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**MORPHOLOGY AND VARIABILITY OF
DORYLAIMUS STAGNALIS DUJARDIN, 1845
AND THEIR JUVENILE STAGES**

by

SAMINA SHAFQAT AND M. SHAMIM JAIRAJPURI

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**MORPHOLOGY AND VARIABILITY OF
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INTRODUCTION

During the past several years, observations have been made on the morphology and anatomy of different species of dorylaim nematodes (Brzeski, 1963; Coomans, 1965; Anderson, 1966; Lopez Abella *et al.*, 1967). The ultrastructure of feeding apparatus of *Trichodorus christiei*, morphology and ultrastructure of oesophageal region of *Trichodorus allius* and of muscle cells in *Trichodorus christiei* and *Longidorus elongatus* were studied by Hirumi *et al.*, (1968) Raski *et al.*, (1969) and Hirumi *et al.* (1971). Aboul-Eid (1969 a) observed the morphology of excretory and reproductive systems of *Longidorus macrosoma*. The ultrastructure of the oesophageal region of *Longidorus elongatus* and *Xiphinema index* were studied by Wright (1965) and Taylor *et al.*, (1970) & Robertson (1971) observed the ultrastructure of the guiding ring and guiding sheath in *Xiphinema* and *Longidorus* sp. Studies on the ultrastructure of anterior region, vaginal muscles and ovijector of *Aporcelaimellus obtusicaudatus* and *Aporcelaimellus obscurus* were carried out by Lippens *et al.* (1974) and of *Longidorus caespiticola* by Seinhorst & Kozłowska (1975). The ultrastructure and function of the anterior feeding apparatus of *Labronema* sp., cephalic sense organs and body pores of *Xiphinema americanum* were observed by Grootaert & Wyss (1978) and Wright & Carter (1980) respectively. Variations are known to occur in all morphological characters in different populations and also within a single population of any nematode species. The study of morphometric and allometric variability is very useful in taxonomy as it helps in determining the stability and value of taxonomic characters and thereby separating the closely related species. Considerable variations in various body dimensions were recorded in different species of nematodes by Goodey & Hooper (1965), Baqri & Jairajpuri (1970), Azmi & Jairajpuri (1978), Bajaj & Jairajpuri (1977), Malik & Jairajpuri (1983), and Rehman *et al.* (1986). These variations may be in the shape of lip region or number of lip annules (Coomans, 1962, 1963 a; Baqri & Jairajpuri, 1970), tail shapes or number of tail annules (Goodey, 1952; Yuen, 1965; Baqri & Jairajpuri, 1967 & 70), allometric ratios (Brzeski, 1963; Tarjan, 1964; Bird & Mai, 1957) etc. The variations may be influenced by host plants (Goodey, 1952; Bird & Mai, 1965; Fisher, 1965; Bird, 1966), soil temperature (Rhode & Jenkins, 1957; Malik & Jenkins, 1964; Gysels, 1964), geographical location (Golden & Epps, 1965; Tarjan 1968 & 69) etc. Clark (1962) and Loof & Mass (1972) suggested that qualitative characters should be given equal importance as difference in body dimensions alone are usually not sufficient for

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distinguishing the closely related species.

In the present study detailed observations were made on the morphology, anatomy and efforts were made to determine the extent of variability of these characters in the adults and juveniles of *Dorylaimus stagnalis*. Detailed observations were carried out on cuticle, musculature, digestive and reproductive organs of the adult *D. stagnalis*.

MATERIAL AND METHODS

The soil samples containing *D. stagnalis* were collected from the paddy fields, and were processed by sieving, decantation and modified Baermann's funnel techniques. The nematodes were fixed in hot 4% formalin, dehydrated slowly in a dessicator and finally mounted in anhydrous glycerine. The transverse sections of body at different levels were cut with the help of a sharp razor and these were mounted in glycerine jelly. The measurements are based on 50 specimens each of the adults and juvenile stages. The various morphometric and allometric characters were subjected to the following statistical tests in order to determine their relationship and degree of variability, etc.

$$CV = \text{Standard deviation/Mean} \times 100$$

The range of categorization of variability is as follows :

Least variable	=	0-10%
Moderately variable	=	11-20%
Highly variable	=	21% or more

DORYLAIMUS STAGNALIS DUJARDIN, 1845

Dimensions : Table I

Description : *Female* : Body slightly ventrally curved upon fixation, tapering gradually towards extremities but more posteriorly. Cuticle with fine transverse striations, 6-9 μm thick at mid-body and marked with 32-34 longitudinal ridges which gradually fade out towards extremities. Lateral chords 1/4th - 1/3rd of corresponding body width wide at mid-body. Dorsal and ventral body pores 7-10 and 25-30 respectively.

Lip region slightly narrower than adjoining body, marked by a slight depression, 15-23 μm wide and 6-8 μm high. *En face* view shows six amalgamated lips arranged as follows : 2 dorsosublateral, 2 lateral and 2 ventrosublateral (Fig. 2A). Each lip has a papilla on the inner circlet and a papilla on the outer circlet. Each dorsosublateral and ventrosublateral lip bears an additional papilla. Thus the lip region has 16 papillae in all. The oral opening is hexagonal.

Amphids are stirrup-shaped with slit-like apertures, 8-11 μm wide, occupying about 1/2 of corresponding body width, 8-9 μm from anterior end (Fig., 1C). Each Amphid consists of an amphidial pouch (*fovea*) and an amphidial duct (*Canalis amphidialis*). The amphidial pouch is connected to the amphidial duct and leads to sensillar pouch (*fusus*)

containing sensory neurons.

Odontostyle is cylindroid, 5-6 lip region widths long, its aperture 13-15 μm wide or 29-35% of odontostyle length. Odontostyle 38-53 μm long, forked at its junction with odontophore. Odontophore or spear extensions is simple, rod-like slightly longer than the odontostyle, embedded in the oesophageal tissues, its length ranges from 39-62 μm . Guiding ring is 'double', consisting of a 'fixed' and a movable ring connected to each other. Fixed guiding ring at 17-32 μm from anterior end. Length of guiding sheath variable, depending upon the position of odontostyle.

Oesophagus dorylaimoid, 635-888 μm long. Nerve ring encircling anterior slender part of oesophagus at 165-247 μm from anterior end. Expanded part of oesophagus 327-460 μm long or 51-52% of oesophageal length. Location of oesophageal gland nuclei and their orifices as in Table II.

Cardia well developed, 23-57 μm long, elongate cylindroid with a disc and surrounded by intestinal tissue.

Vulva transverse, slit-like, pre-equatorial or equatorial, 35-50% from anterior end. Reproductive system amphidelphic, each sexual branch consisting of a reflexed ovary, oviduct and uterus. Prerectum 202-418 μm long or 5-7 anal body widths. Rectum 45-68 μm long or 1.1-1.2 anal body widths. Tail elongate, tapering gradually 103-304 μm long or 2.7-5.3 anal body widths with 3 caudal pores on each side.

Male : Similar to female in general body shape and morphology except for the reproductive system and ventrally curved posterior extremity. Reproductive system diorchic with usual organs. Spicules dorylaimoid, ventrally curved 78-112 μm long, lateral guiding pieces 9-17 μm long. Supplements consisting of an adanal pair and a contiguous series of 41-47 ventromedians. Prerectum 277-779 μm or 6-11 anal body widths long, extending beyond the range of supplements. Tails short, conoid with bluntly rounded terminus, 30-42 μm or 0.6 anal body width long. Caudal pores vary from 3-5 on each side.

ANATOMY OF *DORYLAIMUS STAGNALIS*

Cuticle : The cuticle is marked with transverse striations, and with 32-34 longitudinal ridges which show as lines in totemounts. These ridges are prominent at mid-body but gradually fade out towards extremities (Fig. 2D). The thickness of the cuticle varies from 5-6 μm in anterior region, 6-9 μm at mid-body and 5-8 μm on tail. The dorsal and ventral body pores vary from 7-10 and 25-30 respectively. These pores are usually more in anterior region of body as compared to posterior region.

Hypodermis : The hypodermis is a thin layer situated beneath the cuticle. A cross-section of body shows the hypodermis bulging out at four different points forming hypodermal chords of which two are lateral, one dorsal and one ventral. Lateral chords are more prominent, 14-15 μm high and 26-30 μm wide or 1/4th - 1/3rd of corresponding body width wide at mid-body. Each consists of 3-4 or more nucleated cells.

Dorsal and ventral chords are comparatively smaller than the laterals and consist of only one or two cells. In the anterior region of body all the four chords are strongly developed, equal in size and appear somewhat T-shaped in cross-section (Fig., 2E).

MUSCULATURE

The musculature in *D. stagnalis* is of two types :

i) *Somatic or unspecialized muscles* : These muscles arranged in the interchordal zones of the hypodermis.

ii) *Specialized muscles* : The specialized muscles are associated with particular organs for specific functions.

Somatic or unspecialized muscles :

Somatic musculature is polmyarian consisting of 5-11 cells in each quadrant. The muscle cells are coelomyarian and made up of two parts : the proximal (upper) nucleated or non-contractile sarcoplasmic part, and distal (lower) contractile part consisting of muscle fibres, attached to the hypodermal layer. The muscle fibres appear broken at the bottom of the cells and in the anterior region of the contractile part. The size, shape and number of the cells varies in different body regions. The height of the somatic muscle cells at midbody is 9-13 μm . The proximal non-contractile part is 5 μm high and 8 μm wide while the distal part is 6 μm high and 5 μm wide.

The cross-sections of anterior and posterior body regions show smaller and fewer (5-6) muscle cells as compared to the mid-body. The height of the muscle cells in anterior and posterior regions varies from 8-9 μm .

Specialized muscles :

These muscles are associated with various organs of body for performing special functions and help in proper functioning of a particular organ system. The nomenclature is based either on the organs they are associated with or the functions that they perform.

i) *Spear muscles* (Fig., 3B) : Two sets of muscles are associated with the feeding apparatus - the protractor and the retractor muscles.

a) *Protractor muscles* : The protractor muscles extend posteriorly from the lip base along the feeding apparatus and join the ellipsoidal swelling of the anterior oesophagus. These muscles consist of 8 muscle bands, 4 sublaterals, 2 subdorsals and 2 subventrals. The protractor muscles are responsible for forward movement of spear (odontostyle) during feeding.

b) *Retractor muscles* : The retractor muscles extend anteriorly from the submedian body wall to the ellipsoidal swelling. There are two sets of muscles, each consisting of 2 muscle bands. The retractor muscles help in the backward movement of the feeding apparatus.

ii) *Vulval muscles* (Fig., 3E,F) : The vulva is provided with well defined muscles. The contraction and dilation of vulva is brought about respectively by the constrictor vulvae and dilatator vulvae. These are described below :

a) *Dilatator vulvae* : These muscles originate at the vulva and attach to the body ventro-laterally. Dilatator vulvae consist of 16 muscle bands. Four pairs are

situated anterior to and four pairs posterior to vulva. The contraction of dilatator vulvae muscles brings about the opening of vulva.

b) *Constrictor vulvae* : The constrictor vulvae originate at base of vagina and extend ventro-laterally to the body wall. The function of these muscles is antagonistic to that of the dilatator muscles helping in the closing of vulva.

iii) *Sphincter muscles* (Fig., 3C) : The oviduct is differentiated from the uterus by the presence of a sphincter which consists of weakly developed muscles. These muscles, as their name indicates, control the lumen of sphincter or passage of eggs.

iv) *Anal muscles* (Fig. 3G, I) : The anal muscles originate at the lower side of anus and extend to the subdorsal wall of body. The number of muscle bands differs in the males and females. Males possess two bands of muscles, while the females have only one broad muscle band. These muscles help in the opening and closing of anus.

v) *Copulatory muscles* (Fig., 3D) : These oblique muscles are present on both the sides of posterior region of males. They run from the subdorsal to the ventral sides of body wall. The first copulatory muscle lies anterior to the first ventromedian supplement. The number of these muscle bands varies from 95-135. The last copulatory muscle band is at the level of cloacal opening.

vi) *Caudal copulatory muscles* (Fig. 3G) : The caudal copulatory muscles are present at the posterior end of anus and consist of 2 groups of obliquely transverse muscles. They extend horizontally from the latero-dorsal body wall to the ventral body wall. The anterior-most muscle band is present at the lower lip of the cloacal opening. The joint action of the copulatory and caudal copulatory muscles provide more curvature to the tail region during copulation.

vii) *Spicular muscles* (Fig. 3H) : Two types of muscles are associated with the spicules, namely retractor spiculi and protractor spiculi. These are described as follows :

a) *Retractor spiculi* : A pair of muscle band originates and extends anteriorly from the head of spicules to the latero-dorsal sides of body wall. In cross-section these muscles appear to surround the spicular sheath and thus form another sheath of muscles around it. The contraction of these muscles brings back the spicules to their resting position.

b) *Protractor spiculi* : The protractor spiculi muscles consist of 4 bands, one dorsal, two laterals and one ventral. The protractor spiculi muscles which extend anteriorly are attached to the head of the spicules. These muscles also surround the spicular sheath. The dorsal and lateral muscles extend posteriorly and are attached to the tail tip whereas the ventral muscles are connected anteriorly to the cloacal opening. The contraction of these muscles brings about the protrusion of spicules during copulation.

viii) *Muscles of the lateral guiding pieces* : These are retractor muscles which extend up to the sheath of each guiding piece from the latero-dorsal body wall. Contraction of these muscles brings about the retraction of the protruded guiding pieces to the interior of the body.

DIGESTIVE ORGANS

The digestive organs of *Dorylaimus stagnalis* consist of a feeding apparatus

(odontostyle and odontophore), oesophagus, oesophago-intestinal junction (cardia), intestine, prorrectum, rectum and anus. These are described below :

Feeding apparatus : The feeding apparatus consists of odontostyle, odontophore, guiding ring and guiding sheath.

The spear is hollow and axial in position consisting of two parts, the anterior sclerotized odontostyle and the posterior somewhat muscular odontophore. The odontostyle is a cylindroid tube with an anterior dorsal aperture. The walls of odontostyle are bifurcate at base. The odontostyle originates from a special cell present in the sub-median wall of the anterior slender part of oesophagus. The odontophore is simple rod-like, its base enclosed in an ellipsoidal swelling of anterior oesophagus (Fig., 2D). The odontophore is formed by the cuticular layers of oesophagus. In a cross-section the lumen of odontophore appears wide, thick and triangular where it joins the oesophagus (Fig., 2E). The odontostyle is enclosed in a guiding sheath. The guiding sheath forms a 'double' guiding ring around the odontostyle which lies at 17-32 μm from the anterior end of body. The sheath and the guiding ring together guide to and fro movements of the odontostyle during feeding. Protractor and retractor muscles are attached to the ellipsoidal swelling of oesophagus near base of odontophore which bring about the protraction and retraction of the feeding apparatus. In cross-section (Fig., 2C,D), these muscles are easily visible.

Oesophagus : The oesophagus is 'dorylaimoid' type. The anterior slender part is encircled by a nerve ring near its middle (Fig., 2F). This anterior part gradually expands to form the basal expanded part of oesophagus. The cross-section of the anterior part of oesophagus (Fig., 2G) shows a tri-radial lumen surrounded by radial muscles which originate from the oesophageal walls and continue up to the oesophageal lumen. The expanded part of oesophagus is highly muscular.

The oesophageal glands and their orifices are located in the expanded part of oesophagus. One gland is dorsal and two pairs are ventro-sublateral in position. The dorsal gland is large and its nucleus and duct are conspicuous. A cross-section of expanded part of oesophagus shows a cuticularized tri-radiate lumen (Fig. 2H). The oesophagus is divided into three sectors, one dorsal and two ventrolaterals, by three radiating arms of the lumen, one of which is ventral and two subdorsals.

Oesophago-intestinal junction : The oesophago-intestinal junction or cardia is an elongate-cylindroid to conoid structure and is surrounded by intestinal cells. A definite cardiac disc is also present. In a cross-section the radial muscle bands are seen encircling the lumen of oesophagus (Fig., 2I). These prevent regurgitation of food from the intestine when it is full and the turgor pressure is high.

Intestine : The intestine originates from the base of cardiac disc. It is an elongate sac-like tube with a wide lumen. The intestine connects the oesophagus with the prorrectum. The intestine is made up of single-layered cells, 10-13 in circumference (Fig., 2J). Intestine is *heterocytous* (different types of cells), *anisocytous* (different height of cells), and *polycytous* (more than 256 cells in number). Due to excessive granulation the cell nuclei are not clearly visible.

Prorrectum : The intestine leads to the prorrectum. The junction of intestine and prorrectum is marked by a weakly developed sphincter. The prorrectum differs from the intestine in the number, size and colour of the cells, and also in the width of its lumen.

In a cross-section (Fig. 2K) it appears to have only 9-11 cells with a somewhat tri-radial lumen. The length of prerectum varies in both the sexes. The males have longer prerectum measuring 277-779 μm while the females have shorter which measures 201-418 μm .

Rectum : It is a narrow dorso-ventrally flattened tube lined with cuticle. The rectum opens externally through the anus. In males the rectum opens into the cloacal pouch which is also lined with cuticle. The cloaca is a complex structure which accommodates the spicules and other accessory structures. The cloacal pouch and spicules are formed by the spicular primordia. The pouch opens outside the body through the cloacal aperture.

Rectal glands : In males 2-3 uninucleate glands are present beneath the spicules. Each gland has an enlarged nucleus and a canal that leads to the cloacal pouch.

Anus : Anus is a slit-like, midventral opening meant for the disposal of waste material outside the body of the animal. In males because of the formation of cloaca the anal and cloacal openings are common.

REPRODUCTIVE ORGANS

D. stagnalis is amphigonous exhibiting sexual dimorphism in the posterior region of the body.

Female :

The female reproductive system is didelphic and amphidelphic, each reproductive branch consisting of an ovary, oviduct and uterus, a common vagina and vulva (Fig., 4A).

Ovary : Ovary is reflexed, lying dorsal or ventral to the intestine. It is enclosed in a double-walled epithelial sac containing the germ cells. The epithelium is made up of elongate spindle-shaped cells. The ovary is divided into two zones - the germinal or proliferation zone and the growth or maturation zone. In the germinal zone the developing oocytes are arranged in several rows but in the maturation zone the oocytes occur first in double rows and then only in a single row. During the breeding season, due to enlargement of ovary, the germinal zone sometimes comes to lie very close to the vulva. A blind sac may be present at the junction of ovary with the oviduct. A cross-section through the maturation zone (Fig., 4B) of the ovary shows a large nucleus surrounded by epithelial tissue, but a section through the germinal zone shows several cells.

Oviduct : The ovary is followed by an oviduct which is divisible into a narrow elongated anterior part and an enlarged shorter posterior part (*pars dilatator*). The distal narrow part is made up of tall columnar cells with large ovoid nuclei. The outline of the columnar cells are not distinct. The distal part is made up of 6-7 high columnar epithelial cells (Fig. 4B) and appears circular with a narrow lumen in cross-sections.

Sphincter : It is a weakly developed structure that is present between the oviduct and the uterus. The sphincter has weak muscle bands, called the sphincter muscles (Fig., 2C). These help in regulating the passage of ova from the oviduct to the uterus.

Uterus : The uterus is a strongly muscular but highly variable part of the female gonad. It consists of a single layer of high flattened columnar cells and is surrounded by muscles. The muscle layer is made up of circular and oblique fibers. The anterior part of

the uterus serves as a seminal receptacle (fertilization chamber) and also plays an important role in the formation of egg shell. The posterior or proximal parts of both the uteri join to form a common chamber called vagina (Fig. 4C). The maximum number of eggs that were recorded in the uterus at one time ranged between 12-18. Sometimes sperms are present in the proximal part of the uterus.

Vagina : The vagina extends from about half to one-third of the corresponding body-width. It is lined with invaginated body cuticle and has a thick-wall. The vagina of *D. stagnalis* has a narrow lumen and is surrounded by vaginal muscles. The epithelium of the vagina consists of large cells while its musculature is connected to that of uterus but is usually thicker. The length and width of vagina varies from 30-45 μm and 23-53 μm respectively.

Vulva : The vagina opens to the exterior through a transverse slit-like vulva on the ventral side. The vulva may be pre-equatorial or equatorial in position. Its lips are cuticularized due to the invagination of cuticle. The opening and closing of vulva is controlled by dilatator and constrictor vulvae muscles (Fig. 2E, F).

Male :

The male reproductive system consists of paired testes, vas deferens, ejaculatory duct and cloaca. The secondary sexual organs that are associated with the male reproductive system are spicules, lateral guiding pieces and the supplements (genital papillae).

Testes (Fig. 5A) : Testes are paired (diorchic), opposed and outstretched. Each testis is divided into a germinal zone and a growth zone. The germinal zone is made up of numerous rows of spermatogonial cells. The proximal end of this zone has fewer but larger cells. The maturation (growth) zone is made up of many rows of cells with prominent nuclei. Oval sperm with large nuclei develop from these cells. A muscular layer made up of muscle fibres surrounds each testis. This layer is weakly developed around the germinal zone but is well developed around the zone of maturation.

Vas deferens : The proximal ends of the two testes join to form a simple common duct, the vas deferens. It is thick-walled and made up of cuboidal epithelium (Fig., 5C). The vas deferens is differentiated into anterior narrow and posterior broad parts.

Ejaculatory duct : The posterior wider part of vas deferens is called the ejaculatory duct. This duct is thin-walled and made up of columnar epithelial cells. The ejaculatory duct is responsible for the ejaculation of sperm during copulation.

Ejaculatory glands (Fig. 5H) : Three pairs of glands, known as ejaculatory glands, are associated with the ejaculatory duct. These glands are elongate with prominent nuclei and are placed laterally. The duct of these glands open at the rectum-ejaculatory duct junction.

