FOLIA PARASITOLOGICA (PRAHA) 26: 129–137, 1979.

HISTOLOGY AND HISTOCHEMISTRY OF THE CYSTICERCUS OF TAENIA CRASSICEPS (ZEDER, 1800)

J. PROKOPIČ and D. HULÍNSKÁ

Institute of Parasitology, Czechoslovak Academy of Sciences, Prague

Abstract. The morphological structure of the cysticercus of *T. crassiceps* has been studied with histological and histochemical methods. Sometimes, a number of developmental larval stages of a different age originating on the mother bladder by an asexual reproduction, have been found in the same intermediate host. Differences in the histological structure of these larval stages are described in the present paper.

The biology of the larva of the cestode *Taenia crassiceps* (Zeder, 1800) which Rudolphi (1819) described as *Cysticercus longicollis* Rudolphi, 1819, is most interesting. The larva differs in certain biological properties from the remaining larval cestodes of the genus *Taenia*. The initial phase of development of the cysticercus of *Taenia crassiceps* is typical of that which Abuladze (1964) ascribed to his type "cysticercus". However, overage larvae of *T. crassiceps* reproduce asexually in that daughter cysts bud on the surface of the original bladder. If the cysticercus remains for a prolonged period in the same intermediate host, it is possible to find in it even several generations of cysticerci which are of a different age and at different developmental stages. Bondareva's (1968) description of an extreme case of an asexual mass reproduction of larval *T. crassiceps* initiated our histological study on this heterogeneous material.

MATERIALS AND METHODS

Cysticerci of *T. crassiceps* were obtained in postmortem from the subepidermis of *Clethrionomys glareolus* trapped near Hälnäs (Sweden) in 1975. We selected 28 cysticerci of a different shape for histological treatment. The material was fixed with 10 % formalin and then dehydrated and embedded in paraffin by the standard histochemical method of Pearse (1960). A series of paraffin sections were tested for these reactions: PAS (Pearse 1960) combined with acetylation and desacetylation and the saliva test for neutral mucosubstances; Alcian blue (Alcian blau 865 Fluka) pH 2.6 combined with methylation by the method of Fischer and Lillie (1954), and demethylation by the method of Spicer and Lillie (1959; Mowry's modification of the AB-PAS reaction for a differentiation of acid mucosubstances; DDD (2,2-dihydroxy-6,6-dinaphthyl-disulphide) for proteins of the SH group DDD combined with thioglycolic acid (Pearse 1960), PFA-AB (performic acid-Alcian blue) controlled with Alcian blue pH 0.2 and PAA-AF (peracetic acid-aldehyde fuchsine) for the detection of SS groups of proteins; Morel-Sisley's diazotization method and the coupled tetrazonium reaction (TK) for tyrosine; DMAB (dimethylaminobenzaldehyde) for the detection of tryptophane. Of histological methods we used these: Goldner's blue trichrome, Mallory's phosphowolfram haematoxylin, van Gieson's reaction, Gomori's impregnation method, Feulgen's nuclear reaction. For scanning electron microscopy, the fixed material was dried with the critical point method (Anderson 1958), and coated with Au/Pd. Micrographs were made with a JSM 35.

RESULTS

Out of the 28 differently shaped larvae of *T. crassiceps* we found 8 with a completely evaginated scolex (Fig. 1). In two cysticerci (Fig. 2), the evaginated scolex was pressed into the opening of the spiral canal. In two other larvae, we observed an asexual reproduction: germ buds originated at the site where the wall of the scolex passed into the

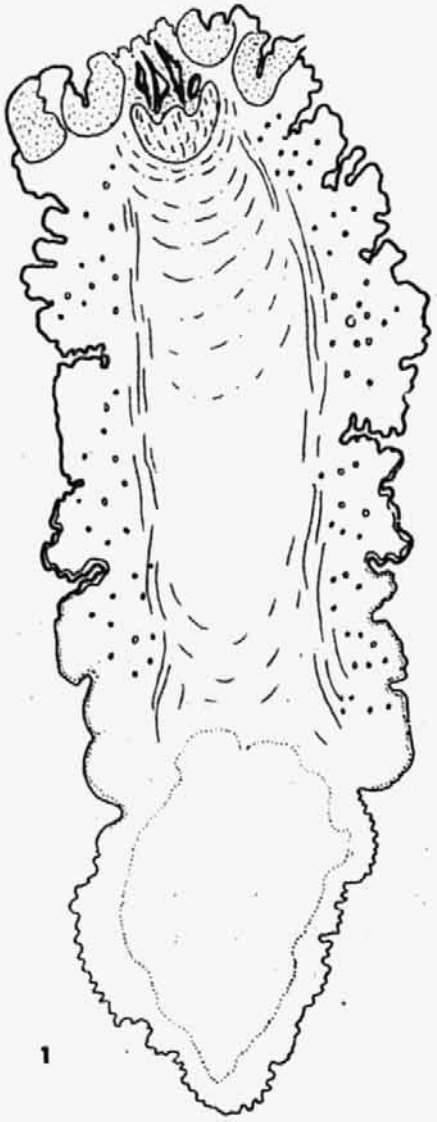


Fig. 1. Larval *T. crassiceps:* fully evaginated scolex and a minute caudal bladder. The surface of the evaginated scolex is covered with the thick tegument of the spiral canal which apically passes into the thinner tegument of the suckers and the rostellum, caudally into that of the bladder (reconstructed from paraffin sections, × 10).

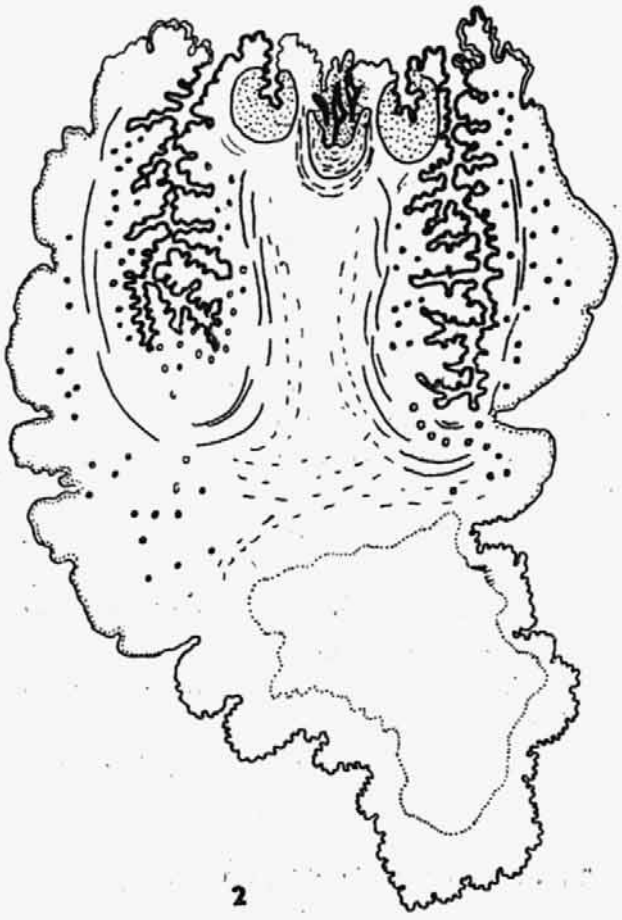


Fig. 2. Older larva of *T. crassiceps* with a scolex re-invaginated partly in the spiral canal. Caudally, the bladder is compressed by the thickened parenchymal portion of the scolex (× 6.6).

wall of the bladder. In a typically overage larva of *T. crassiceps*, the caudal bladder was reduced at its base (Fig. 3 a) by an elongation of the spiral canal and a thickening of the scolex parenchyma. The invaginated rostellum possessed 32 morphologically characteristic hooks (Fig. 3 b). While the scolex of young cysticerci with its invaginated rostellum was small and little developed, the bladder was very big, the bladder wall was thin (Fig. 4).

