

Report on Freshwater Planaria from Indonesia (Sumatra and Java)

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The freshwater planarian materials collected by "The Kyoto University Biological Expedition to Java, 1965" and by "The Kyoto University Biological Expedition to North Sumatra, 1971" have been turned over to me by Dr. R. YOSII, Dr. G. IMADATÉ and Dr. M. HIRANO for examination. The materials consist of twelve vials of preserved specimens (6 vials from Java and 6 vials from Sumatra). Upon examination of these specimens under a binocular microscope, it is found out that all vials contain one species, a species of *Dugesia*. Fortunately, a considerable number of specimens are sexually mature and it is possible to furnish a diagnostic description.

A study of the genital apparatus of this Indonesian triclad shows that the form is a near relative of a Malayan species *Dugesia batuensis* BALL, 1970. The Indonesian form, however, does not correspond to the Malayan *Dugesia* in the details of both external and internal characters, and consequently I consider it is a new species to which I give the name of *Dugesia indonesiana* after its habitat.

I am indebted to Dr. Riôzô YOSII, Professor of Zoology of Yoshida College, Kyoto University, and to Dr. Minoru HIRANO, Professor of Botany of the same College, for the interesting materials from Indonesia. I am also indebted to them for kindly providing me with the opportunity of publishing this paper in their Contributions from the Biological Laboratory, Kyoto University. I owe much to Dr. Gentaryô IMADATÉ, of the Biological Laboratory of Kônodai College, Tokyo Medical and Dental University, who was a member of the 1965 expedition, for the gift of the material from Java reported in the present paper. For reading the original manuscript I am also indebted to Dr. Robert W. MITCHELL of Texas Tech University, U.S.A., a friend of mine in the field of turbellarian studies.

List of Localities and the Species Obtained

Following is the list of planarians upon which this paper is based, with pertinent collection data by the collectors (Fig. 1). The number following each station number indicates the specimen lot number as it is registered in KAWAKATSU's fixing notebook. The altitude of each station is not always strict. Animals of the Specimen Lot Nos. 556, 557, 558, 559, 560 and 1121 were collected in Java, and those of the Specimen Lot Nos. 1115, 1116, 1117, 1118, 1119 and 1120, in Sumatra. *Dugesia* species listed

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in the list is a new species which will be described subsequently in the present paper as *Dugesia indonesiana*.

No. 1. Specimen Lot No. 556. A small artificial pool fed by spring water located at Kaliurang, the northern part of Jogjakarta (Djokjakarta), Djawa Tengah, Java. Altitude, about 900 m. August 10, 1965. Water temp., about 18°C. Four middle-sized specimens and a number of fragments of *Dugesia* preserved in 70% ethyl alcohol. Three specimens of them were observed in a fully sexually mature state (15 mm long and 2.5 mm broad). Coll. Dr. G. IMADATE.

No. 2. Specimen Lot No. 557. A brooklet at Kaliurang, the northern part of Jogjakarta, Djawa Tengah, Java. Altitude, about 1180 m. August 10, 1965. Water temp., about 20°C. Fourteen middle-sized specimens including a number of regenerated worms of *Dugesia* preserved in 70% ethyl alcohol. Two specimens were sexual but in a non-fully sexually mature state (20 mm long and 3.5 mm broad). Coll. Dr. G. IMADATE.