CLOACA AND ASSOCIATED SECONDARY SEXUAL STRUCTURES

Cloaca : The ejaculatory duct joins the rectum posteriorly on the dorsal side, forming a pouch-like structure known as cloaca. The lumen of cloaca is narrow. The epithelial layer that surrounds the cloaca has a similar structure as that of the ejaculatory duct. The cloaca accommodates the spicules and other accessory structures like lateral guiding pieces.

Spicules (Fig., 5, I) : There is a pair of separate spicules which are arcuate, similar

in shape and equal in size. The spicules are narrow at their tips and are provided with median pieces. Each spicule consists of two parts, a head or capitulum and a blade or lamina. The head is sclerotized, rounded and placed dorsally. The lamina is fusiform and ventral in position. Each spicule is covered with spicular sheath. In a cross-section at the level of head, the spicules appear broad with two cavities. The cavities are covered with spicular sheath (Fig., 5F). Retractor and protractor muscles attached to the spicules guide their movements.

Lateral guiding pieces (Fig., 5, I) : These are two small sclerotized structures with blunt ends. Each lateral guiding piece is situated along the externo-lateral part of the spicules. A sheath is present around each guiding piece. The sheath is separated anteriorly but posteriorly it joins the anterior part of the cloacal opening.

Supplements (Fig. 5H) : Supplements are small and elevated structures present on the ventral side of the posterior region of body. These are provided with nerve endings. There is one adanal pair and a midventral contiguous series of 41-47. In a cross-section, the ventral side of the body possessing supplements is more elevated than the contour of the surrounding sides (Fig., 5G).

Tail (Fig., 1 F,G) : It is long and filiform, tapering gradually in the females and measuring 103-304 μm . It has 3 caudal pores on each side. In males, it is short and conoid with bluntly rounded terminus. The length ranges from 30-42 μm with 3-5 caudal pores on each side.

Intersexuality :

During the present study two intersexual specimens of *D. stagnalis* were found. Both were female intersexes.

Intersexuality is not so very rare among the dorylaim nematodes and several workers have reported this genetic abnormality, viz., *Tyleptus striatus* (Jairajpuri & Siddiqi, 1964), *Longidorus macrosoma* (Aboul-Eid & Coomans, 1966), *Longidorus africanus* (Cohn & Mordechai, 1969), *Leptonchus obtusus* (Goseco & Ferris, 1973); *Xiphinema ingens* (Lamberti *et al.* 1975), *Xiphinema insigne* (Bajaj & Jairajpuri, 1977), *Aquatides thornei* (Jairajpuri *et al.*, 1977). All these species were female intersexes, the exception being *Xiphinema insigne* which was a male intersex.

FEMALE INTERSEX OF *D. STAGNALIS* (Table III, Fig. 6)

Description : Body slightly ventrally curved upon fixation and tapering towards extremities but more posteriorly. Lip region is slightly narrower than the adjoining body and is marked off by a slight depression, 15-18 μm wide and 6-8 μm high. Odontostyle cylindroid, 42-45 μm long. Odontophore simple, rod-like, 44-45 μm long. Guiding ring 'double', 24-27 μm from anterior end. Nerve ring encircling the anterior slender part of oesophagus, 357 μm from anterior end. Oesophageal length varies from 608-768 μm . Cardia 23 μm long, elongate cylindroid with a disc surrounded by intestinal tissues. Prerectum 194-380 μm long. Rectum 39-60 μm long. Vulva transverse slit-like, supported by well developed vulval muscles. Reproductive system amphidelphic, each sexual branch consisting of a reflexed ovary, oviduct and uterus. Paired testes present in only one specimen, spicule length varies from 36-57 μm . Tail elongate, tapering gradually, 106-118 μm long.

Remarks : Both the intersexes that were found have predominantly female characters, except that the posterior female genital branch is slightly smaller in length than the anterior branch. Vulva is strongly sclerotized and with well developed muscles. The male reproductive system is poorly developed and appears most probably to be non-functional. Only in one specimen (Fig., 6G) degenerate testes were observed. The spicules are weak, small in size as compared to the normal males. Ventromedian supplements and copulatory muscles were not observed. Almost normal development of female reproductive system indicates that these intersexes could have functioned as normal females.

THE JUVENILE STAGES

First Stage Juvenile (Fig., 7)

Dimensions : Table I

Description : Body slender and almost straight upon fixation, tapering gradually towards both extremities more towards the posterior end. Cuticle with fine transverse striations, 1.5 μm thick at mid-body, marked with 21-22 longitudinal ridges which fade out gradually at extremities. In a cross-section of the moulting first stage juvenile, the inner cuticle shows 23 longitudinal ridges while the outer one has 21 ridges. Lateral chords are 5-8 μm wide and 4-5 μm high at mid-body and there are 5-8 cells in each quadrant (Fig., 7D).

Lip region is slightly narrower than the adjoining body and is marked off by a slight depression, 6-9 μm wide and 3-4.5 μm high. Amphids are strirrup-shaped with slit-like apertures, 3 μm wide occupying about 1/2 of the corresponding body width and located at 3 μm from anterior end. Functional odontostyle 8-15 μm long. Odontophore length varies from 11-21 μm . Replacement odontostyle 11-20 μm long, enclosed within the walls of odontophore and 23-65 μm from anterior end. Guiding ring 'double', situated 5-8 μm from anterior end. Nerve ring 60-85 μm from anterior end encircling the anterior slender part of oesophagus. The total length of oesophagus varies from 125-250 μm . The expanded part of oesophagus is 29-30% of the total oesophageal length. Oesophageal gland nuclei and their orifices are not visible. Cardia is elongate-conoid, 8-23 μm long, surrounded by intestinal tissues and made up of 5-8 cells. Genital primordia 9-21 μm long, 6-12 μm wide, 50-62% from anterior end of body. Prerectum 30-57 μm or 3 anal body widths long, distinguishable from the intestine. Rectum 8-21 μm long. Tail long filiform, about 4-5 anal body widths long.

Second Stage Juvenile (Fig., 8)

Dimensions : Table I

Description : Body slender, almost straight upon fixation, tapering gradually towards extremities, more posteriorly. Cuticle with fine transverse striations, 1.5 μm thick at mid-body and marked with 23-24 longitudinal ridges which gradually fade out at the extremities. Cross-section at mid-body of the moulting second stage juvenile shows

25 longitudinal ridges in the inner and 23 in the outer cuticular ring. Lateral chords are 5-10 μm wide and 4.5 μm high at midbody. There are 5-8 coelomyarian muscle cells in each quadrant and the height of each cell is 3-5 μm (Fig., 8D).

Lip region is slightly narrower than adjoining body, 9-12 μm wide and 3-5 μm high. Amphids are stirrup-shaped with slit-like apertures, 3 μm wide lying at 3 μm from anterior end. Functional odontostyle length varies from 18-26 μm . Replacement odontostyle 20-30 μm long, located far behind the odontophore. Guiding ring 'double', 9-14 μm from anterior end. The nerve ring encircling the anterior slender part of oesophagus is located at 75-92 μm from anterior end of body. The total oesophageal length measures 293-365 μm , expanded part of oesophagus is 31-45% of total oesophageal length. Oesophageal gland nuclei and their orifices not observed. Cardia elongate conoid, 18-30 μm long, surrounded by intestinal tissues and made up of 9-12 cells. Genital primordia 15-30 μm long and 6-15 μm wide. Prerectum 60-101 μm or 3-4 anal body widths long distinguishable from the intestine. Rectum 19-29 μm long. Tail long filiform, about 5-7 anal body-widths long.

Third Stage Juvenile (Fig., 9)

Dimensions : Table I

Description : Body long and slender, slightly curved near the middle, tapering gradually towards extremities upon fixation, more posteriorly. Cuticle with fine transverse striations, 2 μm thick at mid-body and marked with 25-26 longitudinal ridges which gradually fade out at the extremities. In a cross-section of the third stage moulting juvenile, the inner cuticular ring shows 27, and the outer one 25 longitudinal ridges. Lateral chords are 5-8 μm high and 10-15 μm wide. The height of coelomyarian muscle cell is 5-8 μm and there are 5-7 cells in each quadrant (Fig., 9E).

Lip region is slightly narrower than the adjoining body and marked off by a slight depression, 12-15 μm wide and 6-8 μm high. Amphids are stirrup-shaped with slit-like apertures, 3-5 μm wide, and situated at 3 μm from the anterior end. The length of functional odontostyle varies from 27-30 μm . Odontophore 32-38 μm long. Replacement odontostyle 38-42 μm long. Guiding ring 'double' at 15-18 μm from anterior end. The nerve ring is situated at 117-122 μm from the anterior end of body, encircling the anterior slender part of oesophagus. The total oesophageal length varies from 327-551 μm , the expanded part of oesophagus 59-68% of the total oesophageal length. Cardia elongate conoid, 15-33 μm long, surrounded by intestinal tissues and made up of 10-14 cells. Genital primordia 42-135 μm long and 11-29 μm wide in females and 21-143 μm long and 12-23 μm wide in males. Prerectum 77-186 μm long in females and 116-236 μm long in males, easily distinguishable from the intestine. Rectum 23-46 μm long. Tail long filiform in both sexes, about 4-5 times anal body widths long.

Fourth Stage Juvenile (Fig., 10)

Dimensions : Table I

Description : Body long and slender, slightly curved in the middle upon fixation, tapering gradually towards both extremities, more posteriorly. Cuticle with fine transverse striations, 2-3 μm thick at mid-body, marked with 27-29 longitudinal ridges which gradually fade out at extremities. In a cross-section of the moulting juvenile, the inner cuticle ring possess 32, and the outer one has 29 longitudinal ridges. Lateral chords are 8-10 μm high and 14-27 μm wide. The height of the coelomyarian muscle cell is 11 μm and there are 6-8 cells at mid-body in each quadrant (Fig., 10E).

Lip region is slightly narrower than the adjoining body, 15-17 μm wide and 6-8 μm high. Amphids are stirrup-shaped with slit-like apertures, 3-5 μm wide, lying at 3 μm from anterior end. Functional odontostyle is 32-41 μm long, odontophore 33-44 μm long, replacement odontostyle 38-50 μm long. Guiding ring 'double', lying at 17-21 μm from anterior end. Nerve ring at 151-192 μm from anterior end of body encircling the anterior slender part of oesophagus. The total oesophageal length is 505-631 μm , the expanded oesophagus 47% of total oesophageal length. Cardia is elongate to conoid, 21-45 μm long, surrounded by intestinal tissues and made up of 12-15 cells. Genital primordia near mid-body 38-162 μm long and 10-27 μm wide in females, 63-149 μm long and 11-21 μm wide in males. Prerectum 133-201 μm long in females, 209-274 μm long in males. The prerectum is easily distinguishable from the intestine. Rectum 30-48 μm long. Tail long filiform, about 4-5 anal body widths long.

VARIABILITY

Morphometric Variations (Table I, Fig., 11-14)

The lip width, lip height, length of odontostyle, odontophore, oesophagus, position of vulva, length and width of eggs, length of spicules and lateral guiding pieces, number of supplements, rectum and tail length were least variable characters (CV = 2-10).

The total body length, body width in males only, position of guiding ring in males only, anterior and posterior gonad lengths, length of vagina, testes, anal body diameter, prerectum in females only, and thickness of cuticle (both at mid-body and tail) were moderately variable characters (CV = 11-19). The body width, position of anterior and posterior gonads and tail length in females and prerectum length in males showed high degree of variations (CV = 21-26). The lip width and lip height were least variable characters (CV = 9-10) while length of functional and replacement odontostyle, odontophore, oesophagus, prerectum, anal body diameter, tail and width of germinal primordium were moderately variable characters (CV = 15-18) in the first stage juvenile. However, the total body length, body width, guiding ring, expanded oesophagus, cardia, rectum and length of germinal primordium were highly variable (CV = 20-37).

The second stage juveniles showed least variations (CV = 4-9) in body width, lip width, length of functional and replacement odontostyles, odontophore, oesophagus, and anal body diameter. The body length, lip height, guiding ring, cardia, prerectum, rectum, tail and length of germinal primordium varied moderately (CV = 10-18). The width of germinal primordium showed high degree of variation (CV = 27).

In the third stage (male & female) juveniles, the lip width, guiding ring only in females, length of functional and replacement odontostyle, odontophore, oesophagus,

expanded oesophagus and prerectum in males were least variable characters (CV = 4-10). Moderate variation occurred in the total body length, body width, lip height, cardia in males, oesophagus, expanded oesophagus, prerectum in females, rectum, ABD, tail and width of germinal primordium in males (CV = 11-20). The length of cardia in males, length and width of germinal primordium showed highest variations (CV = 25-37).

The total body length, body width, lip width, functional and replacement odontostyles, odontophore, guiding ring, oesophagus, expanded oesophagus, and anal body diameter were least variable characters in the fourth stage female juveniles (CV = 3-10). The cardia, prerectum, rectum and tail were moderately variable (CV = 11-17) while length and width of germinal primordium showed highest variations (CV = 23-50). In fourth stage male juveniles, body width, lip width, lip height, functional and replacement odontostyle, expanded oesophagus, prerectum, rectum, and anal body diameter exhibited least variations (CV = 2-10) while cardia, tail and width of germinal primordium showed moderate variations (CV = 12-19). The body length and length of germinal primordium appeared as highly variable characters (CV = 22-26).

Allometric Variations

(Table IV, Figs., 15-30)

In adult males and females none of the allometric characters was highly variable except *c* in females (CV = 22). The *a*, *b*, *V* and *T* values in males were least variable (CV = 7-10), while *a* and *c* values in females showed moderate variations (CV = 11-19).

In all juvenile stages *b* and *c* ratios showed least to moderate variations. The *a* value showed least variation in second stage (CV = 10), third stage in both male & female juveniles (CV = 10) and in fourth stage male juvenile (CV = 7), whereas these characters varied only moderately in the first stage juvenile (CV = 11) and fourth stage female juvenile (CV = 11). The *c* value was least variable in the second stage juvenile (CV = 8) and fourth stage female juvenile (CV = 5) but showed moderate variations in first stage juvenile (CV = 11) and fourth stage male juvenile (CV = 13). In third stage male and female, *c* values showed highest variations (CV = 24-28). There was no correlation between body length and length of odontostyle, replacement odontostyle, odontophore in adults and juveniles (Figs. 15-19).

The different ratios e.g., replacement odontostyle/functional odontostyle, odontophore/functional odontostyle, oesophagus/functional odontostyle, oesophagus/replacement odontostyle, and oesophagus/expanded oesophagus, posterior gonad/anterior gonad, body length/anterior & posterior gonads, body length/vulva and testes used for the adults and juvenile stages showed least to moderate variations respectively and could be considered most reliable characters (Fig., 20-30).

DISCUSSION

The morphological observations on *D. stagnalis* and their juvenile stages show some intra-specific variations which may be important for the taxonomic study of the species of this genus in particular and of the related genera in general. Variations were observed in the total body length, size of spear, position of guiding ring, position of vulva, length of anterior and posterior gonads, prerectum and tail. The females are larger than

the males and possess longer spears. The odontophore is longer than the odontostyle in both the sexes.

The adults possess 32-34 longitudinal ridges on body. Only 21-22 longitudinal ridges are present in the first stage, 23-24 in the second, and 25-26 in the third stage juveniles while the fourth stage juveniles have 27-29 longitudinal ridges on the body. The structure of stoma and female gonad is on the same pattern as described by Coomans (1963 a, 1964). Roggen *et al.* (1967) suggested that the odontophore is formed by the outer cuticular layers of the oesophagus in species of *Xiphinema*. In case of *D. stagnalis* also the odontophore seems to have arisen from the outer cuticular layers of the oesophagus.

The male reproductive system of *D. stagnalis* resembled that of *Anatonchus amiciae* and *Longidorus macrosoma* (Coomans & Lima, 1965; Aboul-Eid, 1969a) with slight variations in the shape and size of the gonads.

The anatomical observations on *D. stagnalis* and their juvenile stages showed smaller dorsal and ventral hypodermal chords consisting of one or two cells only but larger lateral chords which are made up of 3 or more cells. Each hypodermal quadrant has 5-9 cells showing the polymyarian type of cell arrangement. These cells are of coelomyarian type and form the somatic musculature of the nematode. The coelomyarian muscle cell is made up of 2 parts : i) nucleated sarcoplasmic non-contractile part, and ii) contractile part (*cf.* Hirumi *et al.*, 1971). The size, shape and number of the cells varies at different body levels in the adults as well as the juvenile stages. In the anterior region of body the number of these cells is fewer (5-6) and they are of smaller size as compared to those at mid-body which are larger, more numerous (5-11), both in the adults and juveniles.

The juveniles can be distinguished from the adults on the basis of their body size and in having two odontostyles (one functional and the other replacement) while the adults have only one odontostyle, i.e., the functional one. The first stage juveniles can be differentiated from all the other stages on the basis of their small body size and the position of replacement odontostyle which is located anteriorly. The second, third and fourth stages can be differentiated from each other on the basis of the lengths of the functional and replacement odontostyles, and the number of germinal cells in the primordia. The first stage has 2 germinal nuclei, second has 4-6 while the third and fourth stages have 8-10 and 20-60 germinal nuclei respectively.

The shape of the tail in both the sexes is filiform up to the fourth stage juveniles. However, the males exhibit sexual dimorphism in tail which becomes short and conoid just before the final moulting. The female possess long filiform tails all through.

The statistical analysis of morphometric and allometric characters of the adults and juveniles of *Dorylaimus stagnalis* revealed that the characters vary to different degrees in all stages. Wu (1960) in *Ditylenchus destructor*, Bird & Mai (1967) in *Trichodorus christei*, Tarjan (1969) in *X. americanum*, Bajaj & Jairajpuri (1977) in *Xiphinema basiri*, Azmi & Jairajpuri (1978a) in *Helicotylenchus indicus*, Malik & Jairajpuri (1983) in *Xiphinema americanum* and Rahman *et al.* (1986) in *Xiphinema brasiliense* and *Xiphinema radicolica* found that the lengths of odontostyle, odontophore, tail, position of guiding ring and vulva are least variable and hence reliable characters for taxonomic purposes.

During the present study all the above mentioned morphometric characters (except

female tail) of male and female *Dorylaimus stagnalis* were found to be least variable. In addition, the lip width, lip height, length of expanded part of oesophagus, lateral guiding pieces, rectum and the number of supplements also showed little variations. All juvenile stages, except the first stage, exhibited low to moderate degree of variations in almost all the morphometric and allometric characters. Nearly all the characters of the first stage juveniles exhibit high degree of variations and hence cannot be considered reliable.

The position and length of odontostyle, the replacement odontostyle and odontophore may be used for differentiating juvenile stages as well as the size of the primordia and the number of primordial cells which were found to be least variable. The lengths of odontostyle, odontophore, oesophagus, tail etc, did not show any correlation with the total body length as was also observed by Sturhan (1963) for longidorid nematodes. Azmi & Jairajpuri (1978 a) in *Helicotylenchus indicus* and Malik & Jairajpuri (1983) in *Xiphinema americanum* came to the same conclusion.

Taylor and Jenkins (1957) demonstrated that deviations from the mean values were minimum for vulva position and maximum for the tail length in *Pratylenchus* sp. In *Rotylenchus goodeyi*, b and c values showed wide range of variations (Coomans, 1962). Brezeski (1963) concluded that the value a has little taxonomic importance, while b, c and V are more consistent in *Eudorylaimus* sp. Azmi & Jairajpuri (1978a) concluded that a, V and G values are more or less constant and are thus least variable characters. However, Rehman et al. (1986) found that a, b and V ratios least and c moderately variable in *Xiphinema radicum*, while all ratios were moderately variable in *Xiphinema brasiliense*. The present studies on *Dorylaimus stagnalis* revealed that ratio a in males, b, V, T, replacement odontostyle, functional odontostyle, oesophagus/functional odontostyle, oesophagus/replacement odontostyle, replacement odontostyle/functional odontostyle and oesophagus/expanded oesophagus are least variable and consistent allometric characters in the adult and juvenile stages.

The present population of *D. stagnalis* showed variations in most of its taxonomic characters as compared to those described by Dujardin (1845), Mulvey & Anderson (1979), and Khera (1970). The females of the present population differ from those described by Dujardin, (1845) in having smaller body length, and lower a and V values. The males also have a shorter body and lower c value. From the population of *D. stagnalis* that was described by Mulvey & Anderson (1979), the present specimens differ in having lesser values of almost all the characters. The Jodhpur population of this species reported by Khera (1970) has smaller body and lesser a, b, c and V values than the present one. Baqri (1985) has identified this population as *Laimydorus finalis* Thorne (1975). The population described by Khera (1970) from Lucknow is also comparatively smaller and possesses lower b values than the present one from Aligarh. All populations of *D. stagnalis* which have been reported from different places showed variations in one or the other characters. This kind of variation (intraspecific) seems to be a natural phenomenon and may be induced by different factors such as habitat (Goodey, 1952; Bird & Mai, 1965; Fisher, 1965), soil temperature (Rohde & Jenkins, 1957; Malik & Jenkins, 1964) and geographical location (Golden & Epps, 1965; Tarjan, 1968 & 1969) besides other biotic and abiotic factors. Since these populations were described from different habitats (e.g. paddy fields, bank of ditches and lakes, other aquatic habitats, forests and from the stomach of fish) and localities (e.g., Canada, France and India) these naturally show variations due to differences in their environment (ecophenotypic variability).