In histological sections, the length of the cysticerci was 2.1–2.3 mm, the width of the scolex portion was 1.15–1.25 mm. The length of evaginated cysterci was 2.25 to 2.50 mm, the width of their rostellar area 0.70–0.90 mm. A connection between the scolex portion and the thin, folded tegument of the bladder was established by a transitory zone measuring 0.45–0.40 mm at a width of 0.60–0.70 mm. The bladder

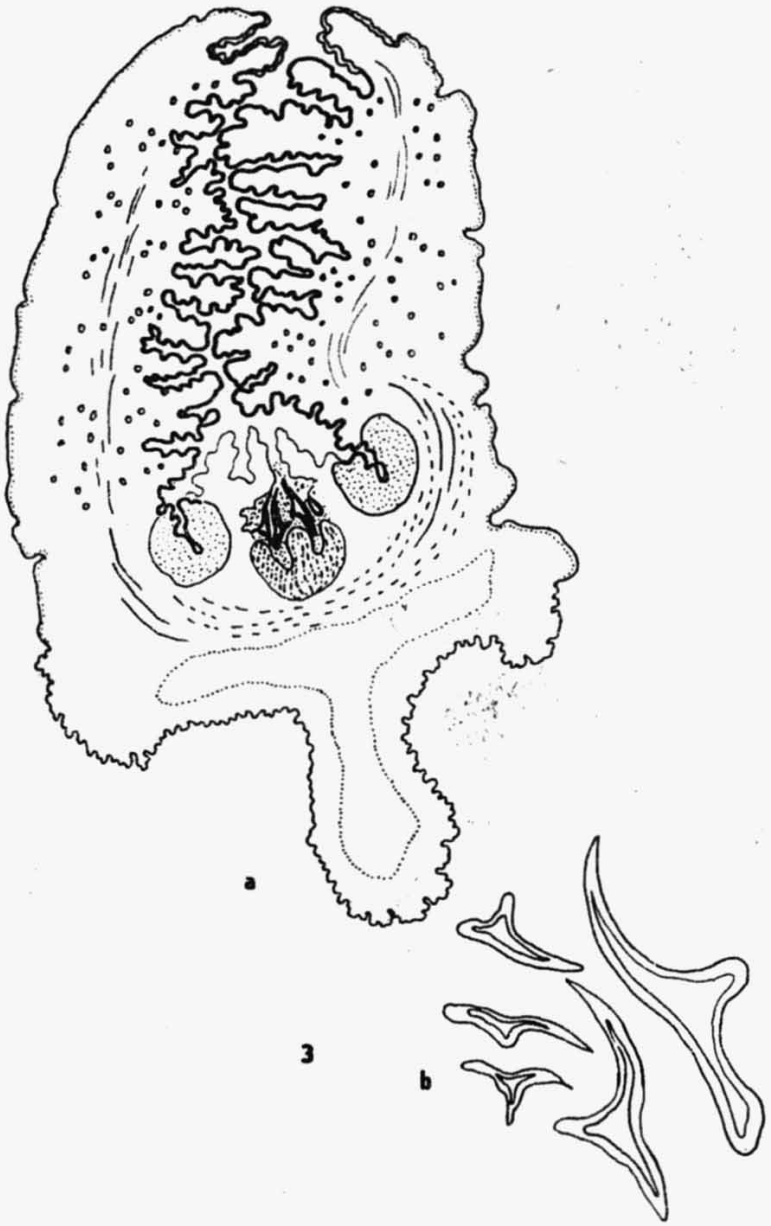


Fig. 3. a — Typical larva of *T. crassiceps* with its invaginated rostellum at the bottom of the spiral canal. The bladder is compressed and reduced by excessive growth and a thickening of the parenchyma of the canal wall (×5.8), b — Small and large hooks of a larval *T. crassiceps* (×17.5).

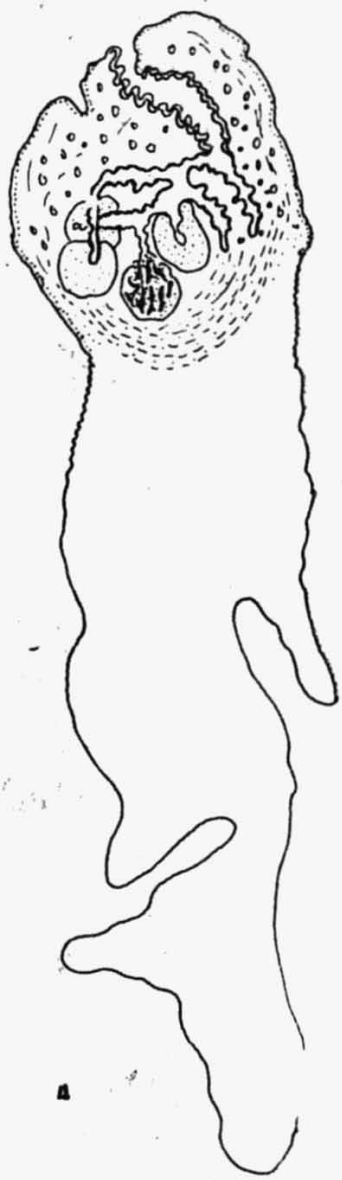


Fig. 4. The thin-walled bladder of a young *T. crassiceps* is several times bigger than the small scolex portion (×12.1).

was 0.40–0.50 mm long at a width not surpassing that of the transitory zone. Proliferating, young cysticerci with a large bladder measured 2.40–2.50 mm in length, the width of their scolex portion was 0.55 mm. The small scolex was almost spherical (length 0.570 mm, width 0.550 mm). The bladder with numerous folds or lobate processes measured 1.75–1.83 mm in length. Elongate daughter bladders were seen on several

large bladders (Fig. 5a). The formation of a scolex bud at the site where the scolex wall passed into the bladder was observed in one cysticercus (Fig. 5 b); in two other cysticerci, the bud was situated at that end of the bladder facing the scolex. The cysticercus was 2.2. mm long at a width of 1.15 mm. The cellular bud produced by an evagination of the bladder wall measured 145 μm × 125 μm. The wall of the asexually

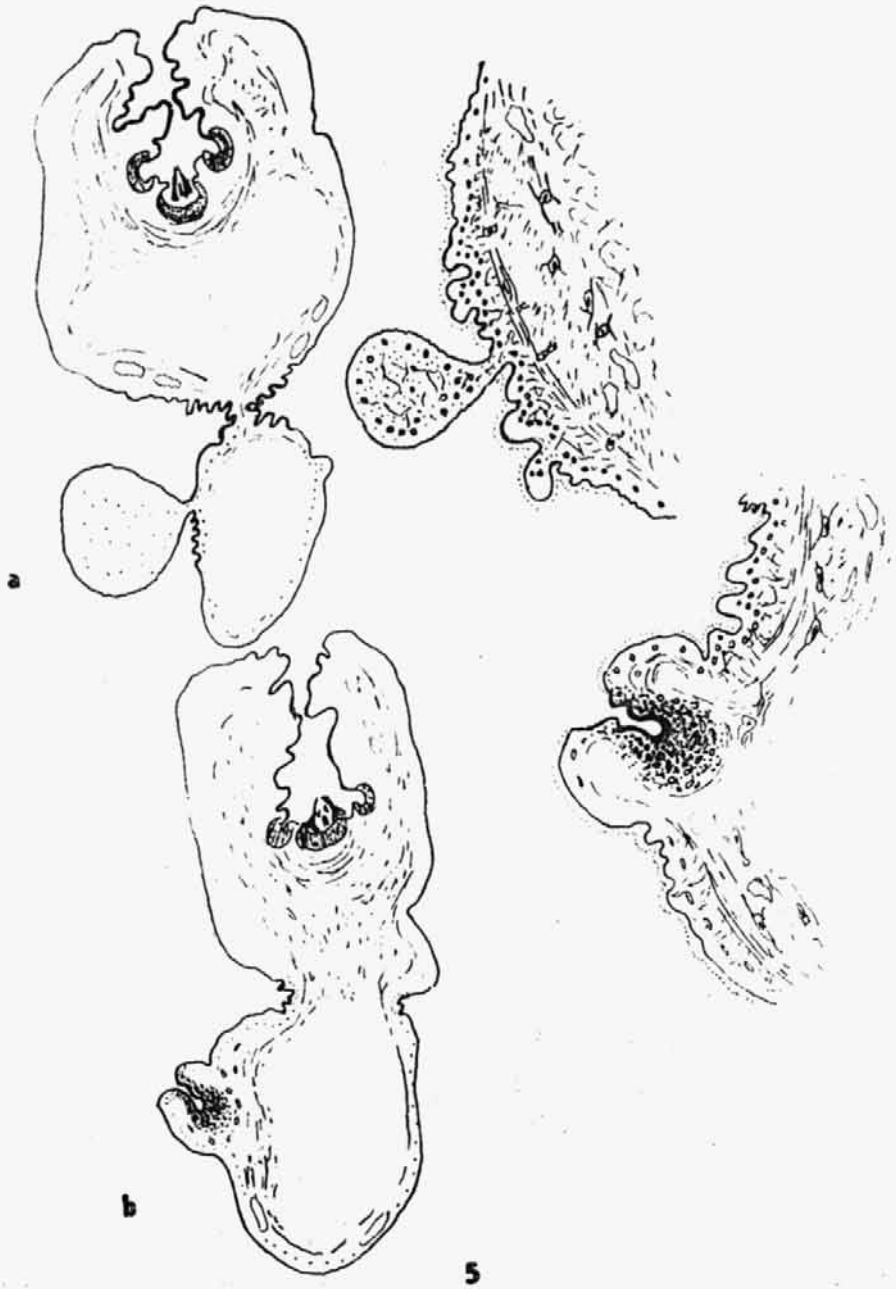


Fig. 5. Schematic illustration of budding in a larval *T. crassiceps*. a) — budding of secondary bladders from the mother bladder, b) — budding of a new scolex anlage on the primary bladder of an older larva.