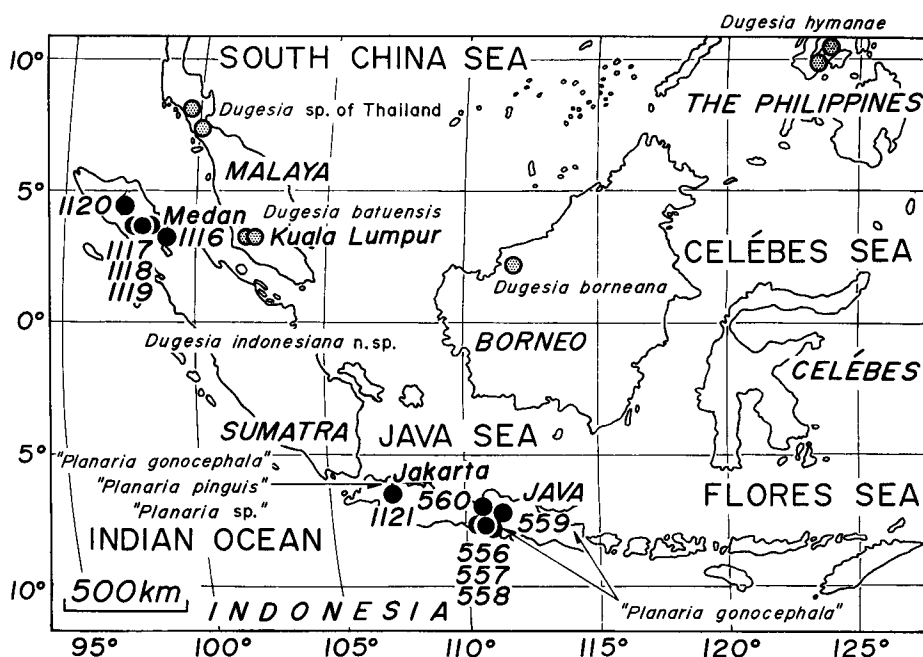


Fig. 1. Sketch map of the southeastern part of the Oriental region, showing stations where freshwater planarians were recorded. Dotted circles indicate the localities of several Asian *Dugesia* species reported in the previous papers (KAWAKATSU 1972 a, b, c, d). DE BEAUCHAMP's (1929) records of planarians from Java are also shown. Solid circles (Station Nos. 556–560, 1116–1121) indicate the localities of *Dugesia indonesiana* spec. nov. reported in the present paper.

Sts. 556, 557 and 558—Kaliurang in Java; St. 559—Tawangmangu in Java; St. 560—Kopeng in Java; St. 1121—the Tjibodas Botanical Garden in Java; St. 1116—Siborangit in Sumatra; Sts. 1117, 1118 and 1119—Kampung Gumpang in Sumatra; St. 1120—Lake Tawar at Kampung Burni in Sumatra.

No. 3. Specimen Lot No. 558. Another brooklet at Kaliurang, the northern part of Jogjakarta, Djawa Tengah, Java. Altitude, about 1180 m. August 2, 1965. One middle-sized specimen of *Dugesia* preserved in 3% formalin solution. The specimen was observed in a fully sexually mature state (20 mm long and 3 mm broad). Coll. Dr. R. YOSHII.

No. 4. Specimen Lot No. 559. A small stream at Tawangmangu, the eastern part of Surakarta, Djawa Tengah, Java. Altitude, about 950 m. August 12, 1965. Nine small sized specimens and a number of fragments of *Dugesia* preserved in 3% formalin solution. All of them were observed in a sexually immature state (8–10 mm long and 1 mm broad). Coll. Dr. R. YOSHII.

No. 5. Specimen Lot No. 560. A small stream at Kopeng, the southeastern part of Semarang, Djawa Tengah, Java. Altitude, about 1500 m. August 3, 1965. Water temp., about 19°C. Seventeen middle-sized specimens and many fragments of *Dugesia* preserved in 70% ethyl alcohol. Two specimens were observed in a fully sexually mature state (20 mm long and 3 mm broad). Coll. Dr. G. IMADATÉ.

No. 6. Specimen Lot No. 1121. A small stream flowing out from a pond in the Tjibodas Botanical Garden (Kebun Raya Tjibodas), the vicinity of Bogor (Buitenzorg), Djawa Barat, Java. Altitude, about 1400 m. September 11, 1971. Water temp., about 17°C. Thirteen middle-sized and large specimens and a number of fragments of *Dugesia* preserved in 3% formalin solution. All of them were observed in a sexually immature state (20–30 mm long and 1–2 mm broad). Coll. Dr. M. HIRANO.

