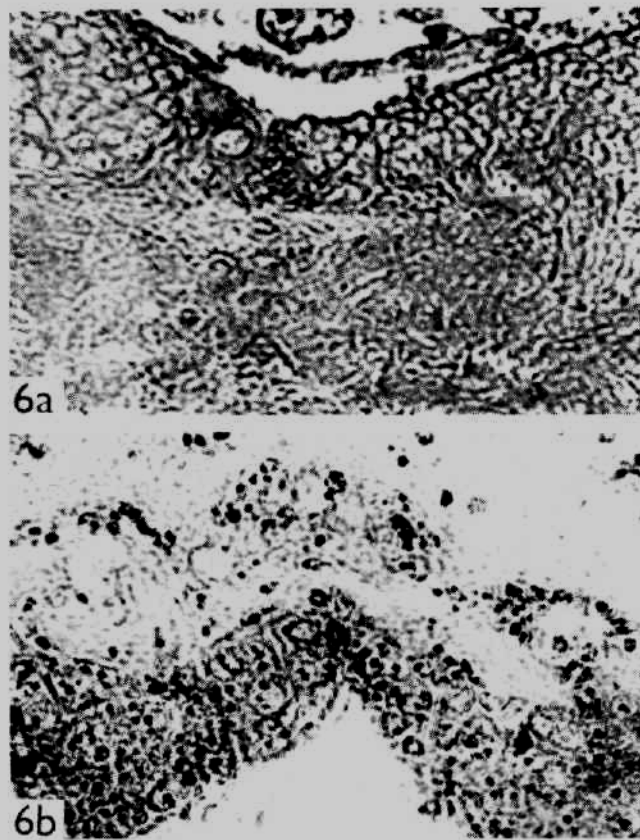
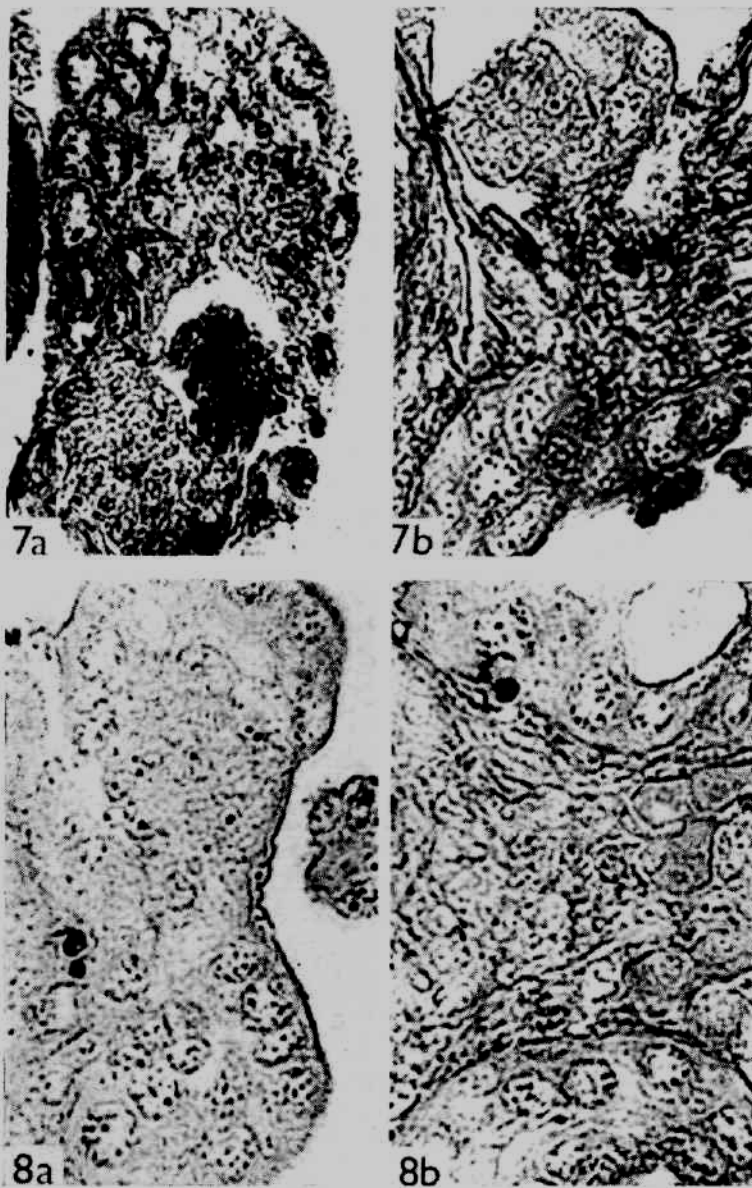


Fig. 6 Parts of sections in the defected brains belong to the fifth category (640 $\times$ ), a) PAF-stain, b) Heidenhain's azan stain.

*Abou-Halawa S. M. A.: Effects of juvenoids on the neuroendocrine system of the flesh fly Sarcophaga crassipalpis*



**Fig. 7 a)** Section in the ring-gland of defected insects (first category). (640 $\times$ ), **b)** Second category. (640 $\times$ ).  
**Fig. 8 a)** Section in the ring-gland belongs to the third category passing through the ca (640 $\times$ ), **b)** Passing through the cc.

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VĚSTNÍK ČESKOSLOVENSKÉ SPOLEČNOSTI ZOOLOGICKÉ  
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