produced bladder was modified by the budding of an older scolex anlage and arose wart-like above the remaining bladder surface (Plate I, Fig. 1). The hole in the centre of the rugate bud originated from an invagination of the tegument into the canal (Plate I, Fig. 2). The rostellum (average size 40—45 μm) of all larvae possessed 14 to 15 small hooks and 17—18 large hooks, but never more than 33. Large hooks measured 173—174 μm, small hooks 125—128 μm.

The tegument of the suckers and the spiral canal up to its opening, observed in a typical *T. crassiceps* (Plate II, Fig. 1) is composed of short microtriches and a homogeneous layer which, as that of other cysticerci, is differentiated in an outer and inner layer. The tegument of the spiral canal is 11—15 μm thick (Plate II, Fig. 2), that of the suckers 8—8.5 μm; the thickness of the microthrix layer is 1—1.5 μm.

The tegument of the everted rostellum and its still invaginated suckers has a thickness of 2.5—3 μm (Plate II, Fig. 3). The inner layer of the tegument of the spiral canal is 10 μm thick, in the suckers 7—7.5 μm, in the rostellar area 1 μm. The inner homogeneous layer rests on a layer made up of connective- and muscle tissue, which is of a different thickness in the spiral canal and the rostellar area. Subtegumental cells in the suckers and the rostellum are not differentiated from the remaining cells; those of the spiral canal are organized in a layer vertical to the surface. The transitory zone at the opening of the spiral canal is similar in its character to that described by Šlais (1970) for *C. bovis*. The dense parenchymal portion of the spiral canal contains numerous calcareous corpuscles and fibrils made up of connective tissue which line the spiral canal. Calcareous corpuscles are less numerous in the rostellar area, but the rostellar area contains a large quantity of connective tissue- and muscle fibrils. In the scolex area, the tegument on the larval surface has a thickness of 3.2—4.5 μm, that of the bladder 1.5 to 2 μm.

In an evaginated cysticercus (Plate II, Fig. 4), the tegument of the spiral canal on the surface of the larva beyond the apical rostellar area is thicker (10—11.6 μm) than that covering the rostellum (2.5 to 3 μm). Frequently, the position of suckers of evaginated scoleces is everted. In sections, the shape of the rostellum is mostly that of an elongate sac. The part with a thickened tegument on the surface of the scolex portion is followed by an area with a finely folded wall covered with a thin tegument (2.4 μm). The underlying layer contains thickened cells with spherical, basophilic nuclei. Various authors have referred to this zone as to the neck region.

Apart from very young larvae with large bladders, the bladder wall of cysticerci examined in the present study was generally thick. It contains an appreciable number of muscle- and connective tissue fibres, numerous excretory canals and a minimum of calcareous corpuscles. The thickness of the bladder tegument is 1.2—2.8 μm (Plate III, Fig. 1). The height of the microthrix border is 4.5—6.8 μm. A thin, homogeneous, layer of the tegument abuts a thicker layer of connective tissue. Subtegumental cells are bigger than those in the spiral canal. Both the tegument and the parenchyma of the bladder wall are thickened at the caudal end of the bladder, i.e., at the pole facing the scolex. In older larvae, particularly in those with an outgrown scolex, the parenchyma of the bladder wall attains a thickness of 200 μm and more; in it are thickened excretory canals (Plate III, Fig. 3).

The bladder cavity contains a granular, sometimes fibrillar, substance originating from a coagulation of proteins of the bladder fluid (Plate III, Fig. 2). Frequently, large excretory canals contain a faintly staining substance. The part of the parenchyma which is closer to the bladder cavity, contains large, lacunary canals measuring up to 40 μm in diameter; their wall has a thickness of 0.9—1.0 μm (Plate III, Fig. 4). Nearby are numerous flame cells of which some communicate with fine, slit-like canals. The walls of these canals have a remarkable capacity of heavy staining (Goldner) (Plate IV, Fig. 1). The part of the parenchyma which is closer to the tegument contains less large excretory canals. These pass into almost spirally coiled canals (24 μm in diameter). The thickness of their wall is about 1 μm. Below the tegument, the diameter of the canals is reduced to 6.4 μm. The slit-like canal ascends almost vertically to the surface

of the tegument- its wall has a thickness of 1.2 μm (Plate IV, Fig. 3). Fine, hairlike processes on the inner surface of the wall of larger canals are revealed in an examination using the oil immersion lens. The lumen of larger canals contains granules. Host cells, also observed in the spiral canal of the scolex, stick to the microthrix border at the caudal end of the bladder (Plate IV, Fig. 2). Generally, the slit-like canal passes into a tegumental fold at the caudal end of the bladder (Plate IV, Fig. 4). The tegument of the fold has a thickness of 1.4 μm, and bears microtriches measuring 4—5 μm in length. A thinner tegument with longer microtriches (6.4 μm) covers the remaining part of the bladder.

Young larvae have a relatively big bladder. Its tegument is thin, the homogeneous layer of the tegument attains a maximum thickness of 1—1.2 μm. In tegumental folds, cells below the thin tegument are compressed in a single row, while there is a distance between cells underlying a smooth tegument (Plate V, Fig. 1). The parenchymal layer is thin, an excretory system has not started to differentiate in the youngest, big, bladders. Several cells are spindle-shaped and have a clearly basophilic plasma. At sites where the bladder bulges, the parenchyma becomes even thinner, and cells form groups showing 4—6 nuclei below a fine muscle layer (Plate V, Fig. 2). The bladder wall forms lobate extensions at sites with a denser concentration of cells. However, the coarse folding of the wall appears to be an artifact due to fixation. Sometimes, small daughter bladders containing mainly basophilic cells (Fig. 5 a) originate at these sites of the bladder wall. Their tegument is thicker than that of the mother bladder, and folded (Plate V, Fig. 3).

The origin of another new scolex (Fig. 5 b) could be seen in the transitory zone, i.e., in the area between the scolex and the bladder, or in the caudal part of the original bladder. The tegument and the multiplied cells produce a wart-like protruberance on the bladder surface. At the site where the tegument passes into the scolex bud, it attains a thickness of up to 5.6 μm. A thickening both of muscles and cells can be seen under the mildly folded tegument (Plate V, Fig. 4). Cellular nuclei measure 3.3×3.8 μm. The basal part of the scolex anlage is entered by fibrils from the surrounding bladder wall. Larger cells in the centre of the scolex anlage proceed in parallel direction to the transverse axis of the anlage. The tegument of the scolex anlage is differentiated from the remaining tegument by a darker colour using Mallory's staining method. The formation of the scolex anlage is similar to that observed with other larvae of the genus *Taenia*.

In the second larva, the invaginating tegument forms an invaginated canal in the scolex anlage. The opening of the canal makes a wart-like protruberance on the surface of the primary bladder. The tegument of the canal is 5—6 μm thick. It is folded at the site where it opens onto the surface. There, its thickness is 6.5—7 μm (Plate VI, Fig. 1). Scanning electron microscopy of a similar scolex anlage at the caudal end of the primary bladder reveals its microthrix structure. Microtriches on the surface of the wart-like protruberance of the wall, apparently belonging to the modified bladder, are aligned in rows formed by the circularly folded tegument. The points of microtriches are thicker and shorter than those on the bladder (Plate VI, Fig. 3). At the opening of the canal invaginating into the scolex anlage, microtriches are slender, their point is thorn-like and long (Plate VI, Fig. 2), but they are shorter inside the invaginated canal. Adhering to them are host cells and a secretion (Plate VI, Fig. 4).