No. 7. Specimen Lot No. 1115. A small pool at Siborangit, the southern part of Medan, Sumatera Utara, Sumatra. Altitude, about 400 m. August 11, 1971. Water temp., about 25°C. A number of fragments of *Dugesia* preserved in 3% formalin solution. Coll. Dr. M. HIRANO.

No. 8. Specimen Lot No. 1116. A brooklet near the Station No. 7 at Siborangit, the southern part of Medan, Sumatera Utara, Sumatra. Altitude, about 400 m. August 11, 1971. Water temp., about 25°C. Three large sized specimens and one fragment of *Dugesia* preserved in 3% formalin solution. Only one specimen was observed in a fully sexually mature state (25 mm long and 1.2 mm broad). Coll. Dr. M. HIRANO.

No. 9. Specimen Lot No. 1117. A brooklet at Kampong Gumpang, the northwestern part of Kutatjane, Sumatera Atjeh, Sumatra. Altitude, about 500 m. August 20, 1971. Water temp., about 20°C. Twenty-seven middle-sized specimens and a number of fragments of *Dugesia* preserved in 3% formalin solution. About half of them were sexual; 7 specimens were observed in a fully sexually mature state (15–20 mm long and 1.5–2 mm broad). Coll. Dr. M. HIRANO.

No. 10. Specimen Lot No. 1118. A brooklet at Kampong Gumpang, the northwestern part of Kutatjane, Sumatera Atjeh, Sumatra. Altitude, about 600 m. August 20, 1971. Water temp., about 22°C; pH 5.7. Two small sized specimens of *Dugesia*

preserved in 3% formalin solution. All of them were observed in a sexually immature state (6–8 mm long and 1 mm broad). Coll. Dr. M. HIRANO.

No. 11. Specimen Lot No. 1119. A brooklet at Kampong Gumpang, the northwestern part of Kutatjane, Sumatera Atjeh, Sumatra. Altitude, about 650 m. August 20, 1971. Water temp., about 22°C; pH 5.5. About 40 middle-sized specimens and many fragments of *Dugesia* preserved in 80% ethyl alcohol (they were strongly contracted). Fourteen specimens were sexual; 10 specimens were observed in a fully sexually mature state (10–12 mm long and 4 mm broad). Coll. Dr. M. HIRANO.

No. 12. Specimen Lot No. 1120. A small stream near Lake Tawar at Kampong Burni, Bies, the northwestern part of Takingeun, Sumatera Atjeh, Sumatra. Altitude, about 1200 m. September 3, 1971. Nine small sized specimens of *Dugesia* preserved in 80% ethyl alcohol. All of them were observed in a sexually immature state (5–10 mm long and 1.2 mm broad). Coll. Dr. M. HIRANO.

Order TRICLADIDA

Suborder PALUDICOLA or PROBURSALIA

Family PLANARIIDAE

Genus *Dugesia* GIRARD, 1850

***Dugesia indonesiana* KAWAKATSU, spec. nov.**

Figs. 2 and 3; Pls. 1–5

Of the preserved specimens examined, most were cut in serial section at 8 microns; a few head pieces were mounted whole. Sections were stained with Delafield's haematoxylin and eosin.