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Table I
MORPHOMETRIC VARIATIONS IN JUVENILES AND ADULTS OF *D. STAGNALIS*

Character	L ₁		L ₂		L ₃ female		L ₃ male		L ₄ female		L ₄ male		Adult female		Adult male	
	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV	MSD (Range)	CV
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17
Length (mm)	.483±.1243 (.370-.873)	26	1.2478±0.145 (.932-1.495)	12	2.077±0.320 (1.272-2.531)	15	2.334±0.321 (1.08-2.927)	14	2.401±0.192 (2.102-2.975)	8	2.561±0.572 (2.176-3.199)	22	3.66±0.461 (2.768-4.662)	13	3.30±0.41 (2.634-4.410)	12
Width	19.83±4.88 (15.2-38)	25	38.61±2.58 (30.4-45.6)	7	59.71±10.75 (38-76)	18	69.35±7.36 (41.8-76)	11	70.14±6.76 (57-83.67)	10	72.99±6.39 (64.6-91.2)	9	96.95±24.83 (72.2-152)	26	94.62±12.04 (76-114)	13
Lip width	7.4±0.69 (6-9)	9	10.5±0.45 (9-12)	4	14±1.33 (12-15)	10	14.62±0.95 (10.5-15)	7	15.18±0.48 (15-16.5)	3	15.06±0.29 (15-16.5)	2	18.55±1.69 (15-22.5)	9	17.92±0.94 (16.5-21)	5
Lip height	3.06±0.29 (3-4.5)	10	3.97±0.71 (3-4.5)	18	6.21±1.16 (6-7.5)	19	6.53±0.82 (4.5-7.5)	13	6.96±0.72 (6-7.5)	10	7.12±0.64 (6-7.5)	9	7.08±0.67 (6-7.5)	9	7.35±0.45 (6-7.5)	6
Functional odontostyle	9.6±1.72 (7.5-15)	18	22.70±2.03 (18-25.5)	9	28.71±1.16 (27-30)	4	29.35±1.01 (27-30)	3	34.32±2.31 (31.5-40.5)	7	32.25±1.22 (31.5-36)	4	42.80±3.74 (37.5-52.5)	9	40.61±2.47 (37.5-46.5)	6
Replacement odontostyle	12.45-2.25 (10.5-20)	18	29.19±1.75 (19.5-30)	6	39.04±3.16 (37.5-42)	8	39.94±3.12 (31.5-42)	8	42.87±2.68 (37.5-49.5)	6	43.43±1.70 (39-45)	4	—	—	—	—
Odontophore	14.22±2.28 (10.5-21)	16	26.58±1.83 (21-30)	7	33.67±2.90 (31.5-37.5)	9	34.07±2.68 (27-39)	8	37.05±2.70 (33-43.5)	7	34.75±2.27 (31.5-40.5)	7	46.86±4.60 (39-62)	10	43.67±2.32 (39-46.5)	5
Guiding ring	4.89±1.03 (4.5-9)	21	11.93±1.29 (9-13.5)	11	16.42±1.63 (15-18)	10	16.60±1.76 (10.5-19.5)	10	18.04±1.14 (16.5-21)	6	18.18±1.08 (16.5-19.5)	6	24.63±3.77 (16.5-31.5)	15	23.91±1.88 (21-30)	8
Oesophagus	161.72±28.10 (125.4-250)	17	338.91±24.53 (292.6-364.8)	7	501.99±55.72 (327.4-551)	11	539±50.33 (311.6-600.4)	9	539.15±25.23 (505.4-630.8)	5	568.82±22.09 (513-596.6)	4	728.55±54.69 (634-888)	8	695.69±46.48 (608-814)	7
Expanded part of oesophagus	55.65±12.86 (37.5-97.5)	23	133.78±12.91 (90-165)	10	248.46±43.79 (224.2-323)	18	268.77±27.96 (135-307.8)	10	267.42±15.49 (239.4-296.4)	6	278.29±11.39 (258.4-307.8)	4	382±34.63 (326.8-459.8)	9	358.13±21.40 (325.6-395.2)	6
Cardia	9.84±3.66 (7.5-22.5)	37	23.47±3.79 (18-30)	16	25.76±6.566 (15-33)	25	30.62±5.59 (15-38)	18	32.80±4.99 (21-45)	15	28.76±5.20 (19.5-37.5)	18	35.72±7.91 (22.5-57)	22	32.88±5.79± (21-39)	18
Vaginal length-	—	—	—	—	—	—	—	—	—	—	—	—	36.9±4.34 (30-45)	12	—	—

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17
Vulva/Testes-	—	—	—	—	—	—	—	—	—	—	—	—	1480.10±155.1810 (1113.4-1850)	10	2247.8±303.3313 (1852.2-2596.0)	—
V/T (%)	—	—	—	—	—	—	—	—	—	—	—	—	40.58±2.74 (34.88-50.24)	7	67.16±4.72 (57.95-75.59)	7
Anterior gonad-	—	—	—	—	—	—	—	—	—	—	—	—	657.24±150.92 (364.8-889.2)	23	—	—
G ₁	—	—	—	—	—	—	—	—	—	—	—	—	17.45±2.89 (11.41-22.67)	17	—	—
Posterior gonad-	—	—	—	—	—	—	—	—	—	—	—	—	784.25±169.60 (478.8-1143.8)	22	—	—
G ₂	—	—	—	—	—	—	—	—	—	—	—	—	20.94±4.05 (12.8-29.77)	19	—	—
Length of eggs	—	—	—	—	—	—	—	—	—	—	—	—	81.75±3.54 (76.5-90)	4	—	—
Width of eggs	—	—	—	—	—	—	—	—	—	—	—	—	36.68±1.84 (33-39)	5	—	—
Spicules	—	—	—	—	—	—	—	—	—	—	—	—	—	—	86.65±7.61 (78-112.5)	9
Lateral guiding piece	—	—	—	—	—	—	—	—	—	—	—	—	—	—	15.04±1.42 (9-16.5)	9
No. of supplements	—	—	—	—	—	—	—	—	—	—	—	—	—	—	45±0.83 (42-47)	2
Prerectum	37.2±5.95 (30-57)	16	82.77±11.27 (60-100.5)	14	158.54±28.37 (76.5-186)	18	200.20±20.24 (115.5-235.6)	10	173.73±19.10 (133-201.4)	11	228.89±19.26 (209-273.6)	8	285.91±42.80 (201.4-418)	15	465.87±103.39 (277.4-779)	22
Rectum	11.76±3.13 (7.5-21)	27	24.15±2.51 (19-28.5)	10	36.83±6.28 (22.5-45.5)	17	39.62±5.28 (22.5-49.5)	13	37.40±4.01 (30-48)	11	41.31±3.02 (37.5-46.5)	7	59.01±4.93 (45-68.4)	8	62.29±4.93 (52.5-76)	8
Anal body width	12.99±2.29 (11.4-19)	18	19.79±1.74 (19-22.8)	9	31.47±4.55 (26.6-38)	14	35.53±4.57 (19-45.6)	13	33.51±2.48 (26.6-38)	7	37.36±3.58 (34.2-45.6)	10	47.35±6.06 (38-57)	13	54.52±5.92 (49.4-68.4)	11

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17
Tail	61.10±10.49 (45.6-95)	17	119.43±17.22 (91.2-152)	14	156.70±23.30 (106.4-201.4)	15	159.72±28.94 (64.6-197.6)	18	165.77±28.59 (76-212.8)	17	182.55±22.01 (136.8-212.8)	12	195.76±41.73 (102.6-304)	21	38.19±2.39 (30.4-41.8)	6
Cuticle at mid-body	—	—	—	—	—	—	—	—	—	—	—	—	6.95±0.87 (6-9)	13	—	—
Cuticle at tail	—	—	—	—	—	—	—	—	—	—	—	—	6.31±0.72 (4.5-7.5)	11	—	—
Length of germinal primordia	15.03±2.99 (9-20.5)	20	21.43±3.81 (15-30)	18	61.96±23.19 (42-135)	37	65.52±28.27 (21-142.5)	13	86.25±43.8 (37.5-162)	50	112.7±29.36 (63-148.5)	26	-	-	-	-
Width of germinal primordia	7.43±1.12 (6-12)	15	9.43±2.58 (6-15)	27	17.53±4.97 (10.5-28.5)	28	18.88±3.77 (12-23)	20	18.03±4.20 (10-27)	23	15.97±3.08 (10.5-21)	19				

Table IV
ALLOMETRIC VARIATIONS IN *D. STAGNALIS*

Character	L ₁		L ₂		L ₃ female		L ₃ male		L ₄ female		L ₄ male		Adult female		Adult male	
	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %	MSD (Range)	CV %
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17
Body length/ Odontostyle	50.21±6.02 (41.11-64.66)	12	55.11±6.08 (44.71-78.97)	11	72.25±10.44 (47.11-86.07)	14	79.43±10.67 (40-97.56)	13	70.29±7.37 (57.22-86.4)	10	82.85±7.66 (69-101.55)	9	86.16±10.88 (62.82-106.56)	13	81.35±8.78 (71.44-99.79)	11
Body length/ Replac. Odontostyle	38.67±4.30 (30.8-48.5)	11	42.85±5.20 (31.06-57.03)	12	53.01±6.06 (42.24-62.61)	11	58.79±7.13 (37.89-69.69)	12	56.11±4.22 (49-67.92)	8	61.47±5.21 (50.02-73.54)	8	—	—	—	—
Body length/ Odontophore	33.96±5.17 (25.02-48.5)	15	46.92±4.40 (37.25-55.13)	9	61.70±9.19 (44.4-80.34)	15	68.42±8.18 (40-79.36)	12	65.09±6.42 (52.85-78.92)	10	76.96±6.76 (65.93-92.72)	9	78.5±10.48 (57.79-106.64)	13	75.1±8.13 (62.07-94.83)	11
Body length/ Vulva	—	—	—	—	—	—	—	—	—	—	—	—	2.469±0.163 (1.99-2.86)	7	—	—
Body length/ Testes	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.49±0.106 (1.32-1.72)	7

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	16	17	
<i>Body length/</i> <i>Anterior gonad</i>	—	—	—	—	—	—	—	—	—	—	—	—	5.94±1.067 (4.41-8.76)	18	—	—	
<i>Body length/</i> <i>Posterior gonad</i>	—	—	—	—	—	—	—	—	—	—	—	—	4.93±0.956 (3.35-7.79)	19	—	—	
<i>Body length/</i> <i>Prerectum length</i>	12.94±1.75 (9.85-19.5)	14	15.21±1.67 (12.73-19.74)	11	13.37±1.55 (10.17-16.62)	12	11.64±1.25 (9.13-15.40)	11	14.04±1.73 (11.38-16.70)	12	11.69±0.99 (10.04-13.31)	8	13.02±2.21 (8.21-18.48)	17	7.28±1.01 (5.22-9.19)	14	
<i>Replac. odontostyle/</i> <i>Funct. odontostyle</i>	1.30±0.08 (1.14-1.6)	7	1.28±0.10 (1.08-1.53)	8	1.34±0.09 (1.1-1.47)	7	1.36±0.09 (1.05-1.47)	7	1.25± 0.10 (1.04-1.45)	8	1.34±0.08 (1.12-1.42)	6	—	—	—	—	
<i>Odontophore/</i> <i>Funct. odontostyle</i>	1.48±0.14 (1.14-1.18)	10	1.18±0.07 (0-1.46)	7	1.17±0.07 (0-1.27)	7	1.17±0.089 (0-1.38)	8	1.07±0.05 (0-1.19)	5	1.08±0.09 (0-1.28)	9	1.10±0.08 (0-1.34)	8	1.1±0.12 (0-1.24)	11	
<i>Oesophagus/</i> <i>Funct. odontostyle</i>	16.87±1.54 (13.93-20.25)	9	14.97±1.04 (13.17-17.34)	7	17.42±1.83 (12.12-20)	11	18.35±1.70 (11.54-20)	9	15.76±1.20 (13.27-17.84)	8	17.65±0.89 (15.41-18.81)	5	17.08±1.19 (15.1-19.35)	10	17.04±1.24 (14.47-20.91)	7	
<i>Oesophagus/</i> <i>Replac. odontostyle</i>	13.05±1.25 (11.08-16.28)	10	11.63±0.87 (9.75-12.93)	8	12.80±0.87 (10.91-14.40)	7	13.49±1.11 (10.93-17.49)	8	12.59±0.84 (10.92-14.32)	7	13.11±0.77 (11.79-14.71)	6	—	—	—	—	
<i>Oesophagus/</i> <i>Expanded oesophagus</i>	2.93±0.24 (2.38-3.45)	8	2.48±0.29 (2.14-3.84)	11	2.04±0.26 (1.65-3.07)	13	2.0±0.09 (1.86-2.30)	5	2.0±0.09 (1.84-2.16)	5	2.0±0.16 (1.92-2.13)	8	1.85±0.10 (1.59-2.09)	6	1.88±0.06 (1.78-2.04)	4	
<i>Prerectum</i> <i>Rectum</i>	3.30±0.71 (2.2-5.0)	21	3.45±0.52 (2.10-4.66)	15	4.26±0.57 (3.18-5.66)	14	5.06±0.48 (4.08-5.97)	10	4.63±0.60 (3.44-5.75)	13	5.59±0.51 (4.6-6.82)	9	4.87±0.73 (3.61-6.87)	15	7.44±1.33 (5.84-10.78)	18	
<i>Posterior gonad</i> <i>Anterior gonad</i>	—	—	—	—	—	—	—	—	—	—	—	—	1.2±0.15 (0.95-1.56)	13	—	—	
a	24.37±2.56 (19.47-31.1)	11	32.08±3.21 (26.4-38)	10	35.07±3.40 (29.5-41.01)	10	33.60±3.28 (26-42.79)	10	34.49±3.70 (28.5-44.66)	11	36.63±2.38 (33.5-40.46)	7	36.68±4.09 (27.38-44.86)	11	35.04±2.91 (30.69-42.02)	8	
b	2.92±0.22 (2.6-3.7)	8	3.60±0.19 (3.1-4)	5	4.10±0.34 (3.4-4.75)	8	4.29±0.33 (3.4-5.13)	8	4.43±0.30 (4.06-5.32)	7	4.68±0.31 (4.03-5.65)	7	5.01±0.48 (3.97-6.18)	10	4.73±0.37 (3.78-5.63)	8	
c	7.82±0.86 (6.3-10.2)	11	10.41±0.86 (8.8-11.9)	8	13.53±3.21 (10.33-19.74)	24	15.11±4.22 (10.9-34.81)	28	15.46±0.76 (11.12-17.47)	6	5	14.78±1.85 (12.64-19.37)	13	19.41±4.31 (12.8-32.76)	22	86.84±12.80 (68.32-145.06)	18
c	4.72±0.60 (3.5-6.3)	13	6.05±0.93 (3.8-8)	15	5.07±0.94 (2.8-6.62)	19	4.5±0.77 (3-5.81)	17	4.93±0.90 (1.28-6.4)	18	4.93±0.79 (3.25-6.54)	16	4.15±0.80 (2.47-6.15)	19	0.70±0.07 (0.5-0.84)	11	
V	—	—	—	—	—	—	—	—	—	—	—	—	40.58±2.74 (34.88-50.24)	7	—	—	
T	—	—	—	—	—	—	—	—	—	—	—	—	—	—	67.16±4.72 (57.95-75.59)	7	

Table II

Location of oesophageal gland nuclei and their orifices

	Range (%)	Mean (%)
DO	50 - 54	52
DN	53 - 56	55
S ₁ N ₁	68 - 83	76
S ₁ O ₁	66 - 78	72
S ₁ N ₂	71 - 86	79
S ₁ O ₂	70 - 83	77
S ₂ N ₁	84 - 92	88
S ₂ O ₁	83 - 90	87
S ₂ N ₂	84 - 93	89
S ₂ O ₂	85 - 89	87

Table III

Intersex

Characters	n ₁	n ₂
L (mm)	2.560 mm	3.138 mm
a	32	38
b	4.2	4.1
c	24	27
c'	—	—
V	45	43
T	—	67.3
G ₁	13.8	12.4
G ₂	11.7	15
Lip width	15 µm	18 µm
Lip height	6 µm	8 µm
Guiding ring	24 µm	27 µm
Odontostyle	42 µm	45 µm
Odontophore	45 µm	44 µm
Oesophagus	608 µm	767.6 µm
Cardia	23 µm	22 µm
Prerectum	194 µm	380 µm
Rectum	39 µm	60 µm
Spicule	36 µm	57 µm
Tail	106.4 µm	117.8 µm
ABD	53.2 µm	49.4 µm

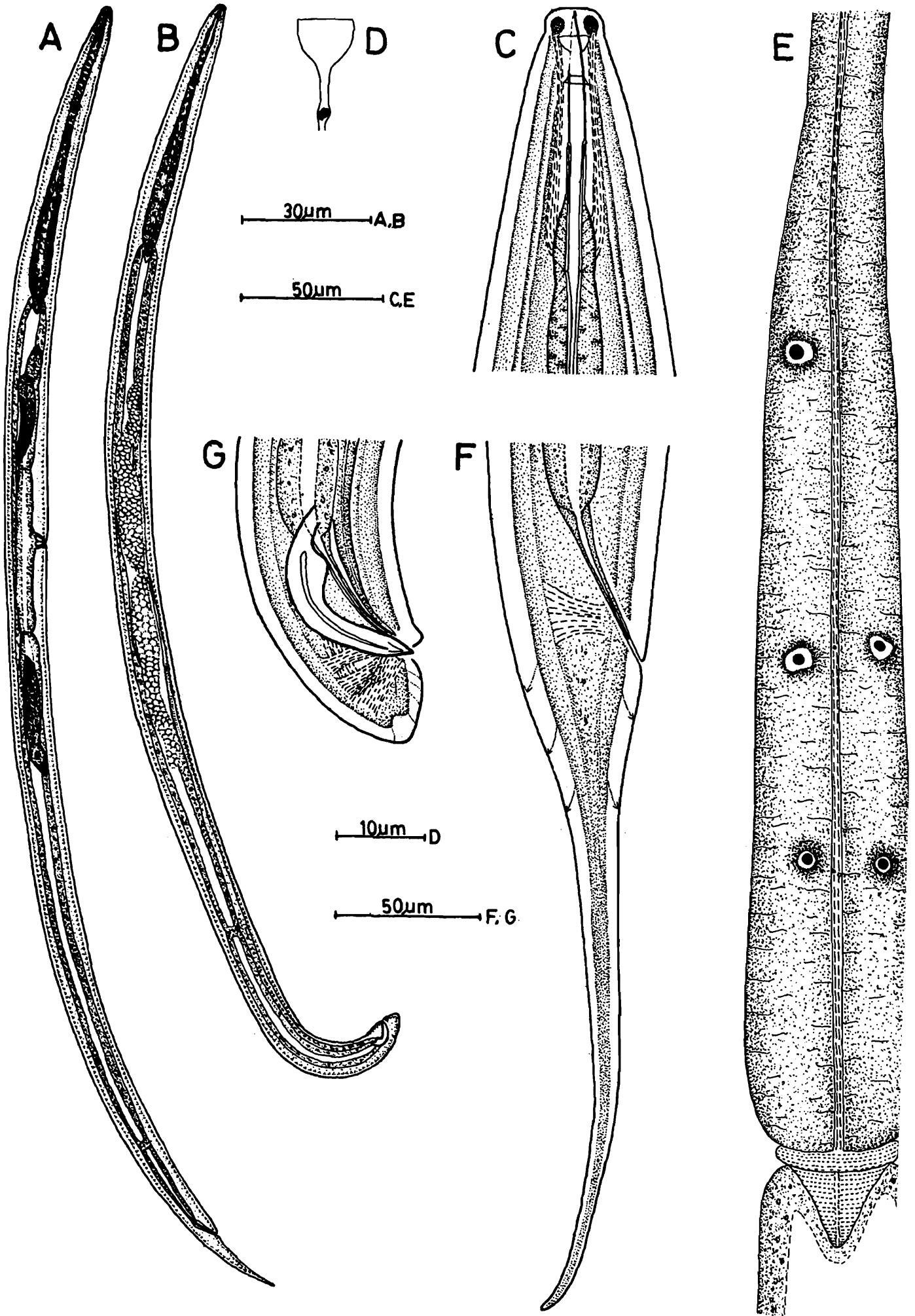


Fig. 1 : A = Entire female, B = Entire male, C = Amphid, D = Anterior region, E = Expanded part of oesophagus, F = Female tail, G = Male tail.