HISTOCHEMISTRY OF THE CYSTICERCUS OF *T. CRASSICEPS*

The microthrix border, both of the scolex and the bladder, contains mucopolysaccharides. Microtriches give a positive reaction for tyrosine and tryptophane, a weakly

positive reaction for SH groups of proteins and hydrophilic lipids. Microtriches on the thin tegument of younger larvae give a less positive reaction for SH groups and lipids. The outer layer of the spiral canal of a typical cysticercus of *T. crassiceps* contains neutral mucopolysaccharides, proteins with SS groups and tyrosine (Plate II, Fig. 2). The inner layer contains acid mucosubstances and tyrosine; it reacts feebly to SH groups of proteins. The tegument of the rostellar area and the suckers gives a weaker reaction for proteins, a stronger reaction for mucopolysaccharides (PAS AB). The thinner tegument on the surface of the larva reacts less strongly for tyrosine and tryptophane (see Plate II, Fig. 1) than the tegument of the spiral canal, but more strongly for SS groups of proteins. Phospholipids are present in the inner layer of the tegument of the spiral canal, in the suckers, the connective tissue of the receptaculum, and in calcareous corpuscles. Subtegumental cells of the spiral canal are positive for tyrosine, tryptophane and SH groups of proteins. Suckers give a positive reaction for glycogen, tyrosine, tryptophane and phospholipids, a weaker positive reaction for SH groups of proteins, a negative reaction for SS groups of proteins. Evaginated cysticerci, in which the tegument of the spiral canal comes to lie on the surface of the larval body, give a highly positive reaction for proteins with SS groups, tyrosine, tryptophane, and for mucopolysaccharides in the vicinity of the suckers. These reactions are weaker in the thin tegument on the surface of a young larva with a big bladdder.

Proteins of the bladder tegument contain tyrosine, tryptophane and SH groups of proteins (Plate III, Fig. 1). The tegument of the big bladder of a young larva (Plate V, Fig. 1) gives a less positive reaction for tyrosine, and a faint reaction for SH groups of proteins; it contains phospholipids and reacts faintly for mucopolysaccharides. Fibrillar substances in the bladder are thickened.

Using the reaction for tyrosine in the thick-walled reduced bladder of a mature cysticercus, we distinguished two types of canals in the excretory system: faintly staining, large canals with a thin wall, and highly positive slit-like canals with a thickened wall reacting positively for acid mucosubstances at the site where the canals passed into the tegument. They also stained heavily in a reaction for SS groups of proteins (Plate IV, Fig. 2.). Thin-walled, large, lacunary canals in the inner parenchymal layer of older larvae with an outgrown scolex possess PAS positive granules, faintly AB positive fibres and phospholipids (Plate IV, Fig. 4).

The tegument of the scolex anlage gives a faintly positive reaction for acid mucopolysaccharides; it is highly positive in the PAS reaction and in that for tyrosine and tryptophane. It stains heavily in Mallory's reaction. Cells of the scolex anlage are PAS-positive, and give a positive reaction for glycogen and tyrosine.

DISCUSSION

The life cycle of *Taenia crassiceps* (Zeder, 1800) is similar to that of other members of the family Taeniidae in that it requires two hosts. The larva, a monoscolex-type of bladder worm, develops in rodents. The definitive host of the cestode is mainly the fox, but it might utilize also other predatory species. The larva of *T. crassiceps* differs from the remaining members of the family in that the aging larva has the ability to reproduce by asexual budding (Bott 1898), or by a proliferation of the bladder (Freeman 1962). Newly budded cysticerci separate from the mother cyst and grow to a stage at which they are capable of further asexual reproduction. In the case of a long-term infection of the intermediate host, it is possible to find in it several generations of cysticerci of a different age and at different stages of their development.

However, all developmental stages of the cysticercus can seldom be found in one intermediate host (Baer and Scheidegger 1946, Freeman 1962). Our material

contained typical, mature, cysticerci as well as young and aging forms. A similar observation has been made by Šlais (1970). However, the budding of a new bladder, or the origin of a new scolex anlage, has been observed in a few individuals only. The development of *T. crassiceps* starts with the formation of a primary bladder with an invaginated scolex anlage as described by Mount (1970). A similar anlage can be seen on bladders originating from an asexual reproduction on the mother bladder of the original larva as observed also by Bott (1898, Bondareva (1968) and Šlais (1973).

Schiller (1973) drew attention to the fact that the various germinative loci in the bladder wall of the same cysticercus were not always genetically homogeneous, and that cysticerci developing from these genetically different zones were genetically heterogeneous giving rise to further mutations accounting for a considerable morphological variability in *T. crassiceps* (Bartels 1902, Bullock and Curtis 1926, Freeman 1962, Baron 1968, Bondareva 1968, Chernin 1974, Chan and Freeman 1976, Belton 1977, and others). E. g., Schiller (1973) and Myib (1967) found cestodes with 2, 3, 4 and more suckers.

A comparison of a larval *T. crassiceps* and a larval *Multiceps endothoracicus* (Hulínská 1975, Hulínská and Šlais 1977) migh disclose superficial similarities only. Scoleces of the *Multiceps* larva differentiate simultaneously and protruberate on the surface of the original bladder. In the larval *T. crassiceps*, reproduction is asexual and occurs by a subsequent budding of new bladders, whereby daughter bladders separate from the mother cysticercus. This accounts for the presence of several generations of larval *T. crassiceps* of a different age and at different developmental stages in the same intermediate host. By contrast, larvae of *M. endothoracicus* recovered from the same intermediate host are all of an identical age and at an identical stage of development. The scoleces separate from the primary bladder at the time of its regression.

As with other cysticerci, we observed host cells in the lumen of the spiral canal, and even on microtriches of the bladder and the scolex anlage. Bilques and Freeman (1969) maintained that microtriches absorbed nutrients, and played a certain role in the spatial orientation of the parasite. Detailed studies have been made on the differentiation of the rostellum of a larval *T. crassiceps*. Gläser (1909) described the formation of hooks, Bilques and Freeman (1969) gave a comprehensive account of the histogenesis of the rostellum and hooks. Mount (1970) added new data obtained in his study on the fine structure of the scolex of a larval *T. crassiceps*.

Microtriches of the bladder contain acid mucosubstances and give a weakly positive reaction for tyrosine and tryptophane. Reactions for proteins of the bladder tegument are conform to those found by Žďárská (1973) in *C. bovis*, except that the tegument of the bladder of young, growing, forms responds with a weakly positive reaction to these tests. Different types of microtriches on the modified bladder wall in the area of the scolex anlage were revealed with the scanning electron microscope. Baron (1968) observed different microtriches on the scolex and the bladder of *C. longicollis* (= *crassiceps*).

The excretory system of cysticerci is very complicated. We distinguished two types of canals in the light microscope: wide, spirally coiled canals below the tegument similar to those described by Žďárská (1975) for *C. bovis*. We observed the transition of these canals into a slit-like canal which opened onto the surface of the tegument. Large canals forming lagoons in the inner layer of the bladder parenchyma, were found in aging cysticerci. As did Žďárská (1975) in her study on *C. bovis*, we confirmed the presence of tyrosine and tryptophane in wide canals; in addition, we obtained evidence of the presence of SS groups of proteins. The canal passing into the tegument contained also acid mucosubstances. A differentiation of the excretory system could not be seen either in a young and growing bladder or in a new bladder produced by budding.

ГИСТОЛОГИЯ И ГИСТОХИМИЯ ЦИСТИЦЕРКА *TAENIA CRASSICEPS* (ZEDER, 1800)

Я. Прокопич и Д. Гулинска

Резюме. Морфологическую структуру цистицерка *T. crassiceps* изучали при помощи гистохимических и гистологических методов. В некоторых случаях в том же самом промежуточном хозяине найдены личиночные стадии разного возраста, возникшие из материнских цистицерков путем бесполого размножения. Разницы в гистологической структуре этих личиночных стадий описаны в настоящей работе.

REFERENCES

ABULADZE K. I., Taeniidae of animals and man. Osnovy cestodologii Moskva, 5: 1964. (In Russian.)

ANDERSON V. F., Techniques for the preservation of three-dimensional structure in preparing specimens for the electron microscope. Trans. N. Y. Acad. Sci. 13: 130—134, 1951.