Description. This is a middle-sized to large, rather slender and pigmented epigeic species. The species shows some local variation in its morphology. The appearance of both sexually mature and immature specimens in the preserved condition from several localities in Sumatra and Java is shown in Figure 2 (A–G) and Plate 1 (Figs. A–E). The Kampong Gumpang specimens (No. 1117 group from Sumatra) are about 20 mm or more in body length and about 2 mm in width. The head is triangular in form having a rather pointed anterior end and with blunt auricles. Behind the head, the body margins narrow slightly. Then, the elongated body remains about the same width to the posterior level of the copulatory apparatus and terminates in the rather pointed posterior end. Although the shape of the head may vary somewhat when the animals are killed, most of the preserved specimens of the present new species in formalin show a head of an equilateral triangle form. Judging from Dr. IMADATE's brief sketch of the head of the Kaliurang specimen (No. 556 group from Java) in life, the present new species may easily be distinguished from the most

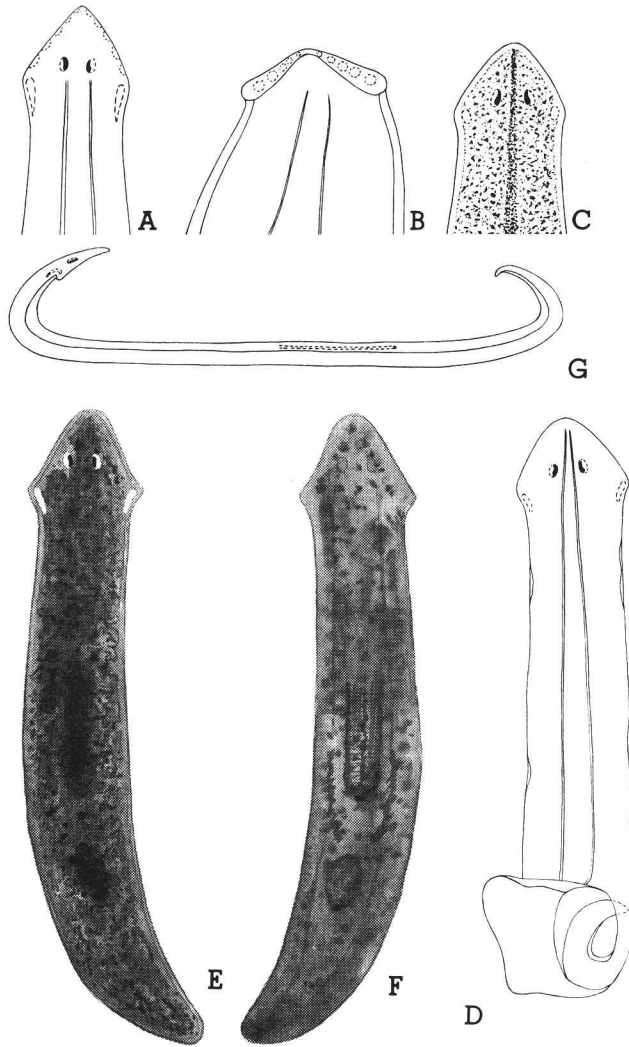


Fig. 2. *Dugesia indonesiana* spec. nov. A: head of a preserved specimen from Siborangit in Sumatra (Specimen Lot No. 1116 group). B: ventral view of the head of a preserved specimen from Kampung Gumpang in Sumatra (Specimen Lot No. 1119 group). C: head of a preserved specimen from Lake Tawar at Kampung Burni in Sumatra (Specimen Lot No. 1120 group). D: preserved sexually mature specimen from Kaliurang in Java (Specimen Lot No. 558 group). E: preserved sexually mature specimen from Kopeng in Java (Specimen Lot No. 560 group). F: ventral view of the same specimen as E. G: preserved sexually immature specimen from the Tjibodas Botanical Garden in Java (Specimen Lot No. 1121 group). Actual length, about 30 mm.

common Japanese species *Dugesia japonica* ICHIKAWA et KAWAKATSU, 1964, which has a rather broad triangular head form.²⁾

According to the observations made by collectors (in litt.), the general color of the living animals is a dark brown, with varying grayish tints. In the preserved specimens the margins of the body and the areas above the pharynx and the copulatory organ are of a brownish gray color. There are numerous, small, very dark brown, or black spots on the dorsal side (Fig. 2 E). In many large specimens examined, an indistinct but rather wide dark longitudinal band is seen on the midline of the body (Fig. 2 C). In some specimens from the localities of Siborangit (No. 1116 group from Sumatra) and Kaliurang (No. 558 group from Java), two dark longitudinal bands are seen on the dorsal surface as shown in Figure 2 (A and G). The ventral surface is a light brownish gray with numerous spots of dark coloration. Usually, the ventral nerve cords show indistinct light lines (Fig. 2 F).