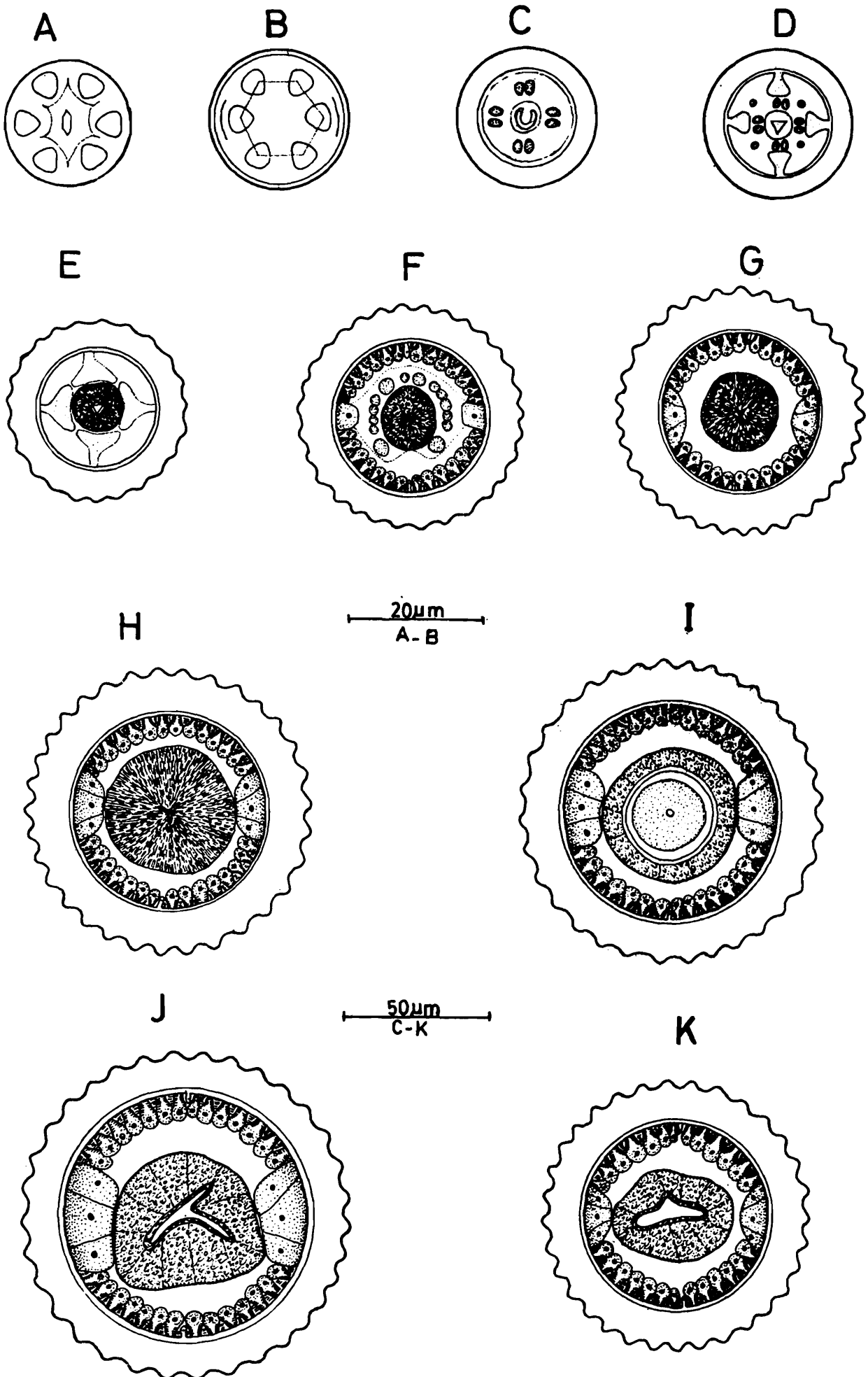


Fig. 2 : Cross sections through body of *D. stagnalis* A = En-face view, B = at the level of amphid, C = at the level of odontostyle showing protractor muscles, D = at the level of odontophore, E = at the base of odontophore, F = at the level of nerve ring, G = through anterior part of oesophagus, H = through expanded part of oesophagus, I = through cardia, J = through intestine, K = through prerectum.

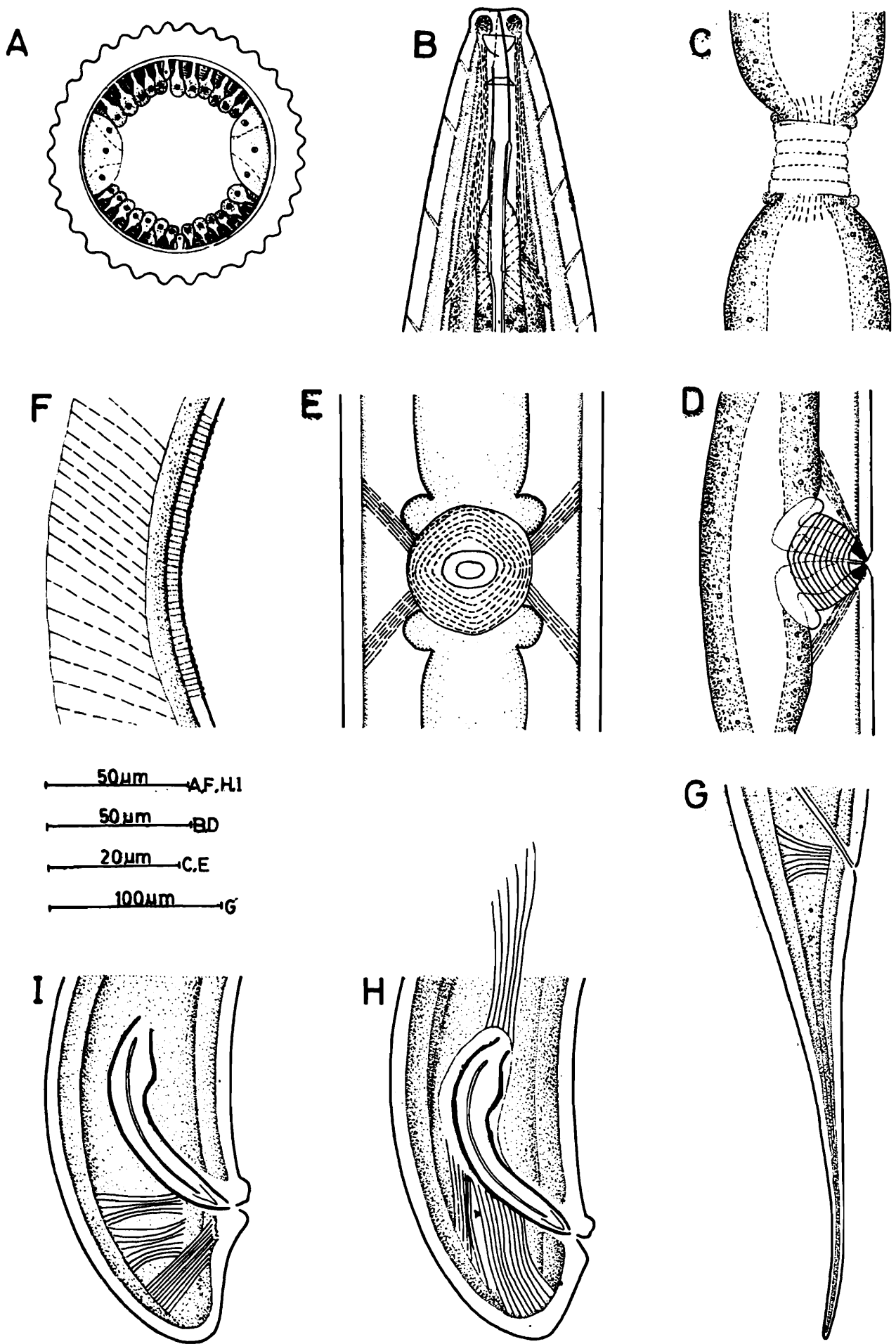


Fig. 3 : A = Somatic muscles / cross section at the level of intestine, B = Spear muscles, C = Sphincter muscles, D = Vulval muscles (lateral), E = Vulval muscles (ventral), F = Copulatory muscles, G = Anal muscles (female), H = Spicular muscles, I = Anal muscles (male).

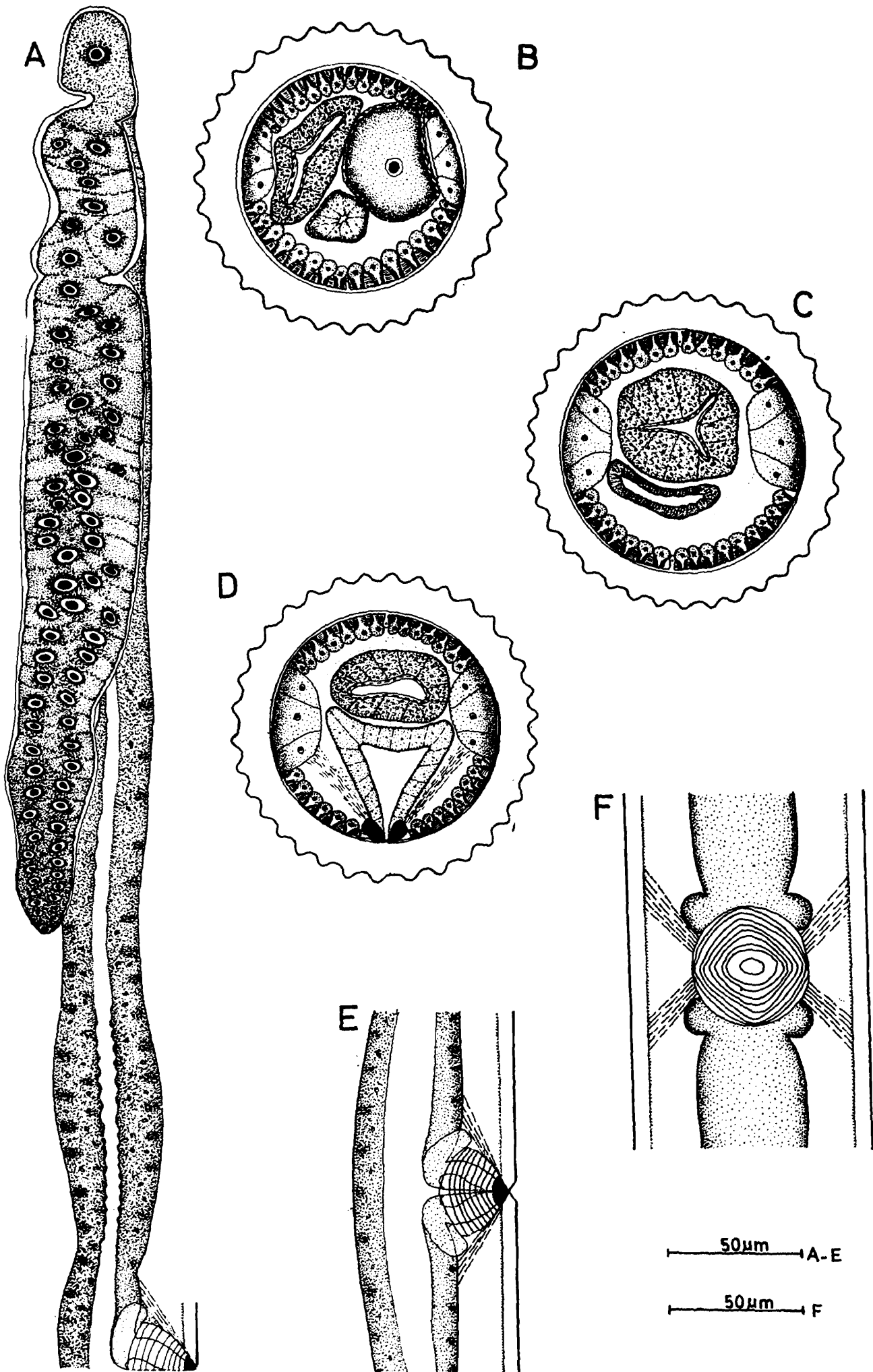


Fig. 4 : Female reproductive system A = Anterior sexual branch, B = C.S. through ovary & oviduct, C = C.S. through uterus, D = C.S. through vulva, E = Vulva region (lateral), F = Vulva region (ventral).

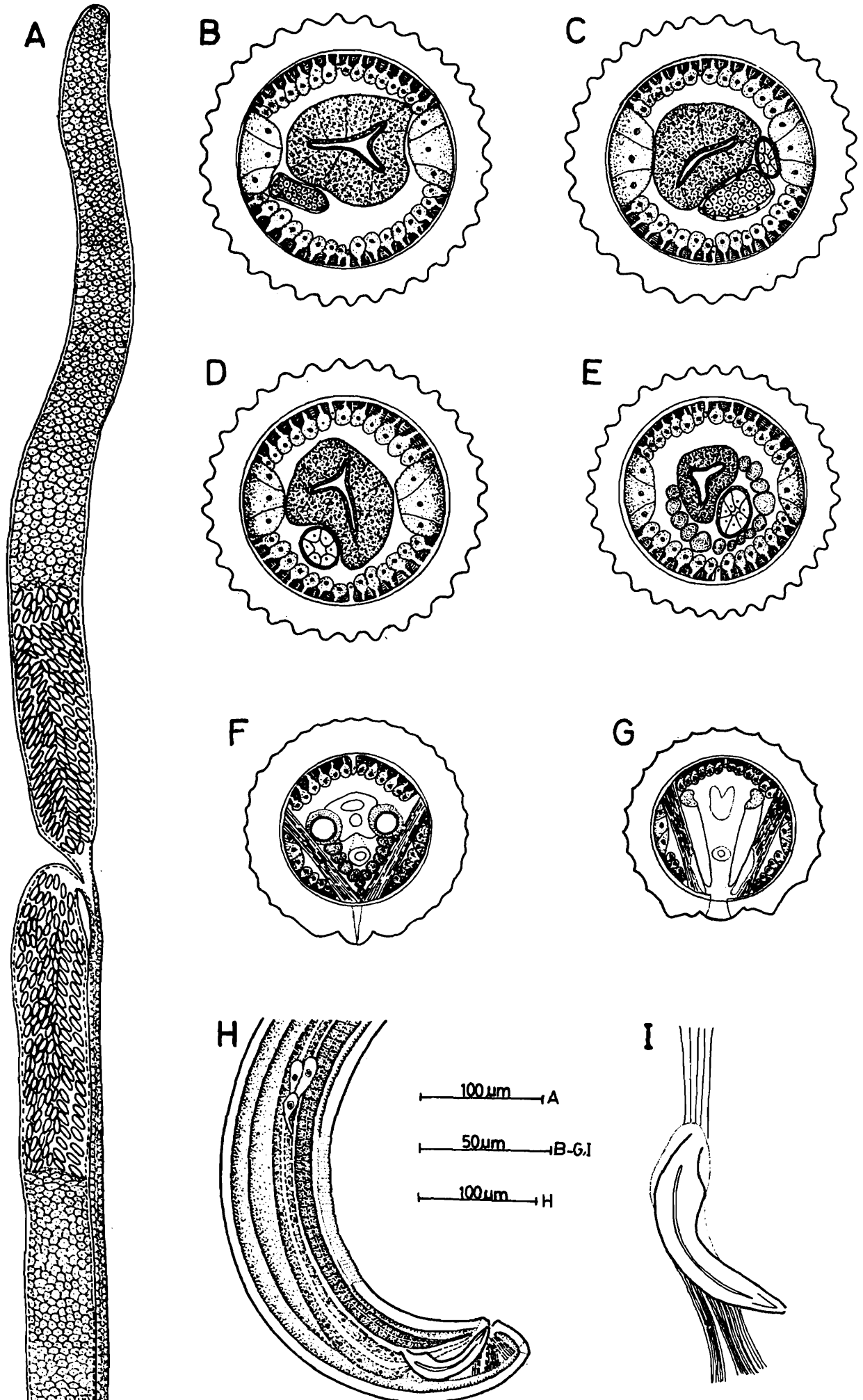


Fig. 5 : Male reproductive system A = Testes, B-G = C.S. through testes, C = Testes & vas deferens, D = Vas deferens, E = Ejaculatory duct, F = Head of spicules, G = Shaft of spicules, H = posterior region, I = Spicule with muscles.

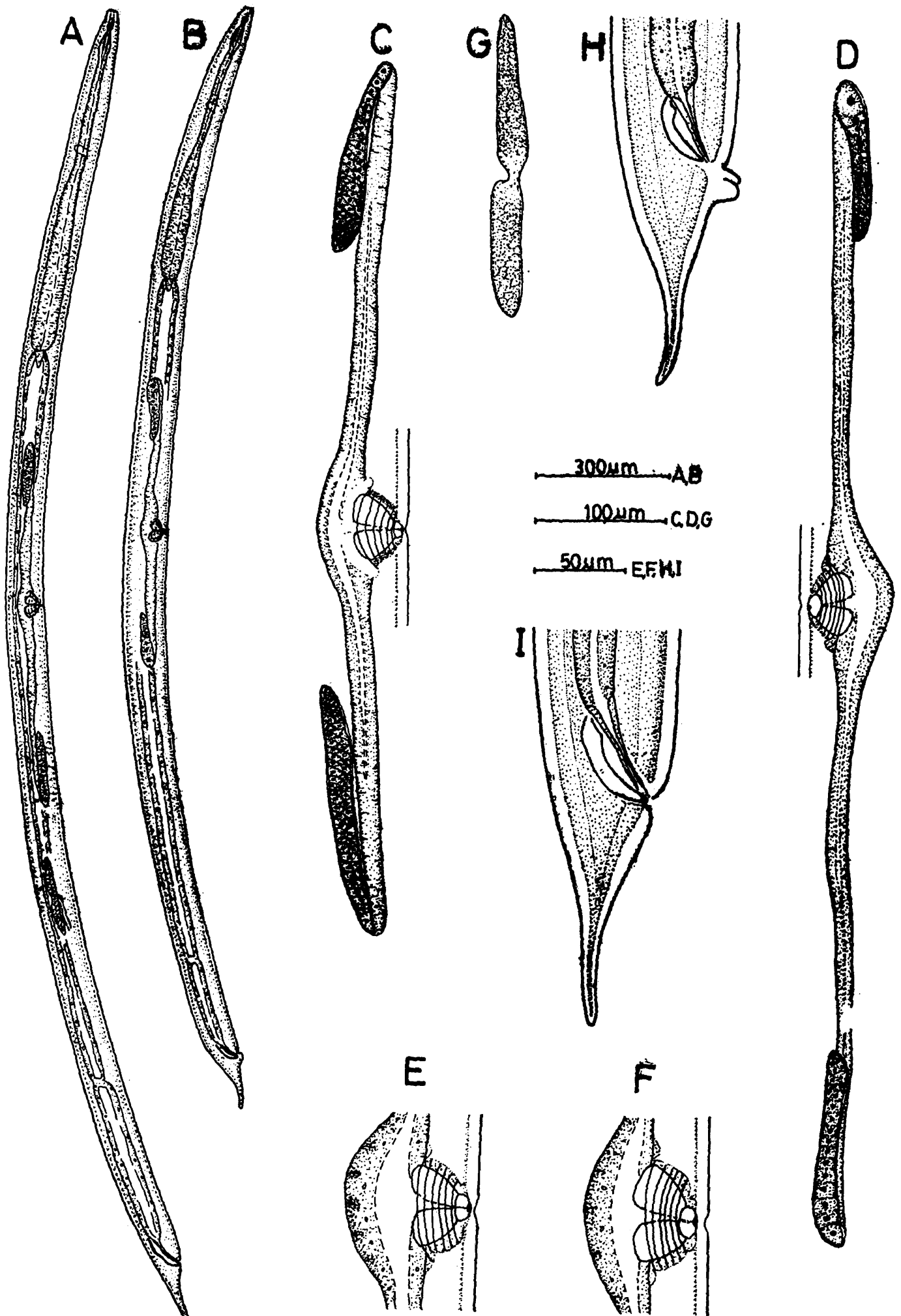


Fig. 6 : Intersex A & B = Entire, C & D = Female gonads, E & F = Vulva, G = Testes, H & I = Tail.

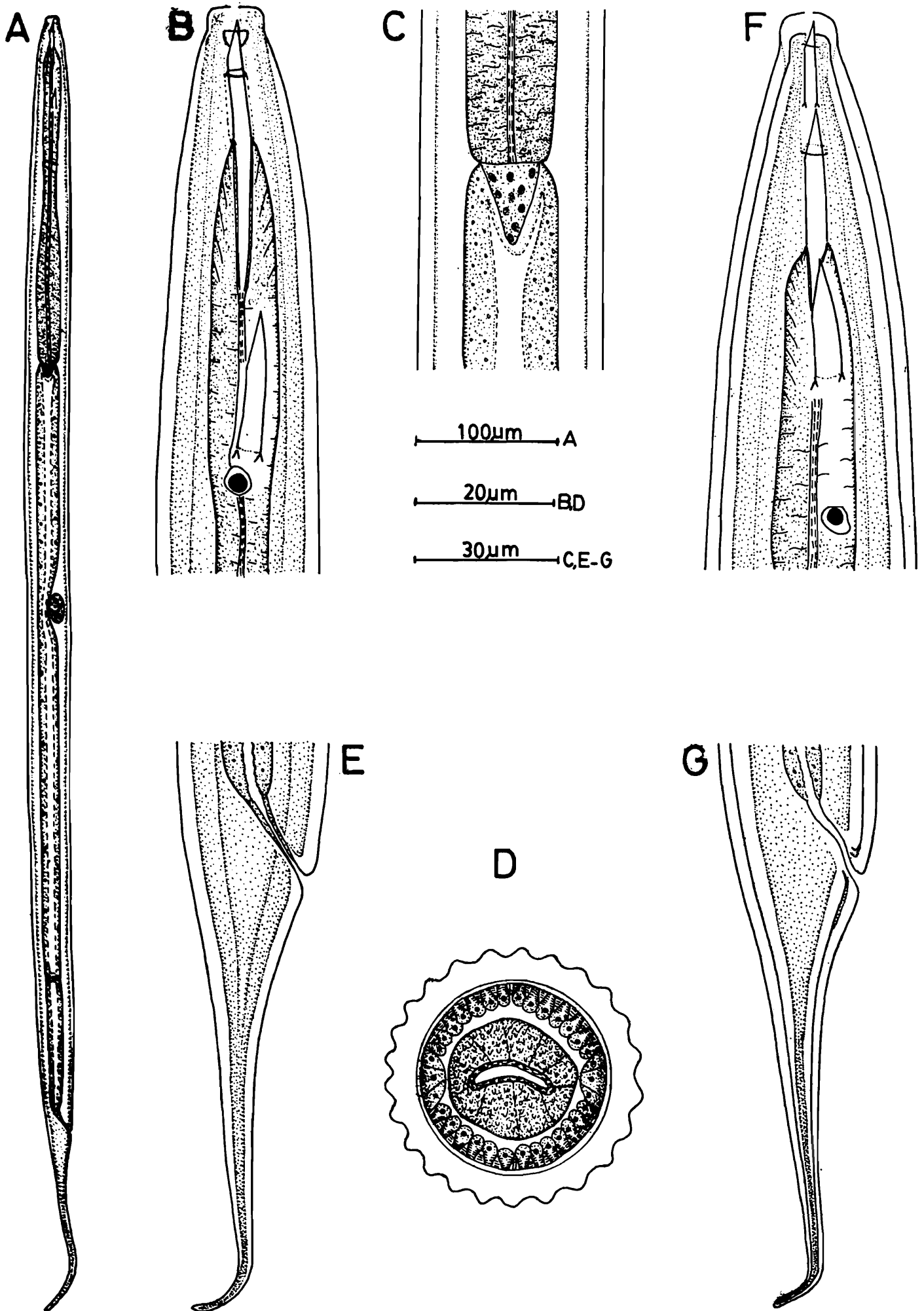


Fig. 7 : First stage juvenile A = Entire first stage juvenile, B = Anterior region of intermoulting stage, C = Cardia, D = C.S. through intestine, E = Tail of intermoulting stage, F = Anterior region of first moulting stage, G = Tail of first moulting stage.