BAER J. G., SCHNEIDEGGER S., Un cas intéressant de tétraplégie d'origine parasitaire. Schweiz. U. allg. Path. Bakt. 9: 61—66, 1946.

BARON P. J., On the histology and ultrastructure of *Cysticercus longicollis*, the cysticercus of *Taenia crassiceps* Zeder, (1800). Parasitology 58: 497—515, 1968.

BARTELS E., *Cysticercus fasciolaris*. Anatomie. Beitrag zur Entwicklung und Umwandlung in *Taenia crassiceps* (Zeder, 1800). Zool. Jahrb. Anat. 16: 511—570, 1902.

BELTON C. M., Freeze-fracture study of the tegument of larval *Taenia crassiceps*. J. Parasitol. 63: 306—313, 1977.

BILQUEES F. M., FREEMAN R. S., Histogenesis of the rostellum of *Taenia crassiceps* (Zeder, 1800) (Cestoda), with special reference to hook development. Can. J. Zool. 47: 251—261, 1969.

BONDAREVA V. J., A cysticercus from a multichambered tumor in the beaver. Gelm. cheloveka, zhivotnykh i rasten. i mery borby s nimi. Nauka, Moskva, pp. 108—111, 1968. (In Russian.)

BOTT A., Über einen durch Knospung sich vermehrenden *Cysticercus* aus dem Maulwurf. Z. wiss. Zool. 43: 116—139, 1898.

BULLOCK F; D; CURTIS M. R., Further studies on the transplantation of the larvae of *Taenia crassicollis* and the experimental production of subcutaneous *Cysticercus* sarcoma. J. Cancer Res. 10: 393, 1926.

CHAN C. Y. S. J., FREEMAN R. S., Intraperitoneal passage of *Taenia crassiceps* in rats. J. Parasitol. 62: 837, 1976.

CHERNIN J., The pathological effect of *Taenia crassiceps* on the rodent host. Proc. Third Intern. Congress Parasitol., München 25—31 Aug. 1974 1: 393—394, 1974.

FISCHER E. R., LILLIE R. D., The effect of methylation on basophilia. J. Histochem. Cytochem. 2: 81—87, 1954.

FREEMAN R. S., Studies on the biology of *Taenia crassiceps* (Zeder, 1810) Rudolphi, 1810 (Cestoda). Can. J. Zool. 40: 969—990, 1962.

HULÍNSKÁ D., Morphogenesis of the larval stages of *Multiceps endothoracicus*. Part I. Zool. Anz. Jena 196: 201—219, 1975.

—, ŠLAIS J., Morphogenesis of the larval stages of *Multiceps endothoracicus*. Part II. Zool. Anz. Jena 198: 75—83, 1977.

MOUNT P. M., Histogenesis of the rostellar hooks of *Taenia crassiceps* (Zeder, 1800) (Cestoda). J. Parasitol. 56: 947—961, 1970.

MYIB B. F., Abnormalities in the development of *Taenia crassiceps* (Zeder, 1800). Riv. Parassitol. 28: 243—247, 1967.

PEARSE A. G. E., Histochemistry. Theoretical and applied. J. A. Churchill Ltd., London, 1960.

SCHILLER E. L., Morphologic anomalies in scoleces of larval *Taenia crassiceps*. J. Parasitol. 59: 122—129, 1973.

SPICER S. S., LILLIE R. D., Saponification as a mean of selectively reversing the methylation blockade of tissue basophilia. J. Histochem. Cytochem. 7: 123—125, 1959.

ŠLAIS J., The morphology and pathogenicity of the bladder worms *Cysticercus cellulosae* and *Cysticercus bovis*. Academia, Praha, 1970.

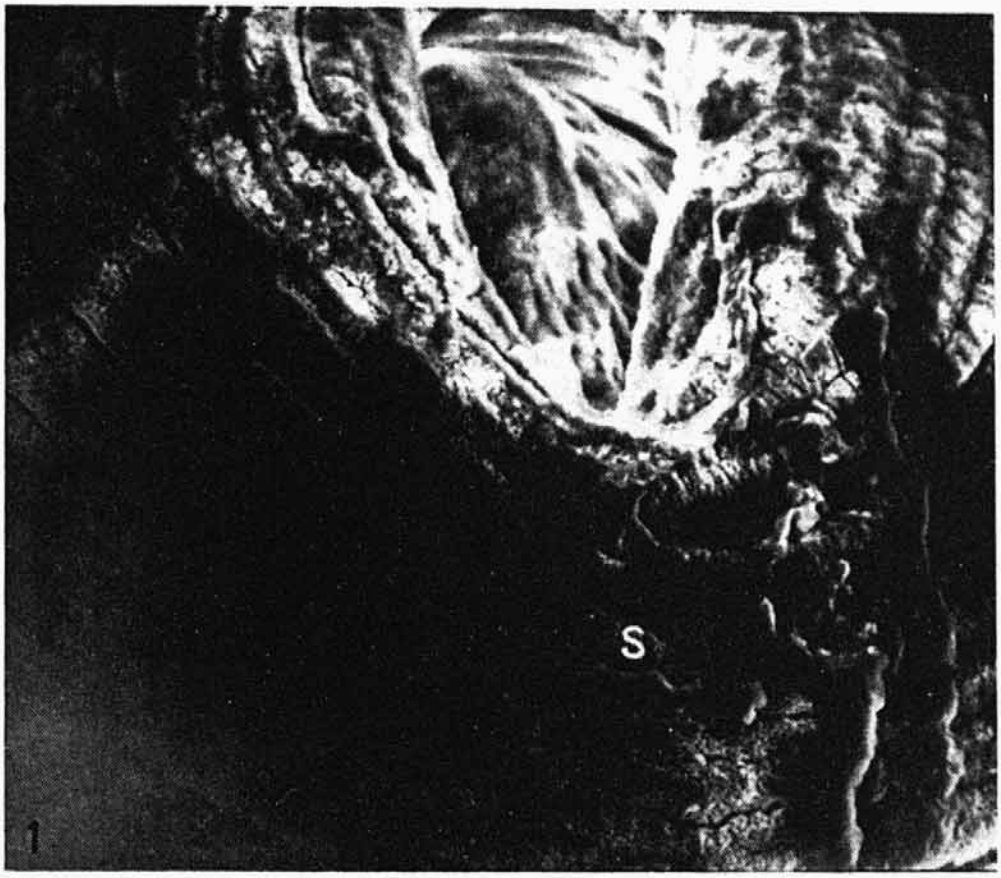
—, Functional morphology and cestode larvae. Advances in Parasitology 11: 395—480, 1973.

ŽĎÁRSKÁ Z., On the histochemistry of the tegument of *Cysticercus bovis*. Folia parasit. (Praha) 20: 307—318, 1973.

—, Histochemistry of the parenchyma of *Cysticercus bovis*. Folia parasit. (Praha) 22: 345—354, 1975.

Received 27 July 1978.