The two eyes are situated on the dorsal side of the head at a slightly anterior level of the auricles; the distance between them amounts to about one third the width of the head at the level of eyes. A white colorless area is conspicuous around each eye. A pair of the non-pigmented auricular sense organ which is an elongated willow-leaf shape is visible on both sides of the head. The sensory spots, white and small stipples at the anterior margin of the head, are seen only in some large, dark colored specimens from the localities of Siborangit (No. 1116 group) and Kampong Gumpang (No. 1119 group) from Sumatra (Fig. 2 A and B).

The pharynx is inserted, in large specimens, somewhat behind the middle of the body and measures in length about one-seventh to one-sixth of the body length. The genital pore is situated in the midline at a somewhat frontal level of the middle of the postpharyngeal region. The histological structure of the pharynx is typical of the family Planariidae: the inner musculature of the pharynx consists of two distinct layers, a thick circular layer adjacent to the epithelium of the pharynx lumen and a thinner layer of longitudinal fibres. The outer musculature of the pharynx consists of two layers, the outer longitudinal and the inner circular muscle fibres.

In the large specimens the anterior intestinal trunk has 15 to 20 or more branches on each side; each posterior trunk has 20 to 25 or more short lateral branches. In the largest non-sexual specimen from the Siborangit locality (No. 1116 group from Sumatra) which attains about 25 mm in body length in the preserved condition, the postpharyngeal region may attain about a half of the body length. In the slides of this specimen, it was observed that the anterior intestinal trunk has about 55 branches; each posterior trunk has about 60 or more short lateral branches.

In the histological sections the dorsal epithelium is much thicker than the ventral and heavily provided with rhabdites. The marginal adhesive zone is better developed in the present new species than that of *Dugesia batuensis*, both from the type locality

2) Some good photographs of the head form in living specimens of *Dugesia japonica* are shown in my recent publication (KAWAKATSU & MIYAZAKI, 1972, pp. 92-93, Pls. VII and VIII).

(hypogean form) and from the Kuala Lumpur locality (epigean form), and that of *Dugesia hymanae* from the Philippine Islands (cf. KAWAKATSU 1972 b, c, d).

A pair of rather large ovaries occurs in the ventral side of the normal anterior position. In some specimens from the Kaliurang locality (No. 556 group from Java), the very large ovaries are situated between the fifth and the sixth intestinal diverticula and occupy nearly all of the dorso-ventral space of the body. The two ovovitelline ducts converge in the region of the copulatory apparatus and open separately into the posterior part of the bursal canal (Fig. 3 C, E and others). Numerous yolk glands (or vitellaria) are distributed along each side of the body from the level of the ovaries almost to the nearly posterior end.

The testes are numerous, of small to middle-sized, and occupy the dorsal part of mesenchyme just beneath the epithelium. They are arranged on either side of the midline in two to three longitudinal zones extending from the posterior level of the ovaries to the nearly posterior end of the body. The large testes may attain in length about the half to one-third the length of the dorso-ventral diameter of the body, but most of them are rather small in size (Pl. 1, Fig. F). The spermiducal vesicles on either side of the posterior part of the pharynx and the copulatory bursa are highly conspicuous in the present new species. On the anterior side of the penis bulb, each spermiducal vesicle narrows to a usual slender duct (sperm duct) that ascends vertically through the penis bulb, and opens into the bulbar cavity separately at its posterior part (Fig. 3 C, E and others).