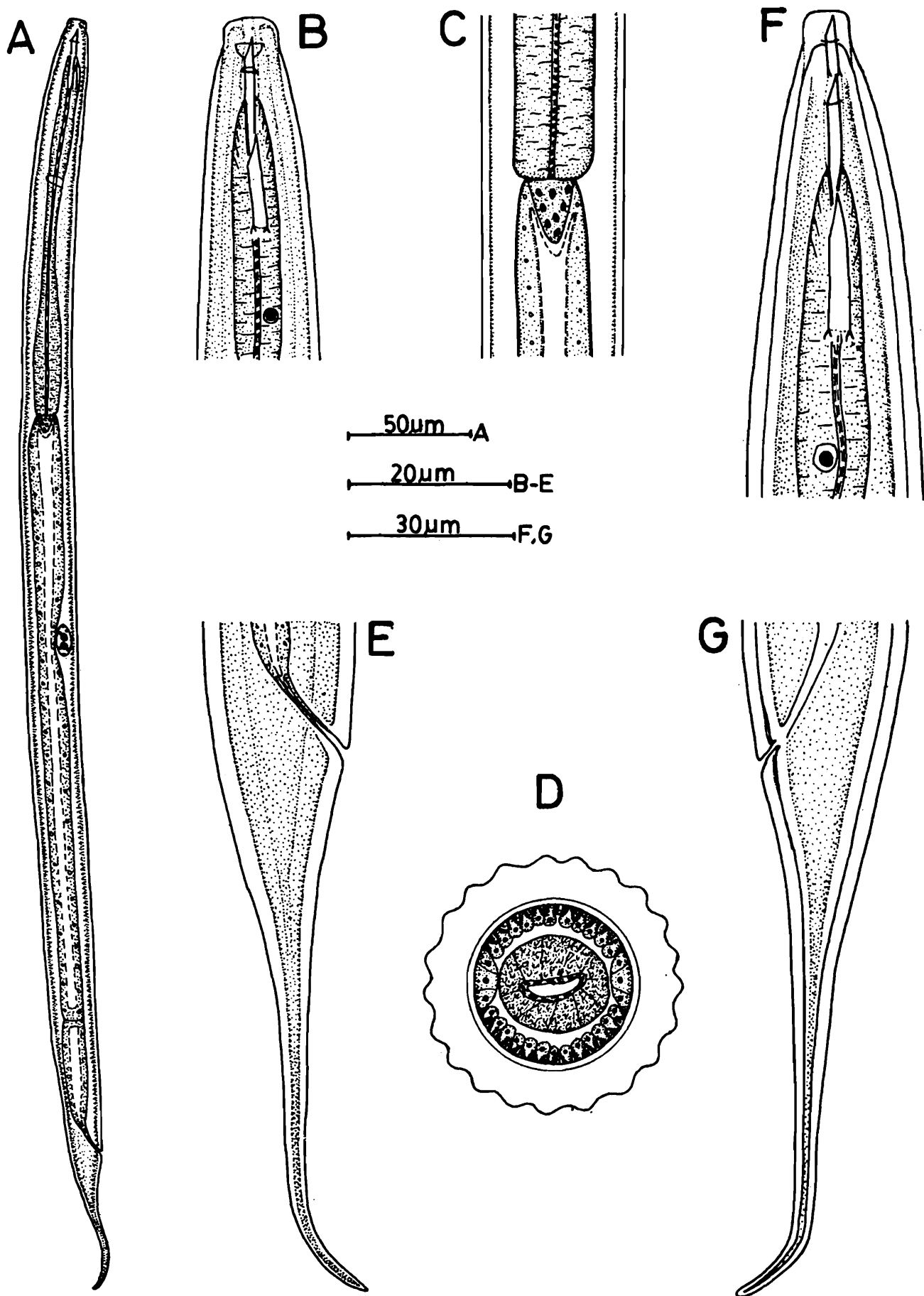


Fig. 8 : Second stage juvenile A = Entire second stage juvenile, B = Anterior region of intermoulting stage, C = Cardia, D = C.S. through intestine, E = Tail of intermoulting stage, F = Anterior region of second moulting stage, G = Tail of moulting stage.

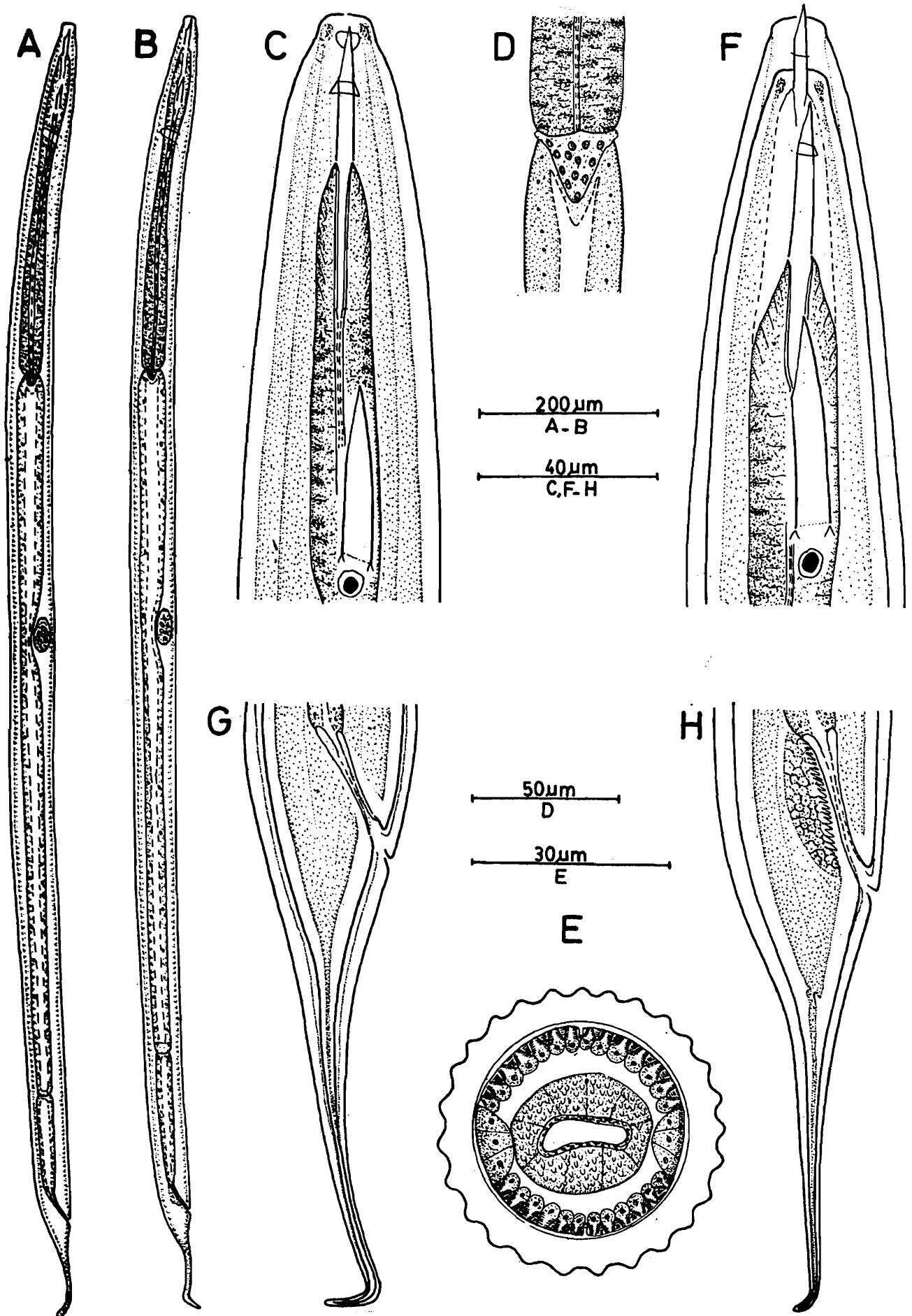


Fig. 9 : Third stage juvenile A = Entire third stage juvenile (Female), B = Entire third stage juvenile (male), C = Anterior region of intermoult stage, D = Cardia, E = C.S. through intestine, F = Anterior region of moulting stage, G = Tail of moulting stage (female). H = Tail of moulting stage (male).

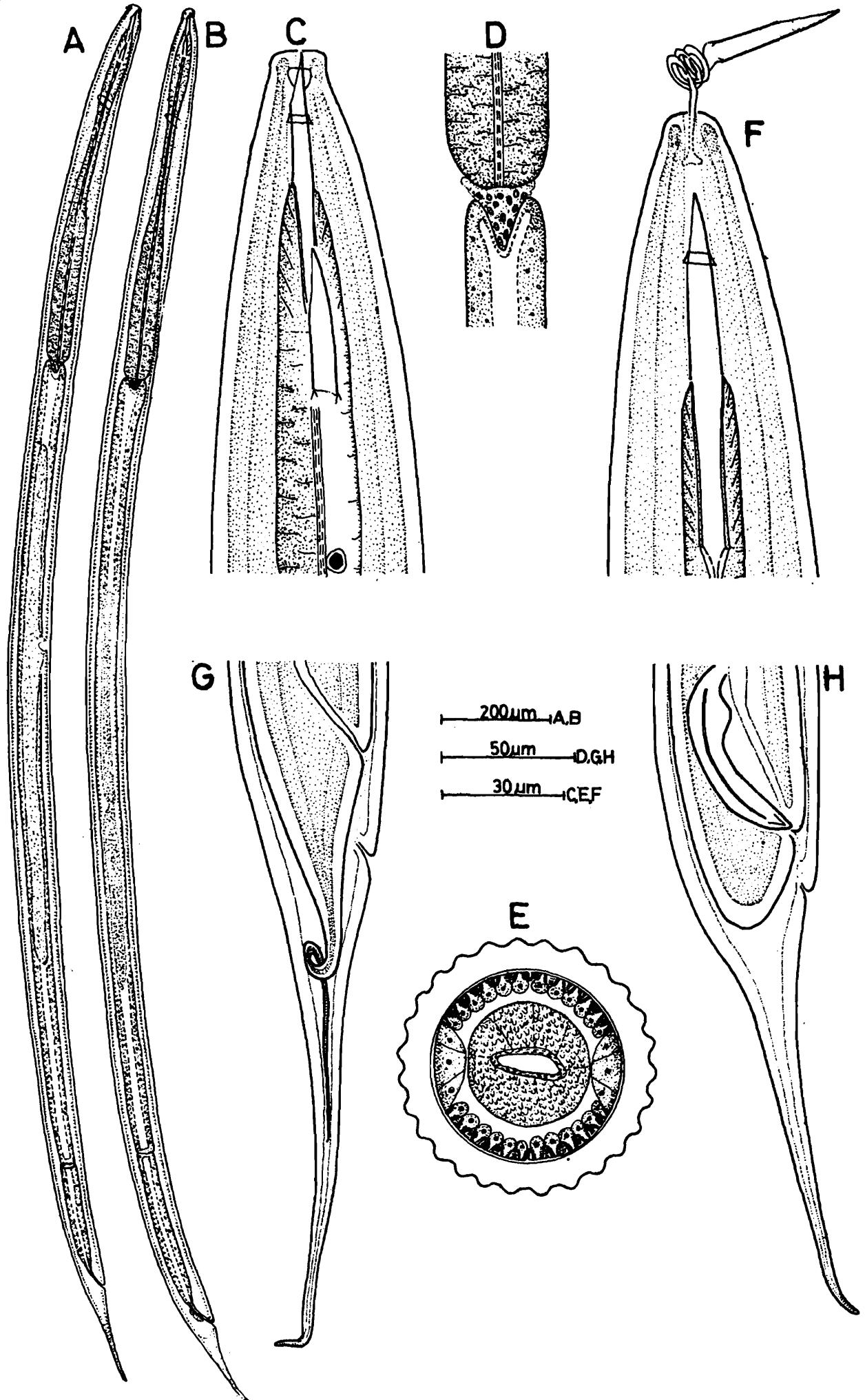


Fig. 10 : Entire Fourth stage juvenile A = Entire fourth stage juvenile (female)
 B = Entire fourth stage juvenil (male), C = Anterior region of intermoulting stage,
 D = Cardia, E = C.S. through intestine, F = Anterior region of moulting stage,
 G = Tail of moulting stage (female), H = Tail of moulting stage (male).

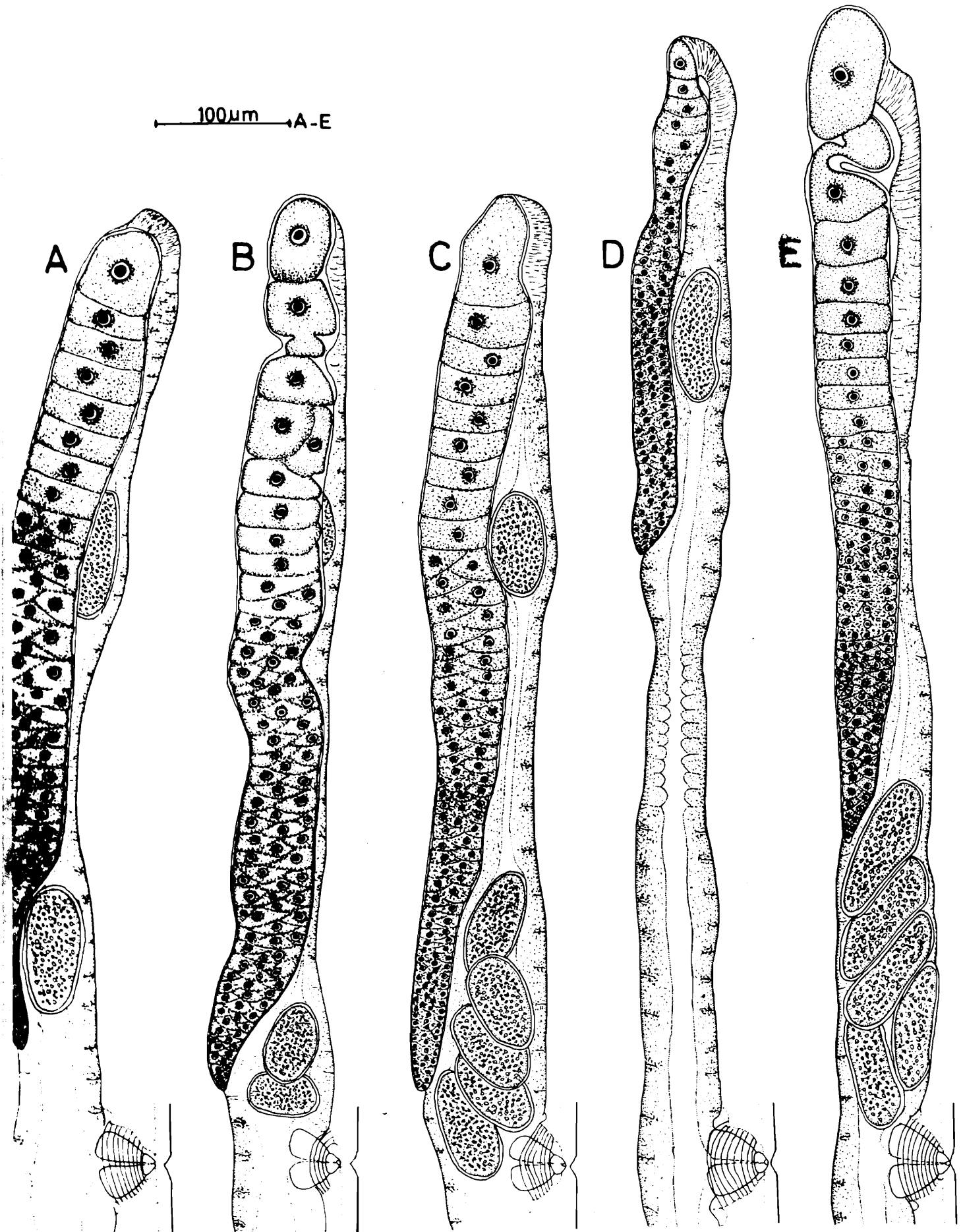


Fig. 11 : Variations in anterior gonad.

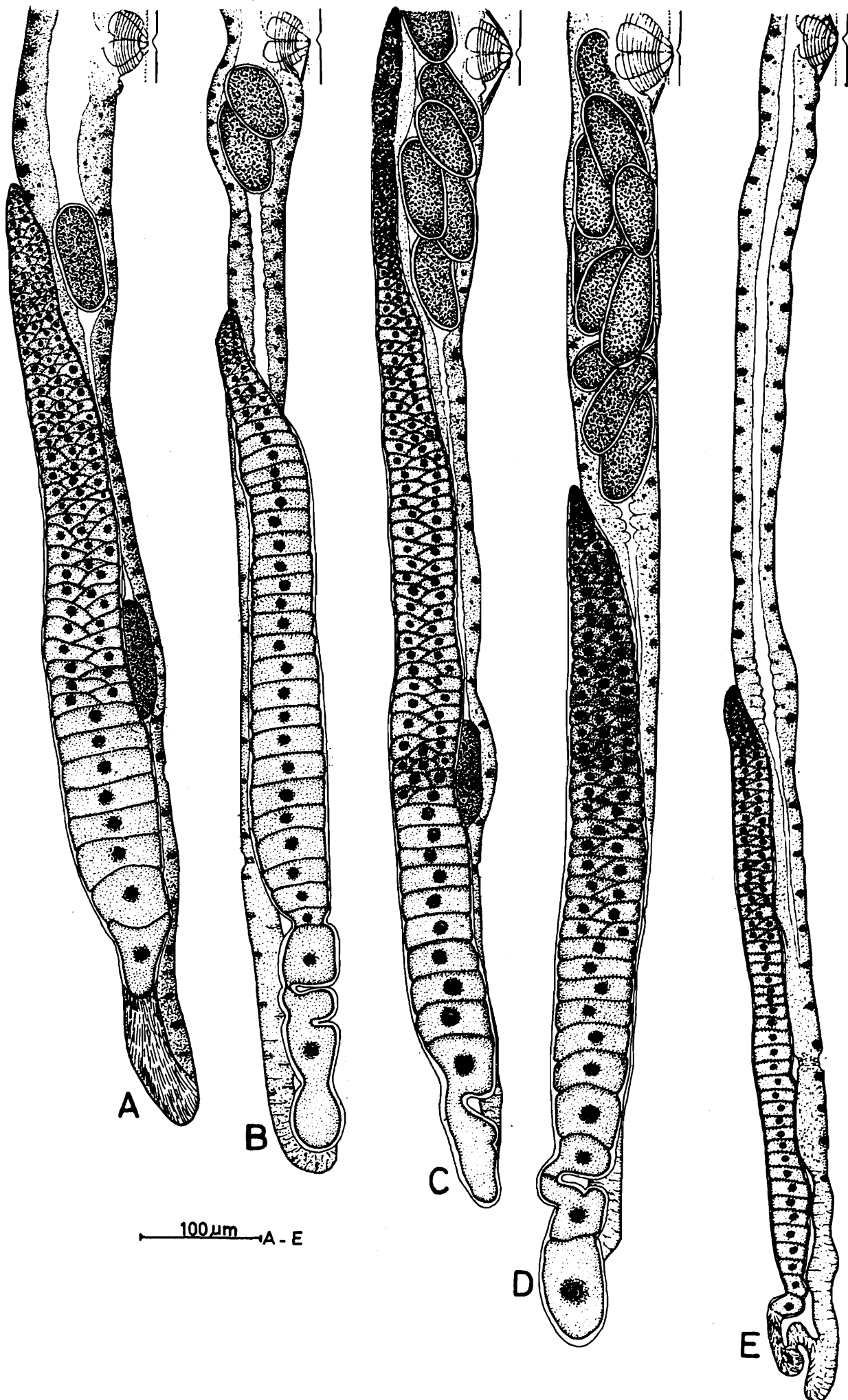


Fig. 12 : Variations in posterior gonad.