J. P., Parasitologický ústav ČSAV,
Flemingovo nám. 2, 166 32 Praha 6,
ČSSR



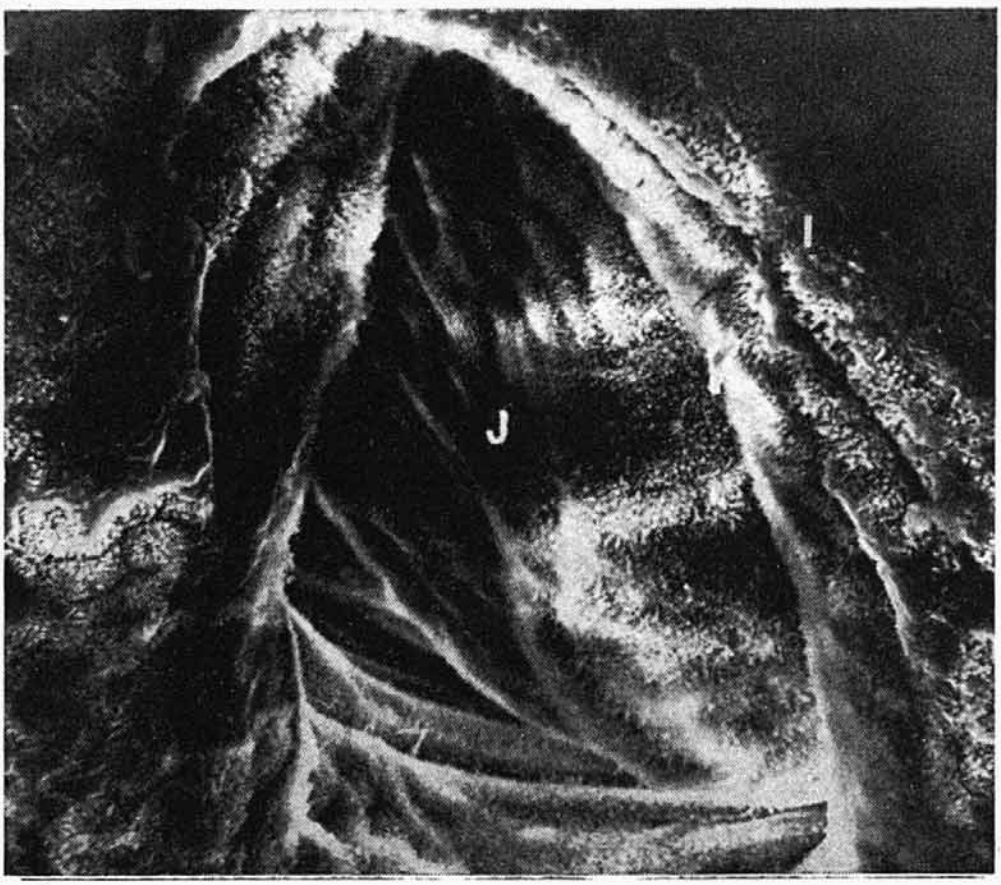


Fig. 1. Scanning electron micrograph of the caudal end of a mother bladder showing a wart-like protruberance of the modified bladder wall on the surface of the scolex anlage. The ring-like folded tegument of the wall passes through a short transitory zone into the invaginated canal (× 750, KV 15).

Fig. 2. Scanning electron micrograph of the transitory zone which passes into the invaginated canal. Densely arranged microtriches are seen on tegumental folds (× 1200, KV 20).

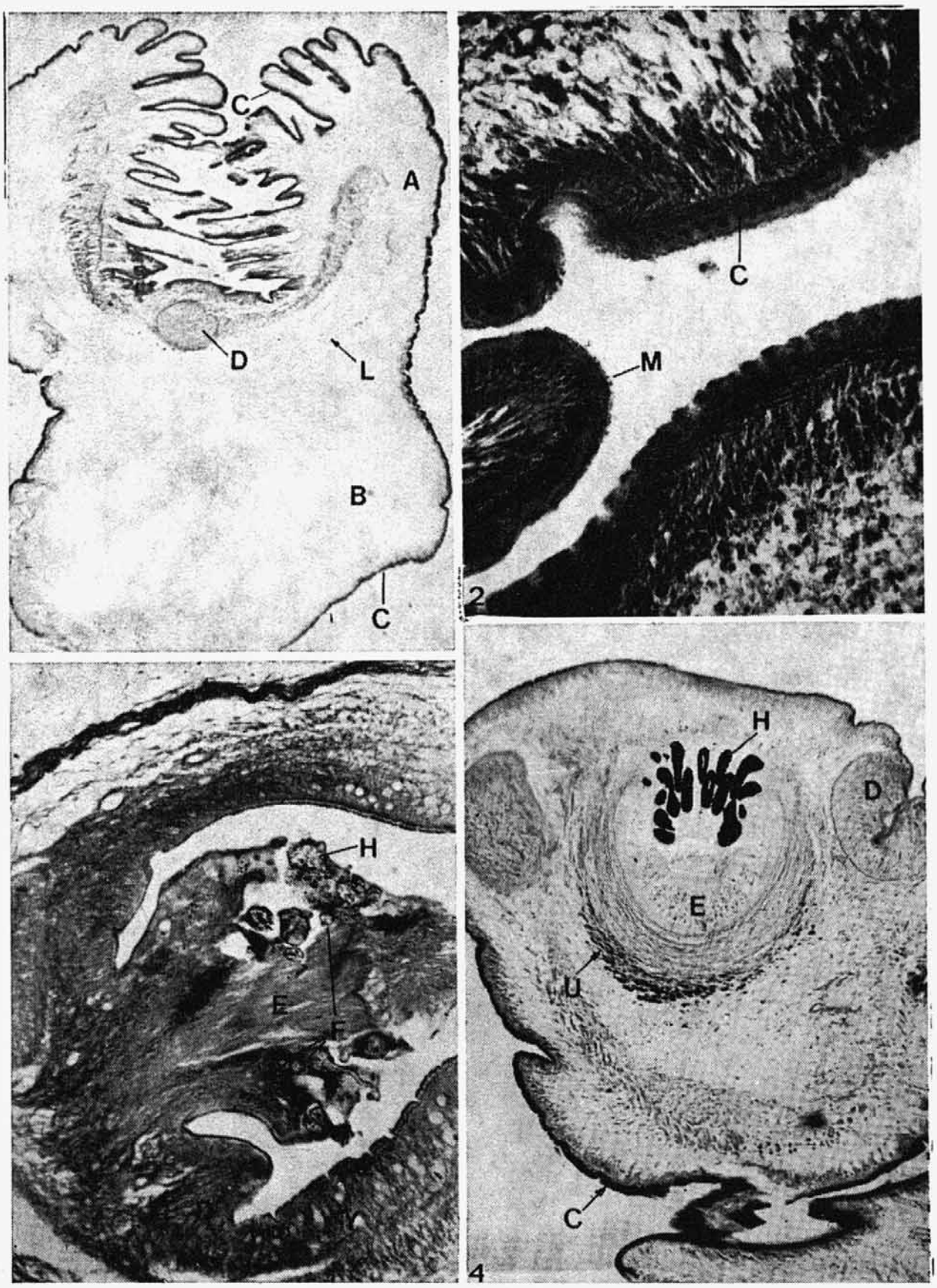


Fig. 1. Tangential section through part of the scolex of a typical larval *T. crassiceps* with an elongate spiral canal and a caudally compressed bladder (TK, × 57).
Fig. 2. The thick tegument of the spiral canal bearing short microtriches, and the thick layer of subtegumental cells (Morel Sisley, × 360).
Fig. 3. An aging larva with a scolex partly outgrown into the lumen of the basal part of the spiral canal, and with suckers below the rostellum. Sections through remaining hooks and granules seen in the tegument (trichrome, × 200).
Fig. 4. Evaginated scolex of a larval *T. crassiceps* with a thickened tegument on the body surface. The sac-shaped rostellum is surrounded by connective tissue- and muscle fibers (PAA AF, × 96).