The sagittal view of the copulatory apparatus of six specimens from five localities in Sumatra and Java is shown in Figure 3 (A, B, C, D, E and F). Photomicrographs of the parts of the genital organs including the copulatory apparatus of specimens from several localities are also shown in Plates 2 (Figs. A and B), 3 (Figs. A-D), 4 (Figs. A and B) and 5 (Figs. A-H). The following description of the genital anatomy is chiefly based upon the slides of the Specimen Lot. No. 1119 group from the Kampong Gumpang locality in Sumatra (Fig. 3 C and D; Pl. 2, Figs. A and B). The copulatory organ in Figure 3 (C) may show the penis preserved in a rather contracted condition (see also the photomicrograph in Pl. 2, Fig. A); in the sketch of Figure 3 (D) (see also photomicrograph in Pl. 2, Fig. B), the organ is preserved in a strongly elongated condition.

The penis has a very large, semispherical or semiovoidal bulb embedded in the parenchyma and a very large, conical papilla of an asymmetrical form projecting into the male genital antrum. Both the bulb and the papilla are highly muscular in nature. The bulb contains a very wide, flask-shaped cavity in a more or less irregular outline, which is the bulbar cavity or the seminal vesicle. It continues to the papilla as a narrow ejaculatory duct and opens at the ventral side of the penis papilla near its tip. A small diaphragm separates the bulbar cavity from the ejaculatory duct. The bulbar cavity is mostly lined by a thick, highly granular epithelium of insunk nuclei. The glandular epithelial cells are less-developed at the ejaculatory duct. The penis bulb is pierced by numerous gland ducts (penis gland) which open