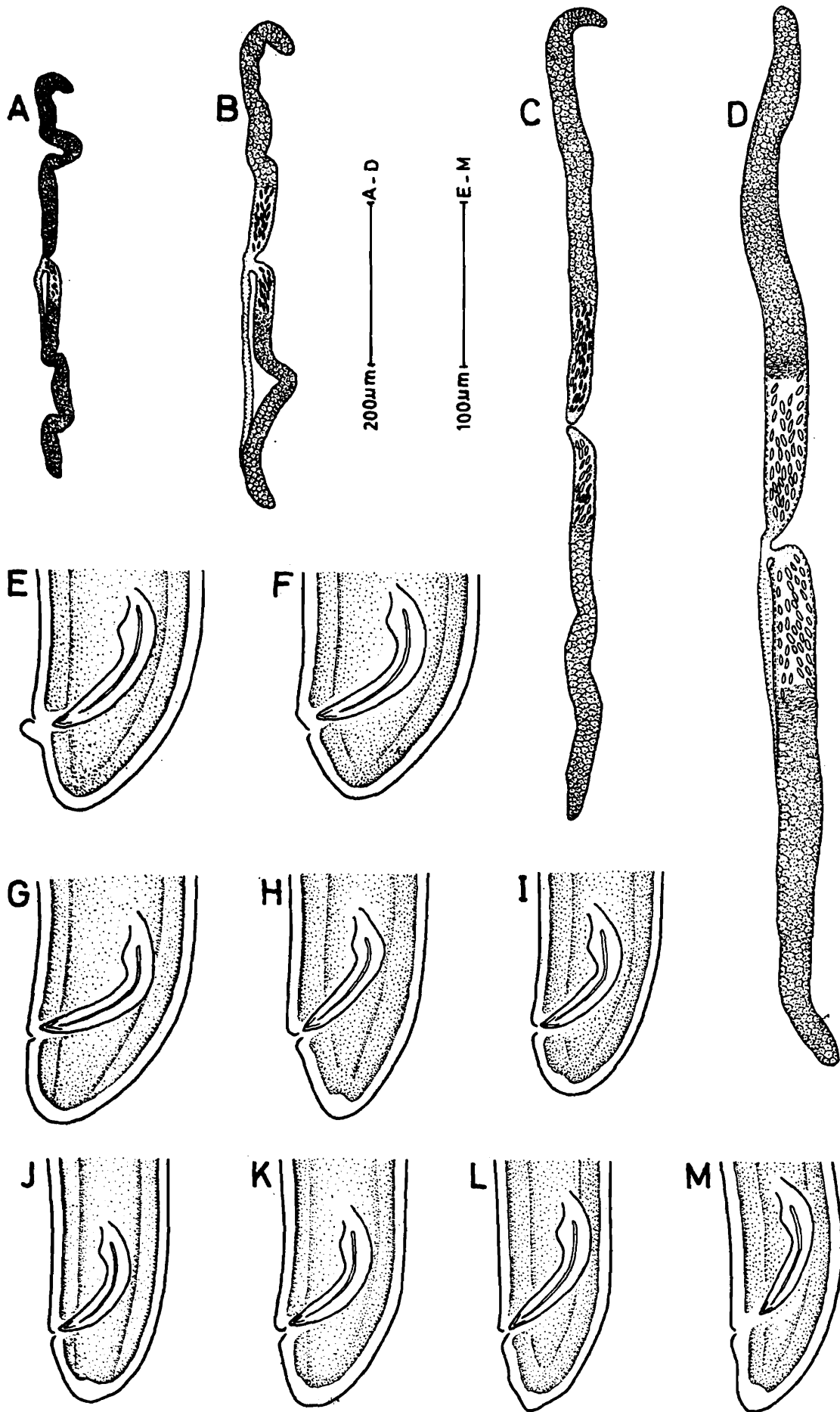


Fig. 13 : Variations in testes and male tail A - D - Testes, E - M - Male tail

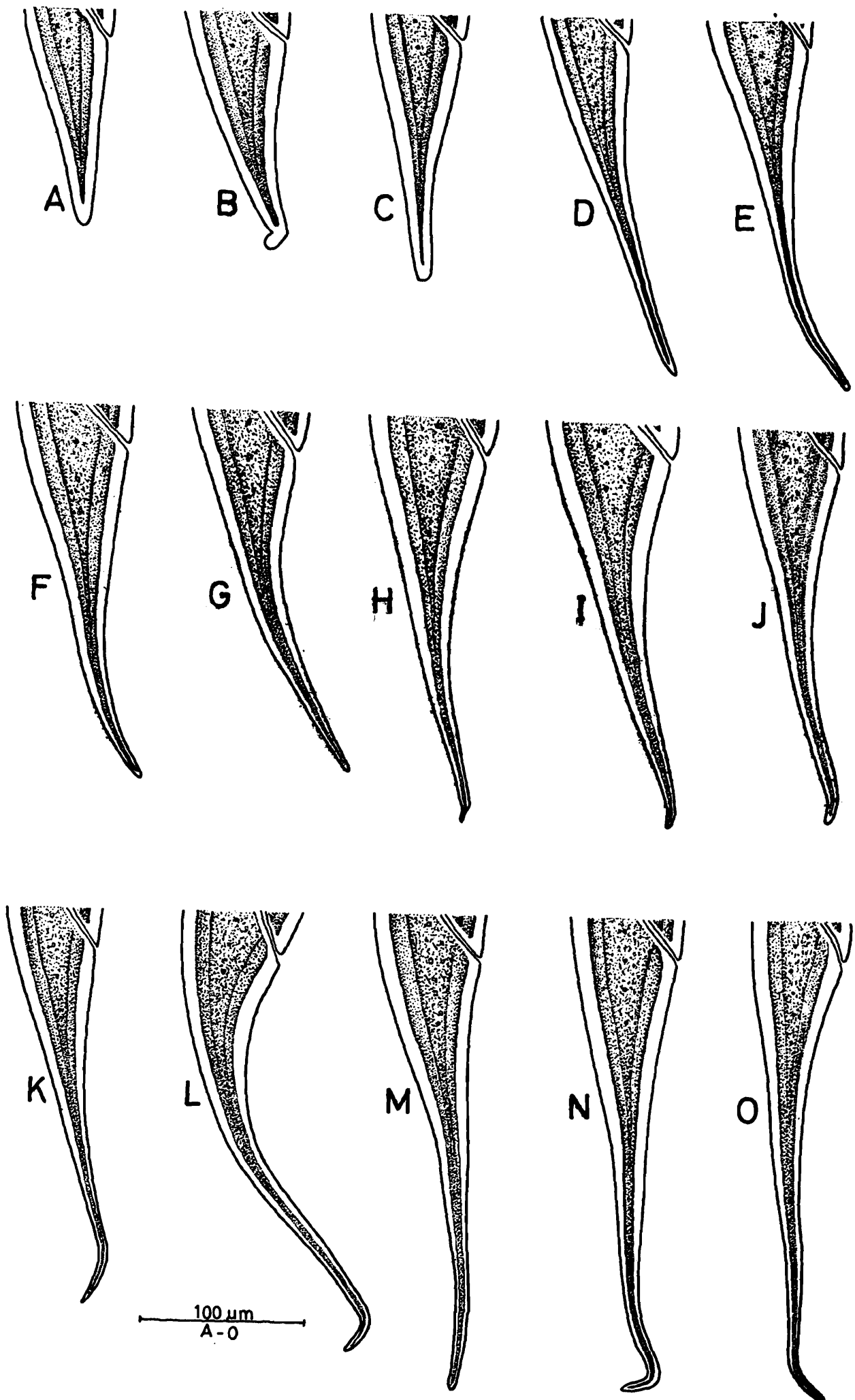


Fig. 14 : Variations in female tail.

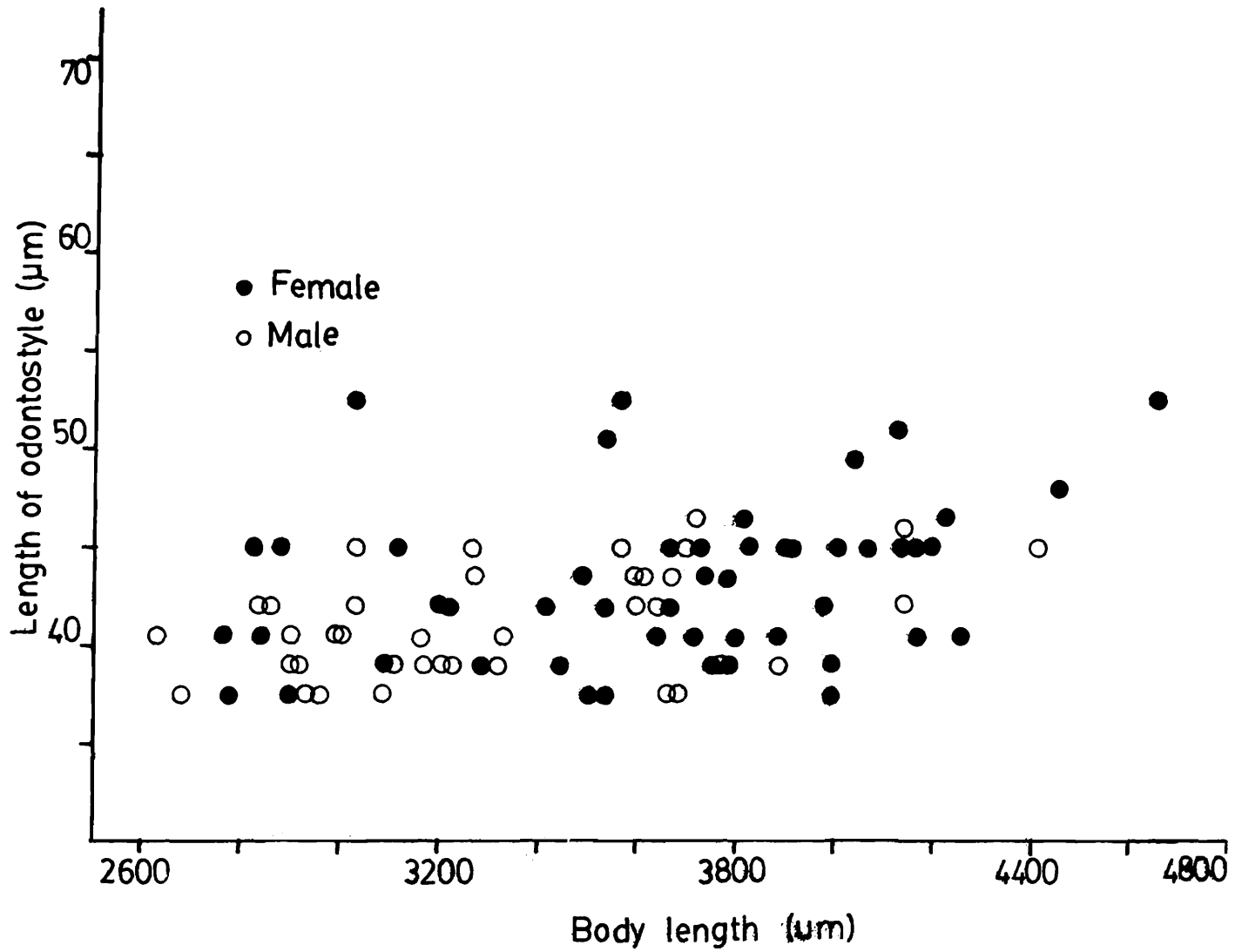


Fig. 15 : Relationship between odontostyle and body length in adults.

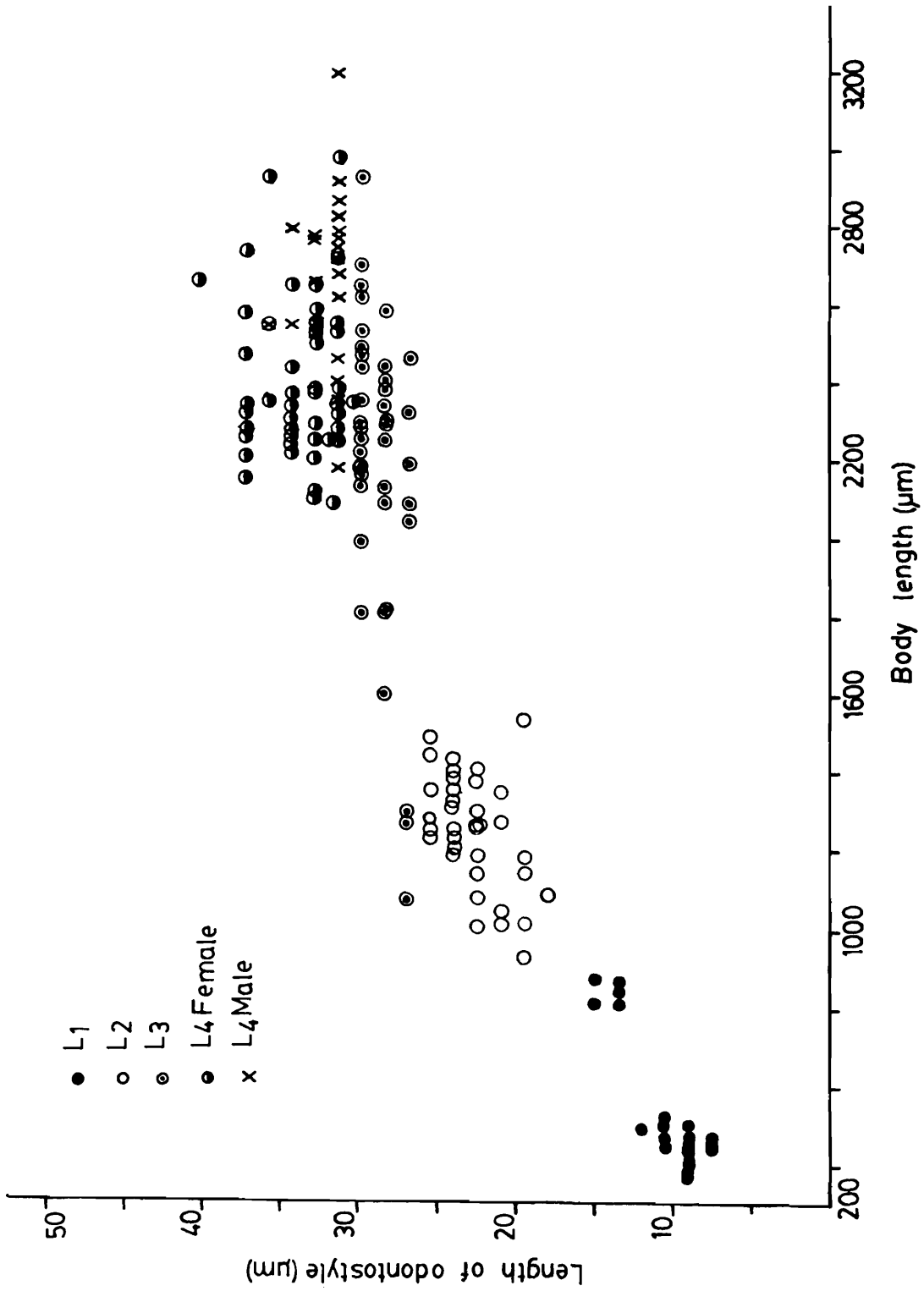


Fig. 16 : Relationship between odontostyle and body length in juveniles.

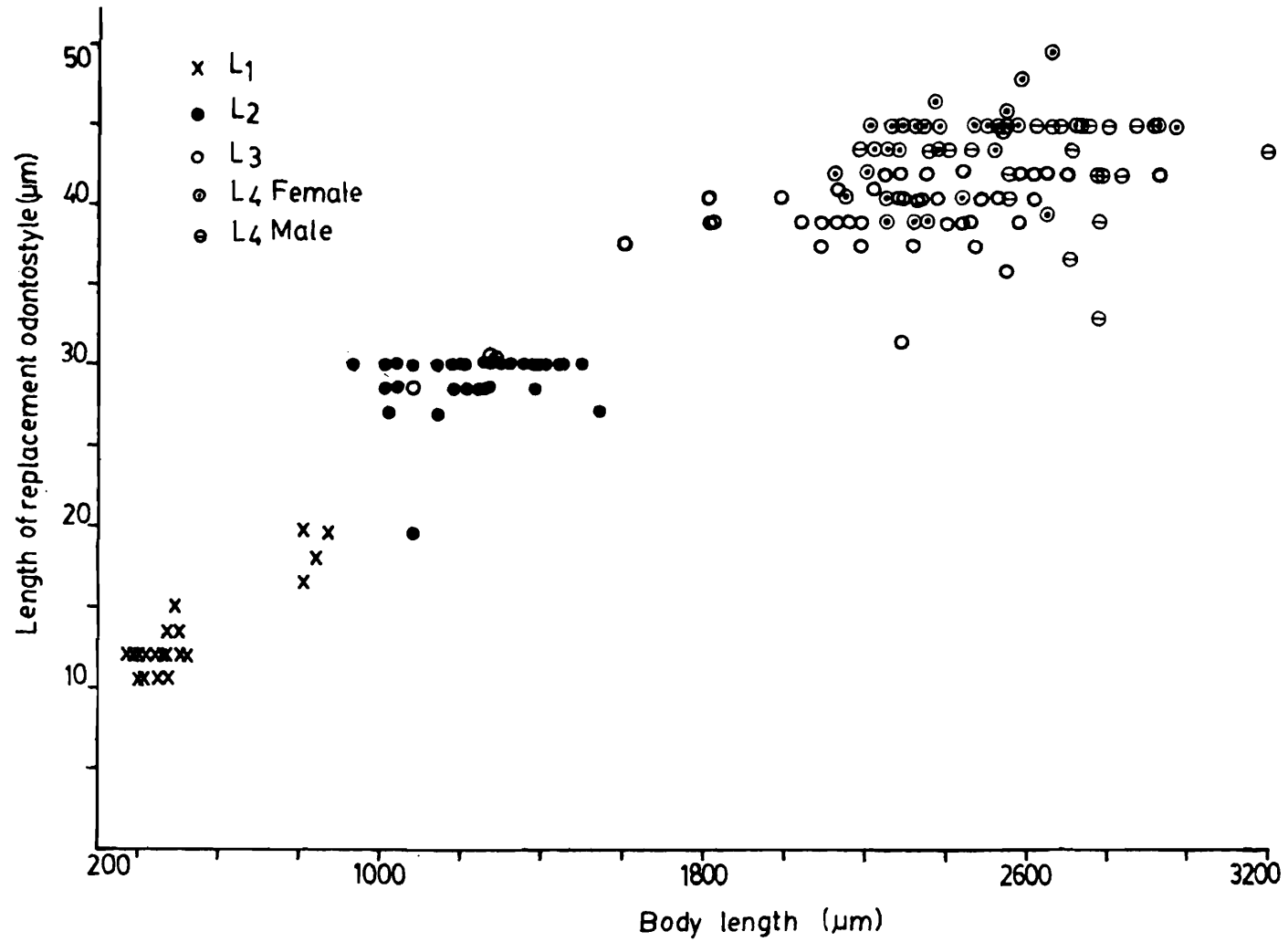


Fig. 17 : Relationship between replacement odontostyle and body length in juveniles.

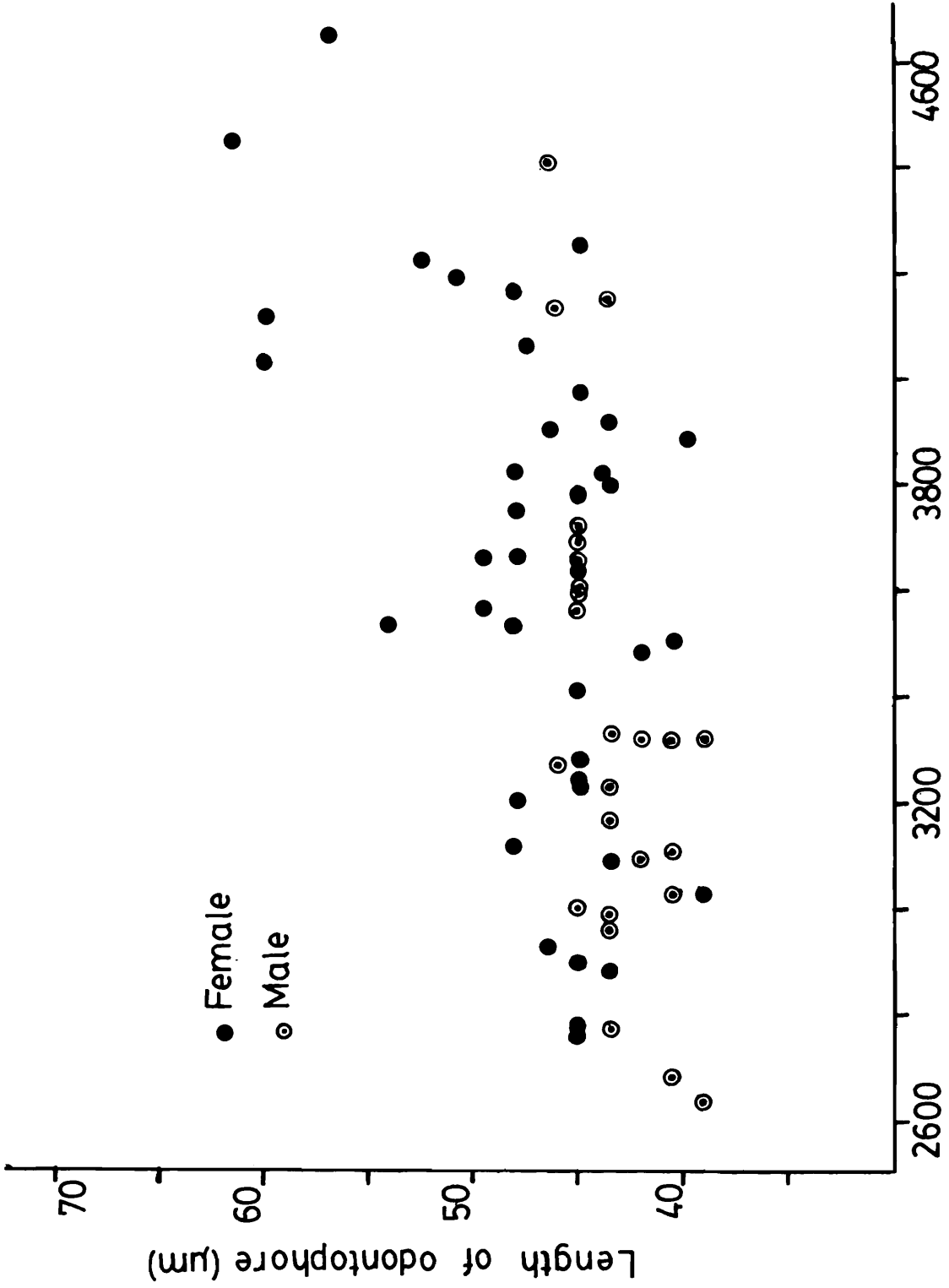


Fig. 18 : Relationship between odontophore and body length in adults.