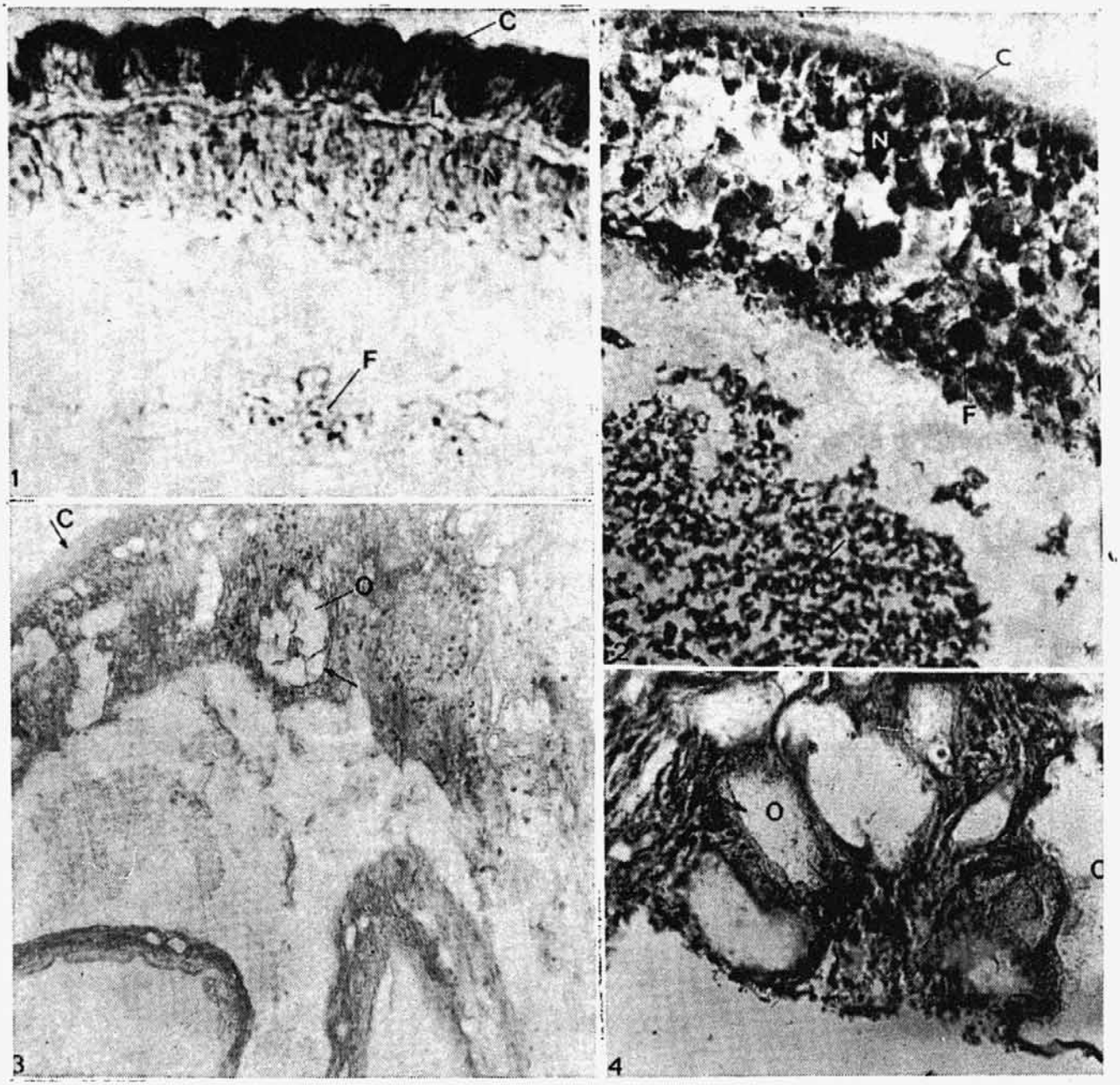


Fig. 1. Tangential section through the folded bladder tegument at the site of its transition into the scolex portion of the larva. Both the muscle layer and subtegumental cells are thickened (DDD-reaction, × 600).
Fig. 2. Tangential section through the caudal end of a bladder containing large excretory canals in the thickened parenchyma (TK, × 300).
Fig. 3. A granular substance in the bladder cavity staining similar to parenchymal cells in their reaction for tyrosine (Morel-Sisley, × 600).
Fig. 4. Transverse section through large, lacunary, excretory, canals in the inner layer of the parenchyma. The lumen of the canals contains fibrillar processes. Between the individual canals are flame cells and fibrils (trichrome, × 700)

EXPLANATION
A-scolex, B-bladder, C-tegument, D-suckers, E-rostellum, F-granules, H-hooks. I-transitory zone, J-invaginated canal, K-spiral canal, L-muscles, M-microtriches, N-subtegumental cells, O-large excretory canal, P-slit-like canal, Qu-spirally coiled canal, R-daughter bladder, S-scolex anlage, T-host cell, U-receptaculum, V-germ cell, Y-zone of growth.

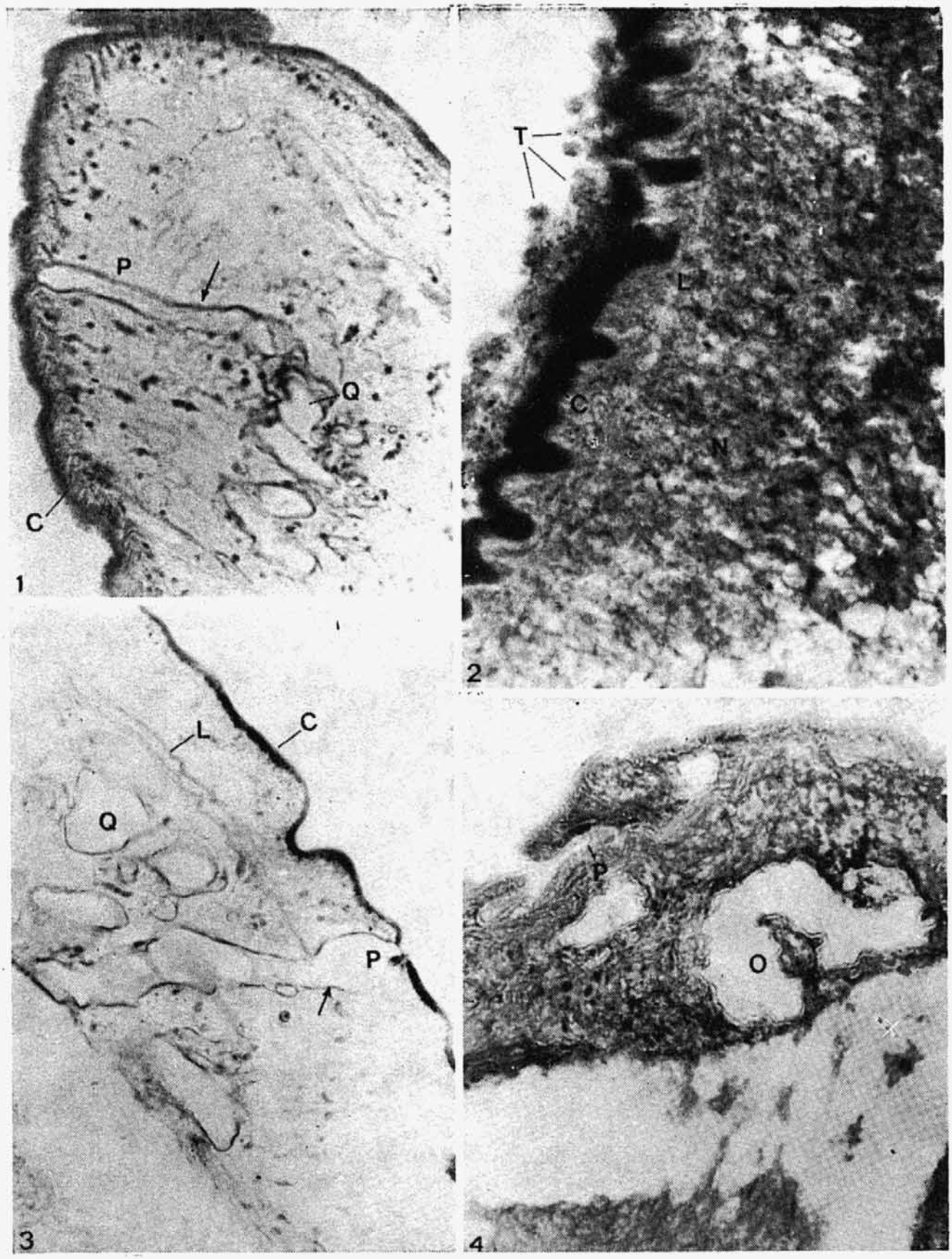


Fig. 1. Tangential section through a slit-like canal running in perpendicular direction to the tegument into the subtegumental muscle layer. Closeby are sections through spirally coiled large canals (Goldner, × 340).

Fig. 2. The site of transition of the wall of a slit-like canal into the tegument stained similarly to the tegument in the reaction for proteins with SS groups (PAA AF, × 500).

Fig. 3. The tegument of the caudal end of the bladder is folded. On it are microtriches with host cells adhering to them (TK, × 650).

Fig. 4. A fold formed by the bladder wall on the caudal end of the bladder. The thickness of the tegument and the staining of the fold are identical to those of the excretory canal passing into the fold (AB + PAS, × 500).