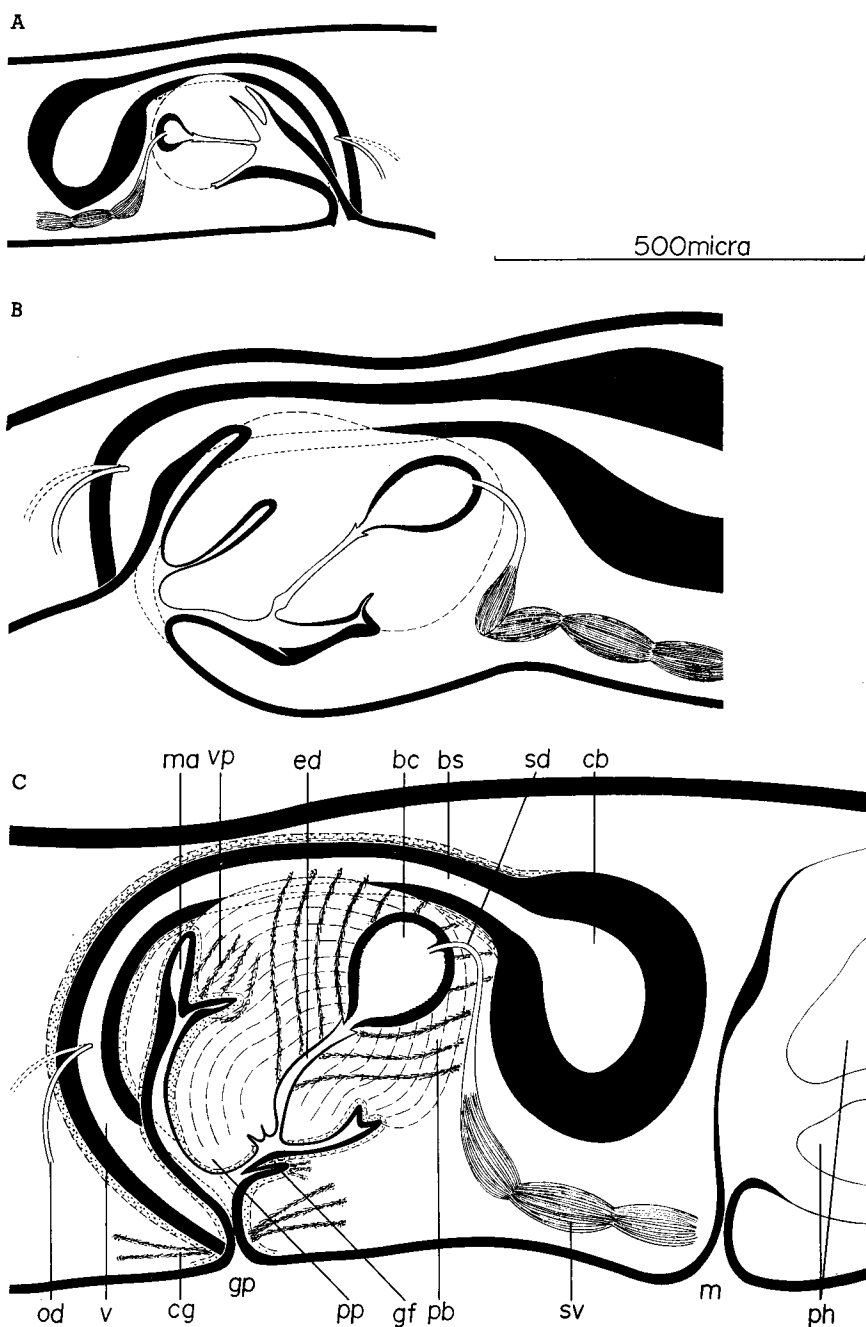
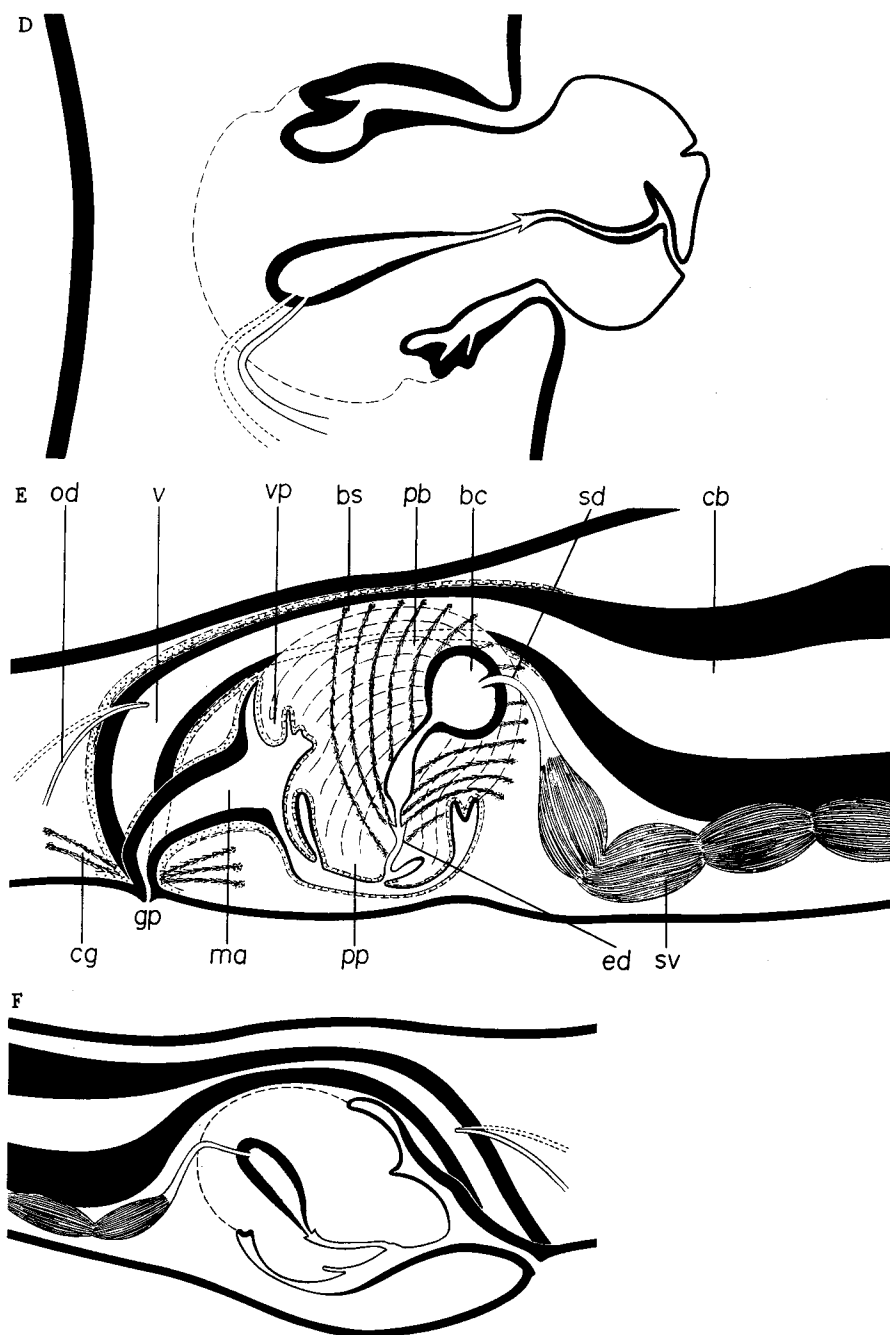