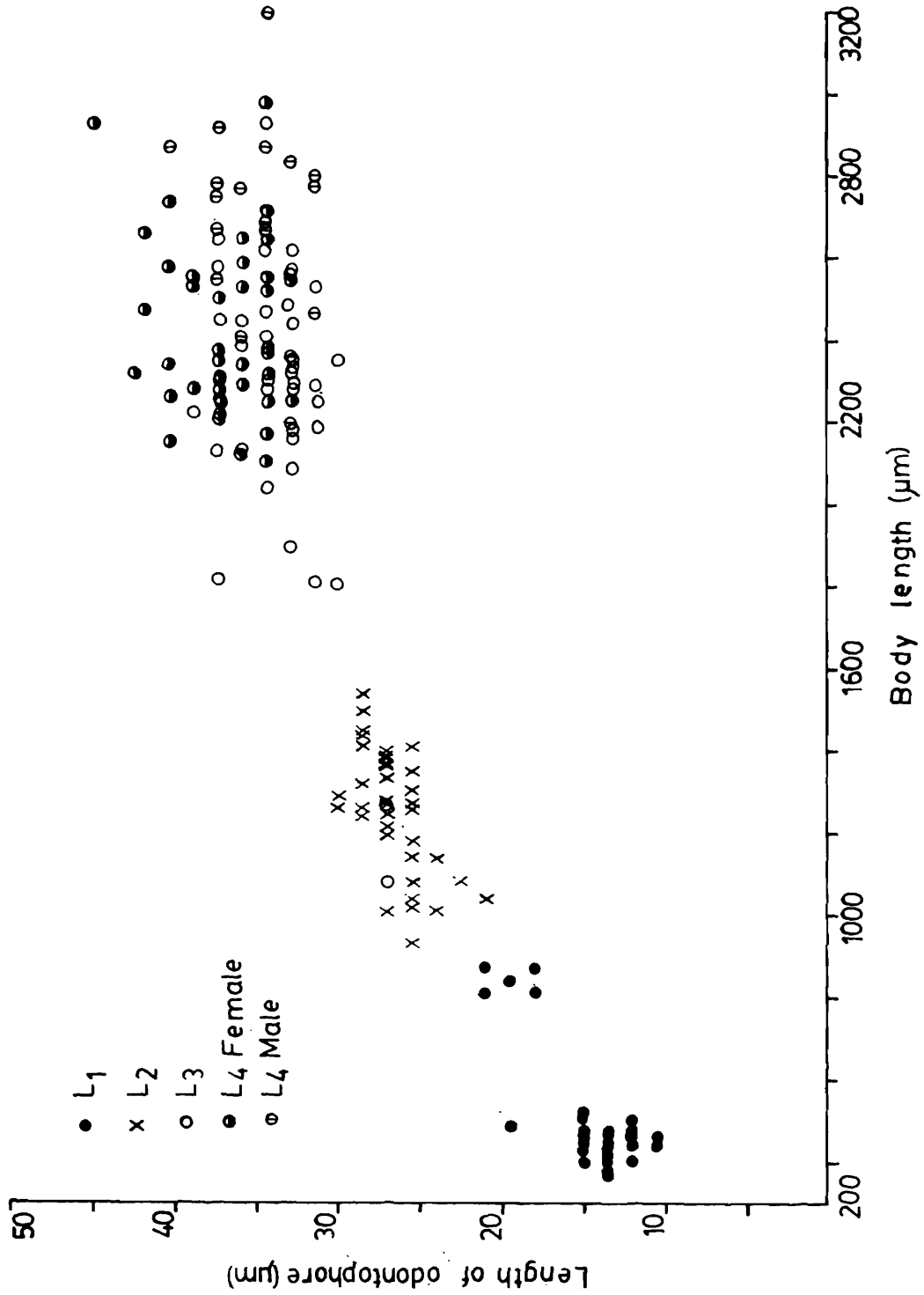


Fig. 19 : Relationship between odontophore and body length in juveniles.

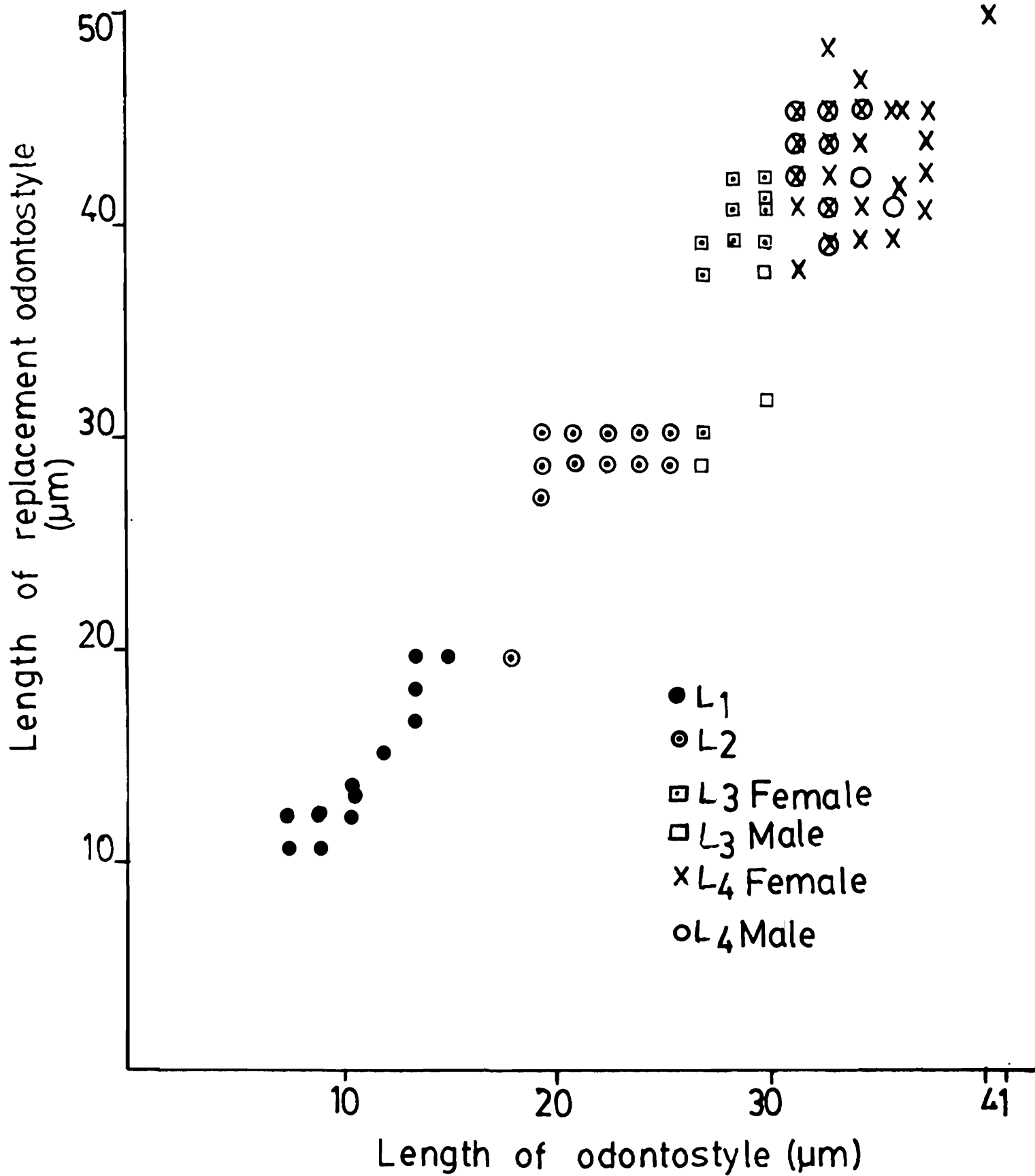


Fig. 20 : Relationship between replacement odontostyle and functional odontostyle in juveniles.

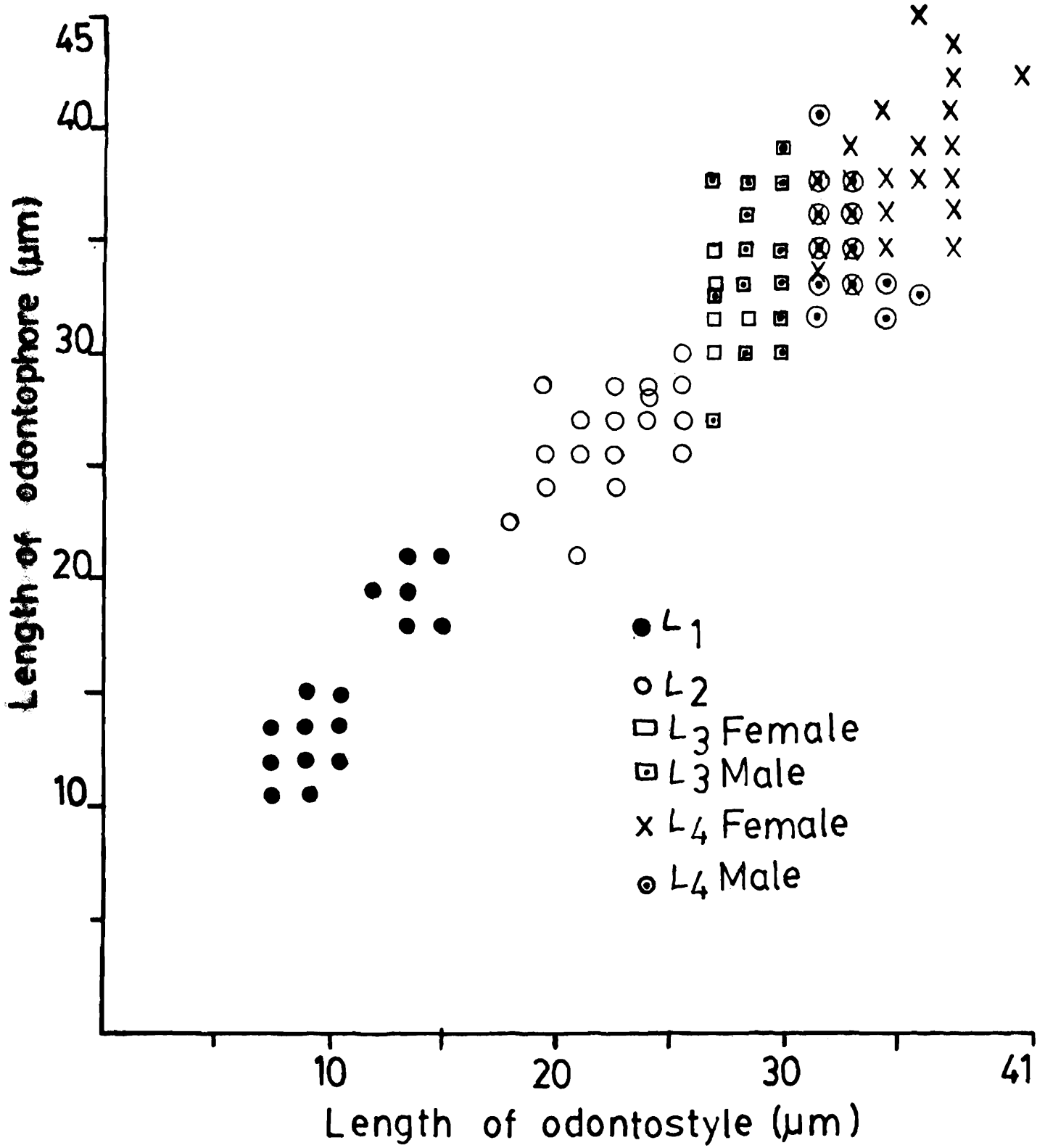


Fig. 21 : Relationship between odontostyle and odontophore in juveniles.

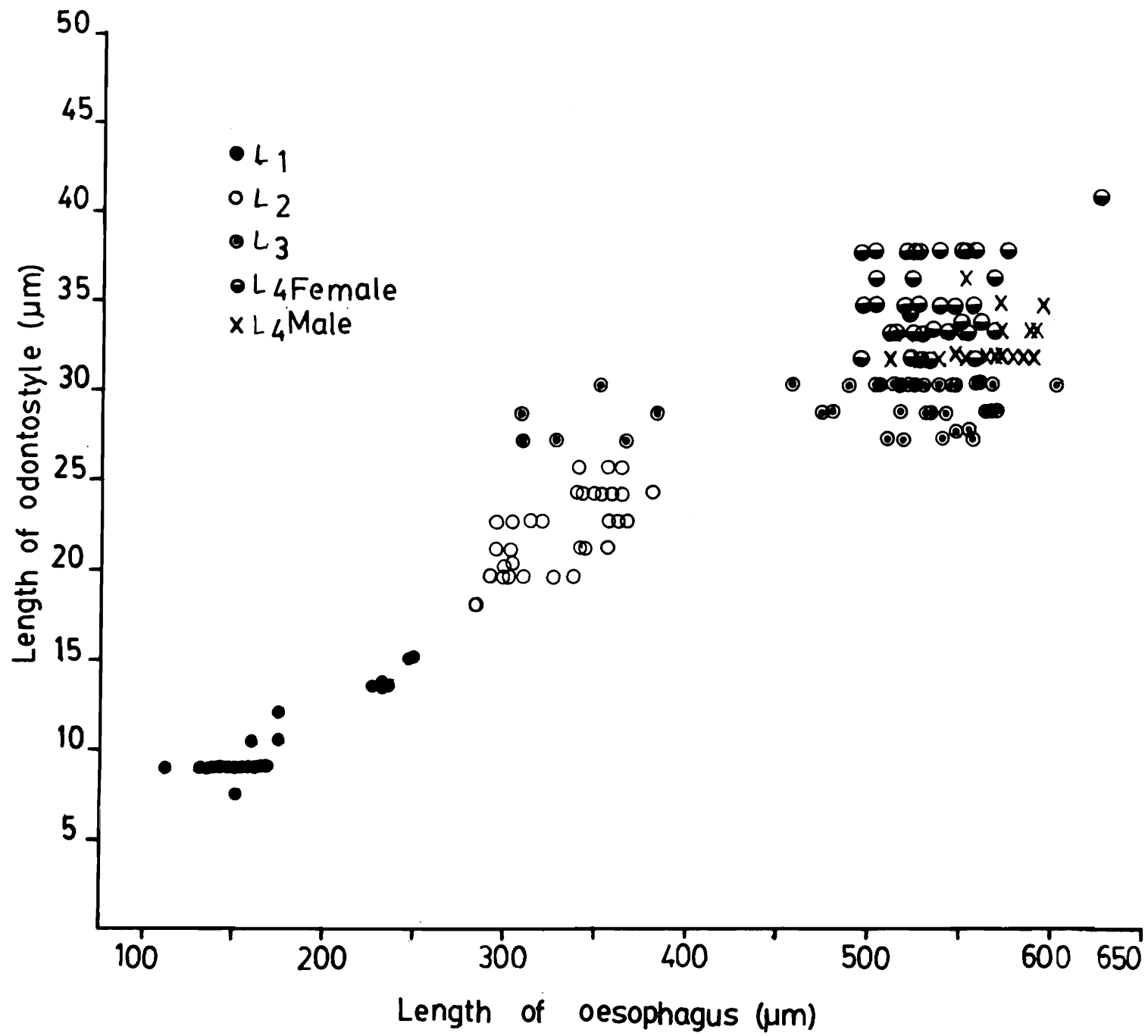


Fig. 22 : Relationship between odontostyle length and oesophageal length in juveniles.

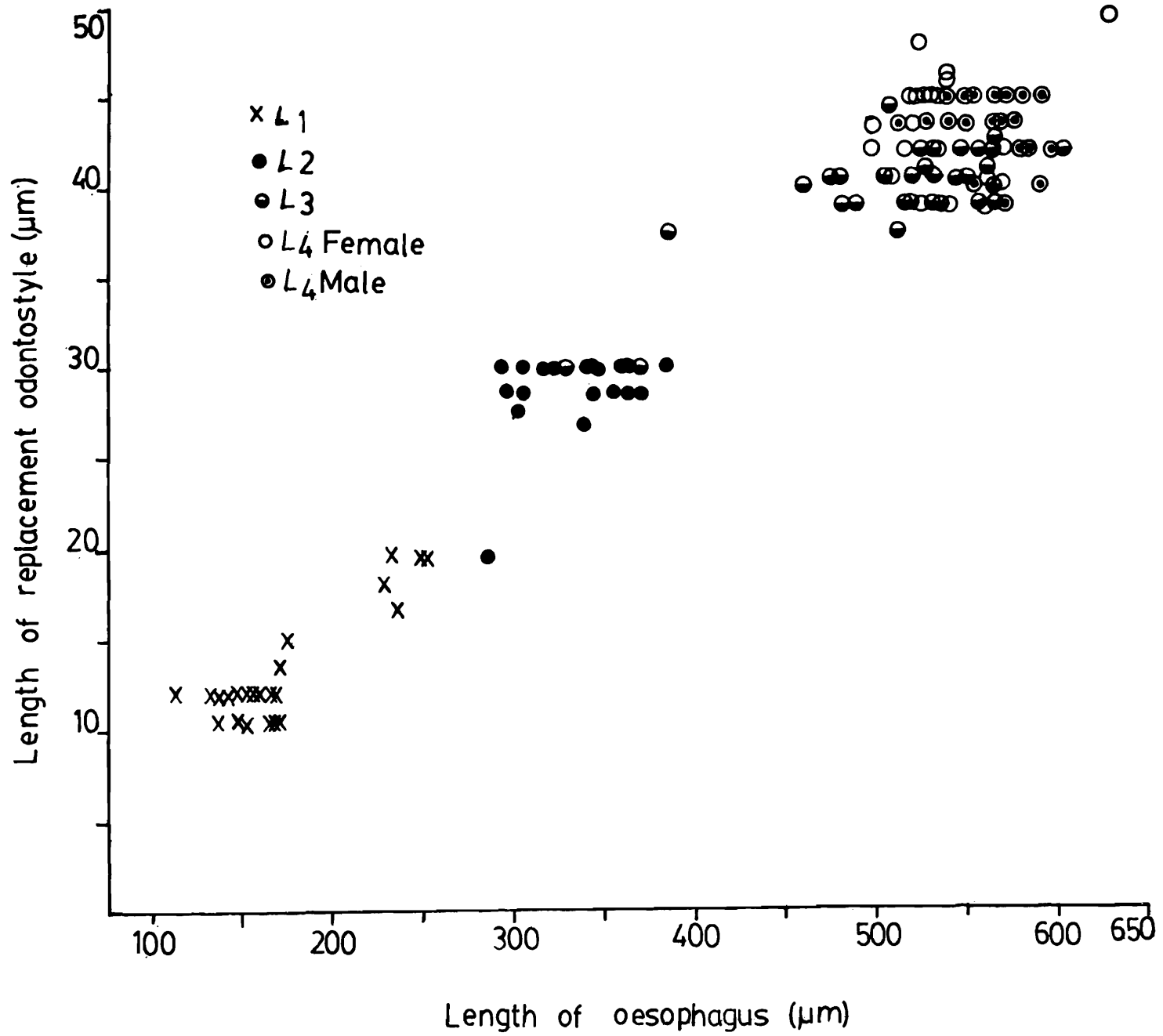


Fig. 23 : Relationship between replacement odontostyle and oesophagus in juveniles.