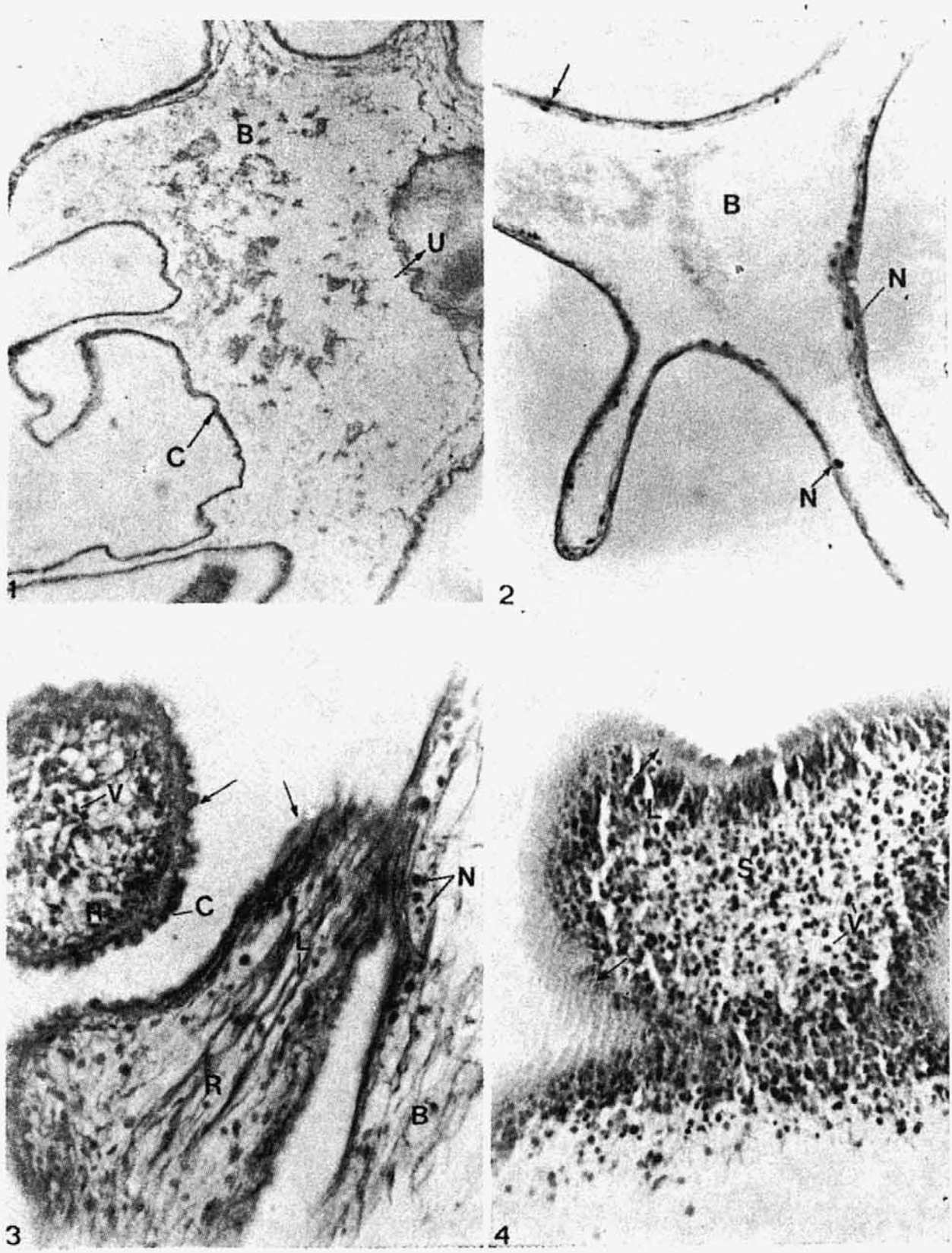


Fig. 1. A large, thin-walled bladder of a young larva of *T. crassiceps*. Coarse folds are artifacts due to fixation. In the area of the small scolex, connective tissue fibrils of the receptaculum enter the bladder cavity (TK, ×57).

Fig. 2. The subtegument of the thin wall of a young bladder contains occasional nuclei situated at some distance from one another (Goldner, ×80).

Fig. 3. Tangential section through daughter bladders, of which one is communicating with the wall of a large mother bladder with a thin tegument, and with solitary nuclei of basophilic cells. The tegument of the small bladder is thick, folded, the subtegument contains numerous cells (Goldner, ×200).

Fig. 4. Tangential section through a cellular scolex anlage protruding above the bladder surface. Thickened cells and muscles are seen below the thickened tegument. The centre of the anlage is filled with large, spherical cells (HE, ×600).

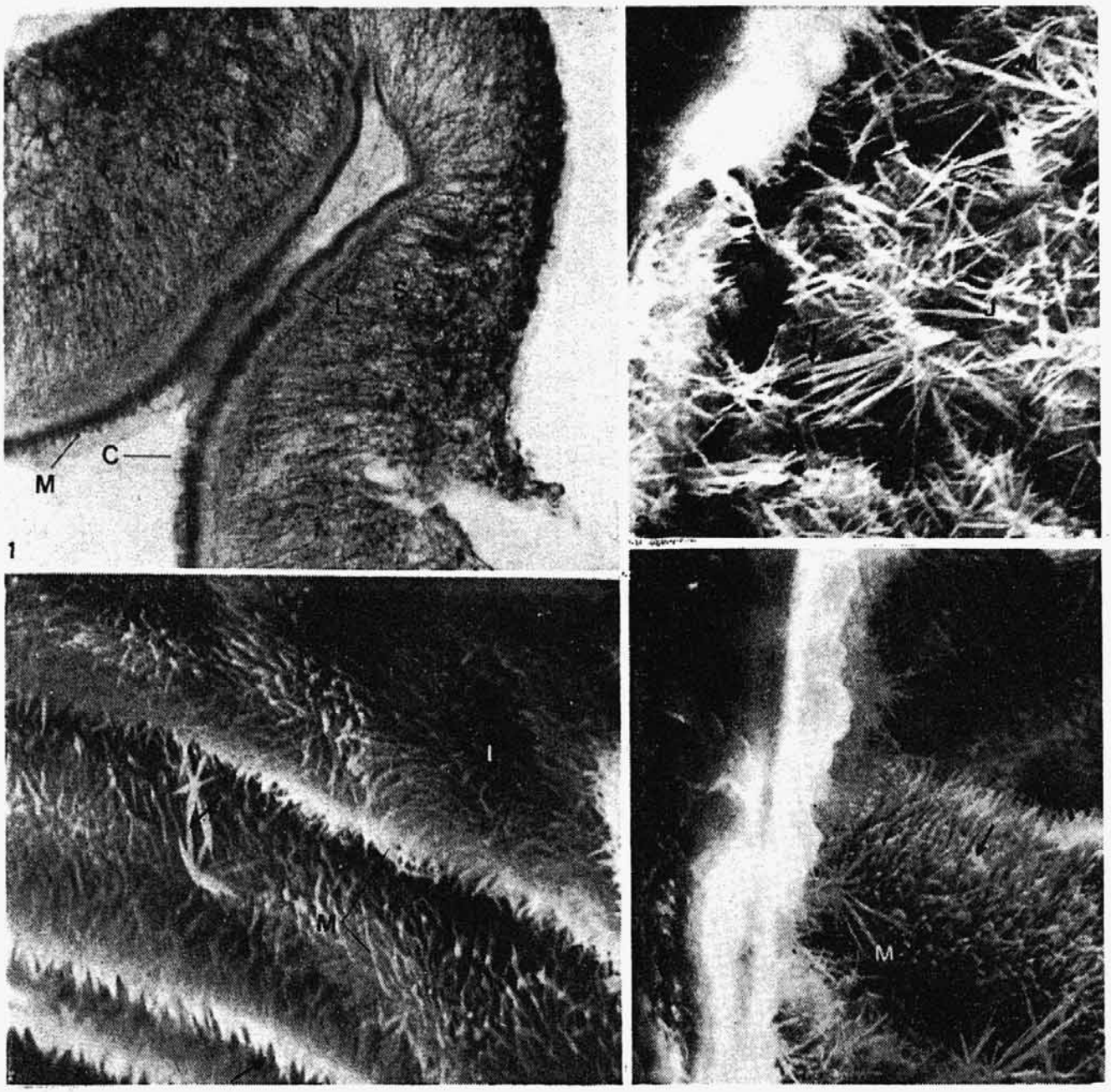


Fig. 1. Scolex anlage with an invaginated canal. Below the thick tegument is a layer of subtegumental cells and muscles. Large microtriches and host cells on the tegument of the modified bladder occur at the site where the tegument passes into the invaginated canal (trichrome, × 900).
Fig. 2. Scanning electron micrograph of microtriches covering the modified bladder on the surface of the differentiating scolex anlage. Circular tegumental folds bear microtriches organized in regular rows (KV 20, × 4 600).
Fig. 3. Scanning electron micrograph of long, sharp, microthrix points in the transitory zone connecting the scolex anlage with the invaginating canal (KV 25, × 5200).
Fig. 4. Microtriches on the tegument of the invaginated canal. Their point is short, stout, partly covered with a secretion (KV 20, × 3 890).