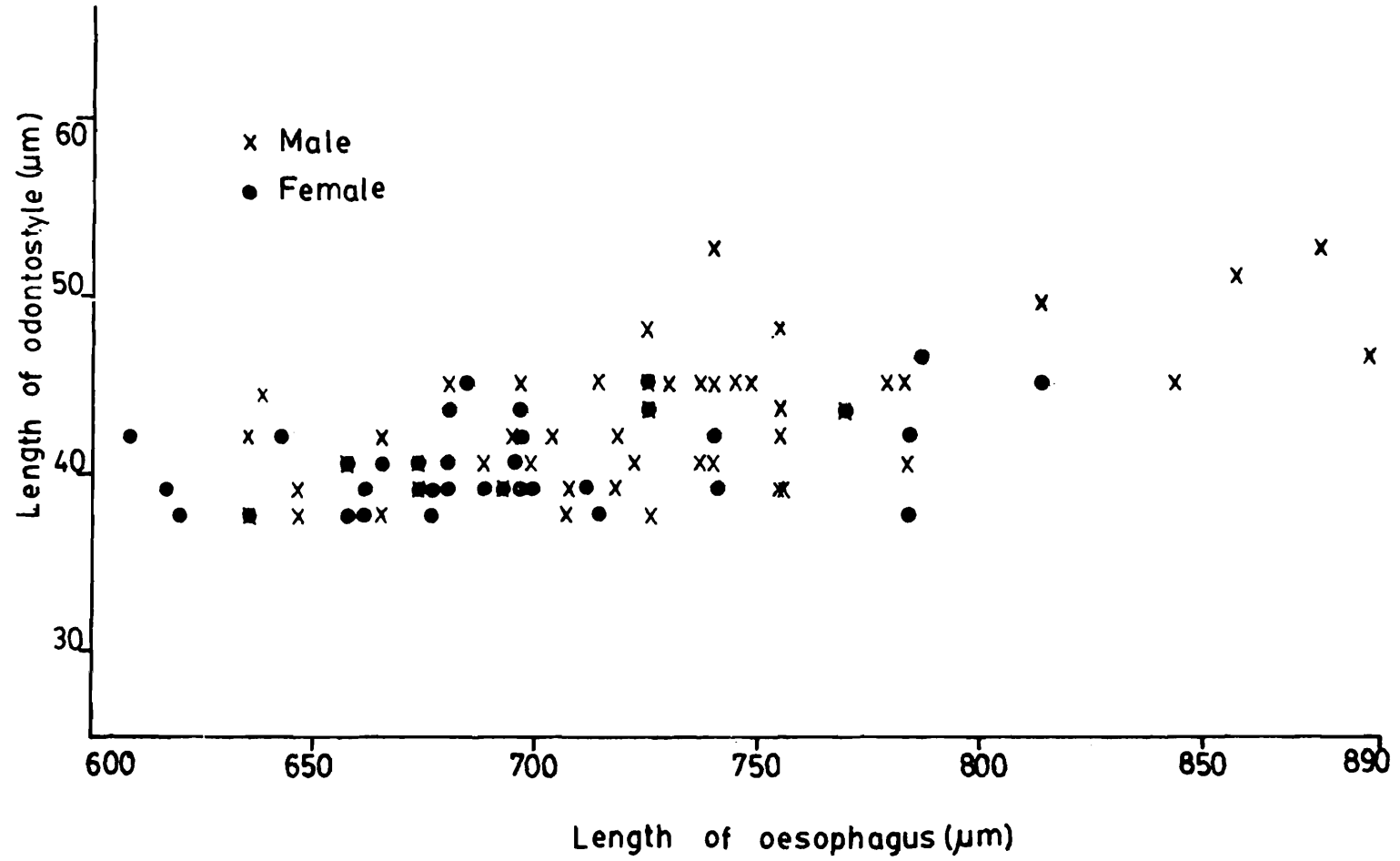


Fig. 24 : Relationship between odontostyle and oesophagus in adults.

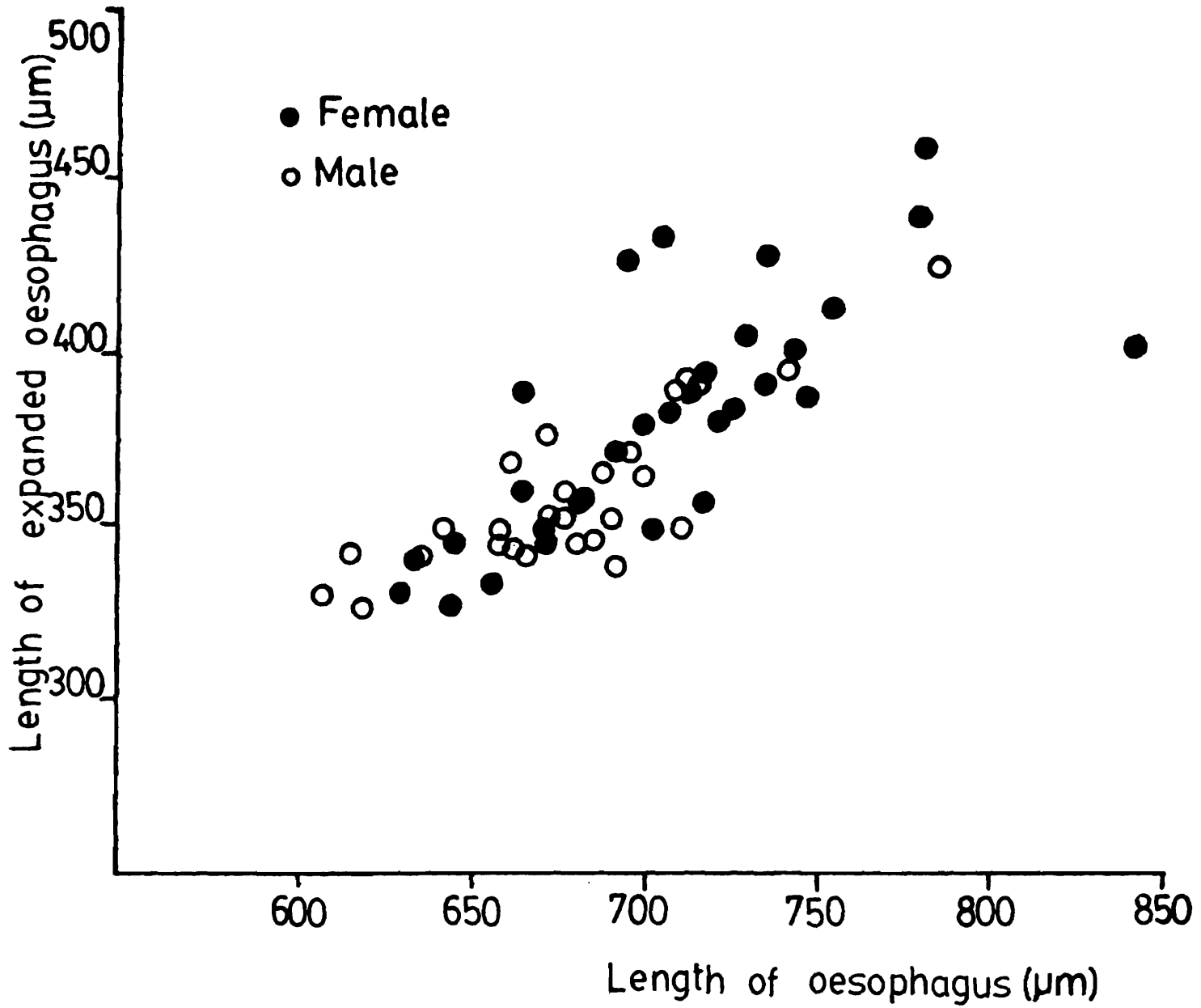


Fig. 25 : Relationship between expanded oesophagus and oesophagus in adults.

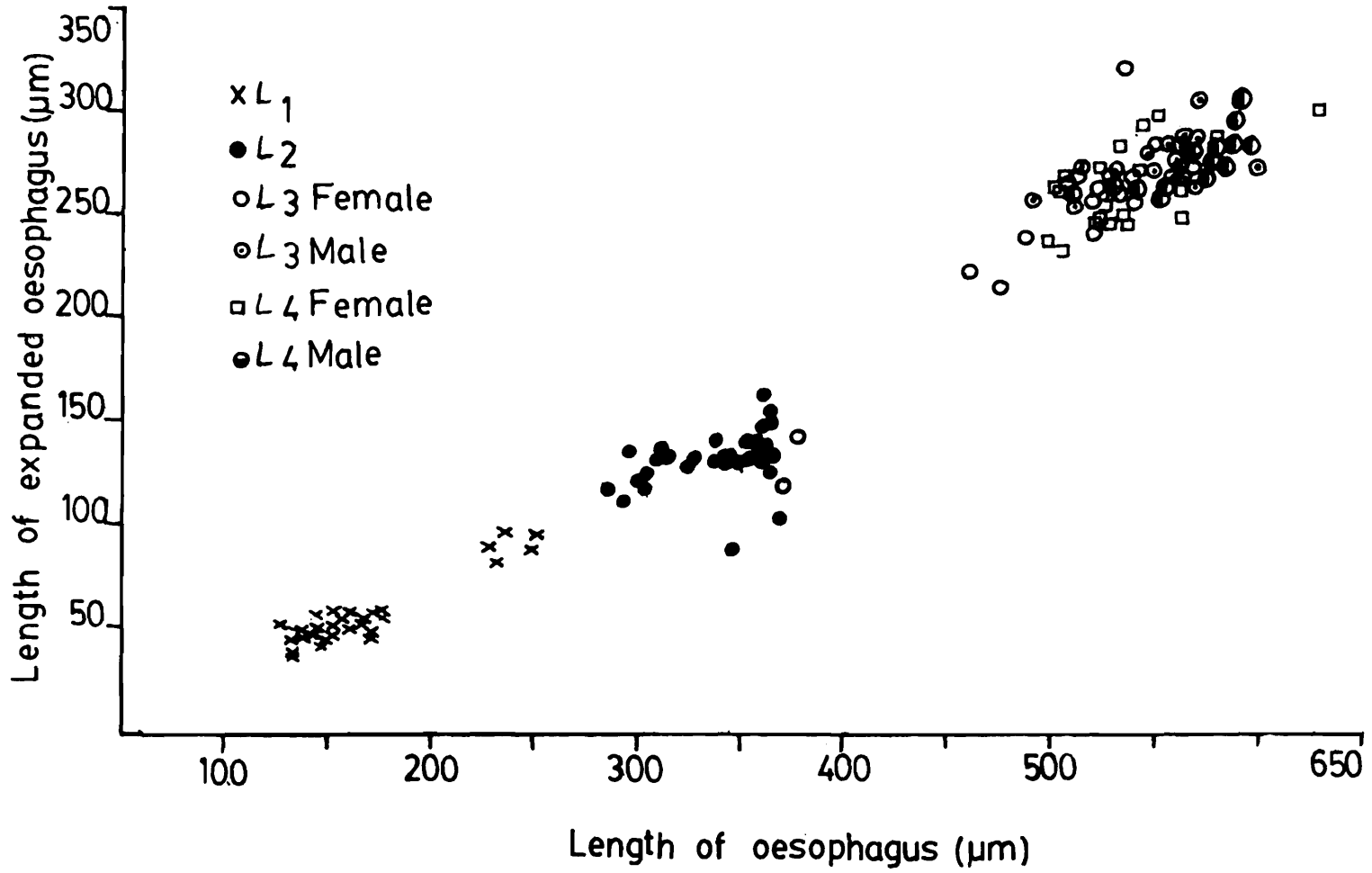


Fig. 26 : Relationship between expanded oesophagus and oesophagus in juveniles.

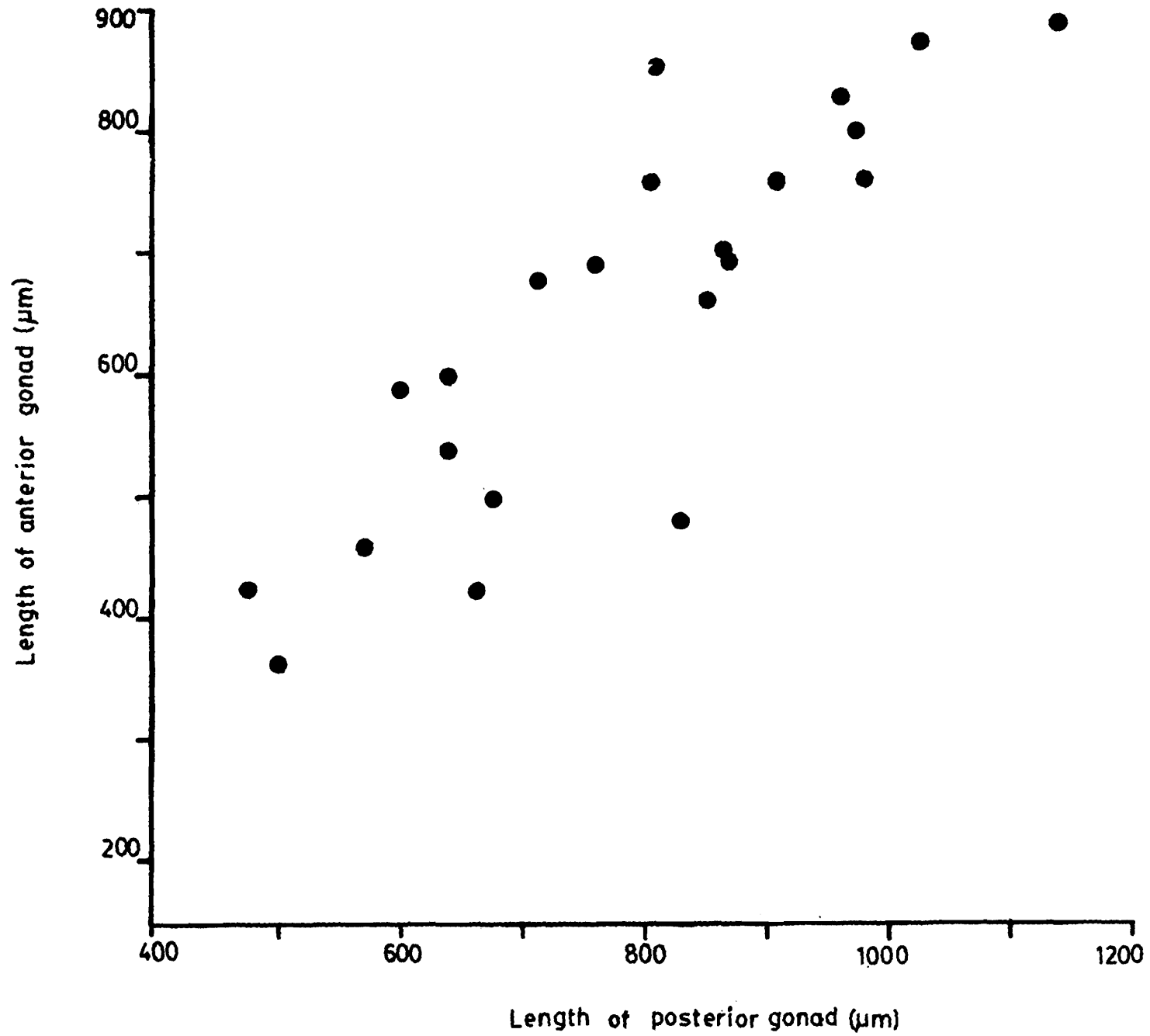


Fig. 27 : Relationship between anterior gonad and posterior gonad lengths in adults.

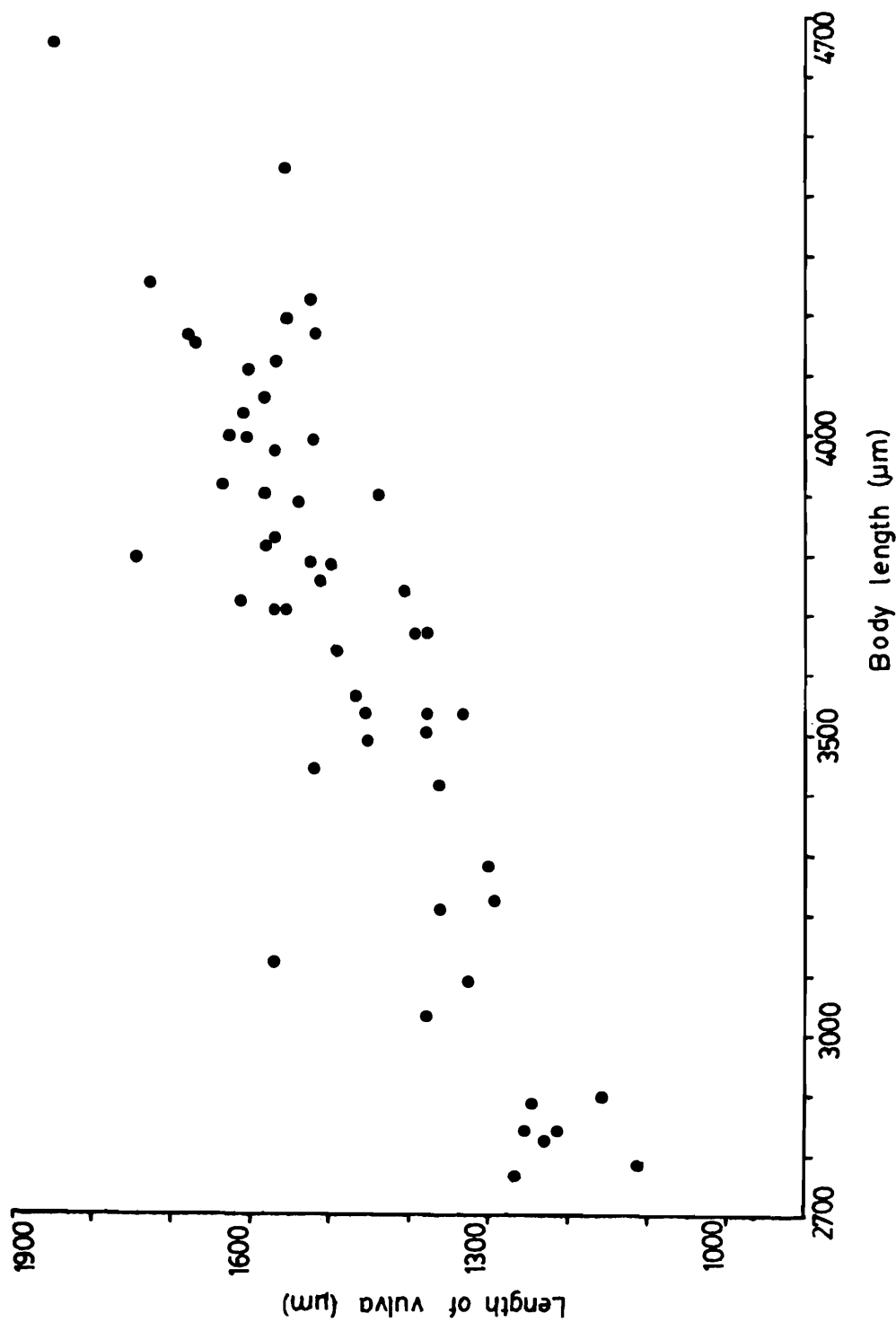


Fig. 29 : Relationship between vulva and body length in adults.

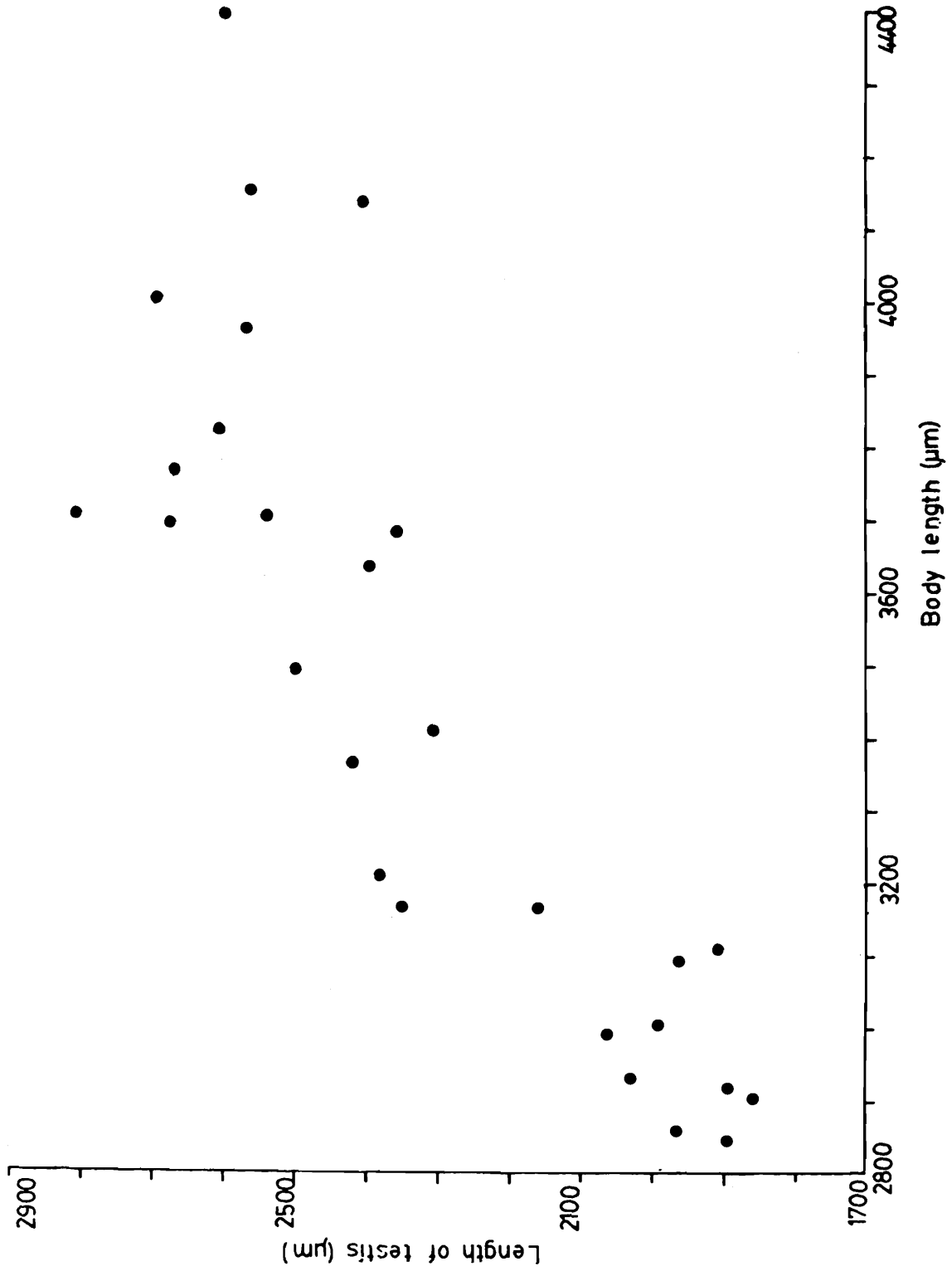


Fig. 30 : Relationship between testis and body length in adults.