Fig. 3. Diagrams showing the sagittal view of the copulatory apparatus of *Dugesia indonesiana* spec. nov. from Sumatra and Java. The same magnifications. A: No. 1116 a (Siborangit in Sumatra). B: No 1117 g (Kampong Gumpang in Sumatra). C: No. 1119 d (Kampong Gumpang in Sumatra; holotype). D: No. 1119 a (Kampong Gumpang in Sumatra). E: No. 556 a (Kaliurang in Java). F: No. 558 a (Kaliurang in Java).



bc, bulbar cavity; bs, bursa stalk; cb, copulatory bursa; cg, cement gland; ed, ejaculatory duct; gf, glandular fold on the floor of the male genital antrum; gp, genital pore; ma, male antrum; od, ovoiduct; pb, penis bulb; pp, penis papilla; sd, sperm duct; sv, spermiducal vesicle; v, vagina; vp, valve at the basal part of the penis papilla (dorsal lip).

into the bulbar cavity as well as the entire course of the ejaculatory duct. The secretion of these ducts consists of heavily eosinophilous granules.

It is observed in every slide examined that the penis papilla of the present new species from the Kampong Gumpang locality has a strongly asymmetrical shape (Fig. 3 C and others). The dorsal lip of the papilla is larger than the ventral one. The valve or diaphragm which forms a ring surrounding the base of the papilla, the character found in several Southeast Asian *Dugesia* species (*batuensis*, *hymanae* and several populations of *japonica* from Southwest Japan and China), is distinct in the present new species. As illustrated in Figure 3 (C), this character is conspicuous when the penis is preserved in a contracted state. Usually, the ventral lip of the valve is very small and inconspicuous. The outer wall of the papilla is covered with a tall, cubical epithelium of an insunk nuclei type. Below the epithelium there are two layers of muscle fibers, one thick circular and the other thin longitudinal.

The epithelium that covers the basal part of the dorsal lip of the penis papilla is much thicker than the other part. It is highly glandular in nature and contains heavily eosinophilous granules. The cell bodies of many eosinophilic gland ducts are distributed at the region of the dorsal valve of the papilla (Fig. 3 C; Pls. 2, Fig. A, 3, Fig. A) (see also Pl. 5, Fig. G).

Figure 3 (D) shows the penis of a specimen from the same Kampong Gumpang locality when the organ is preserved in an elongated state (see also Pl. 2, Fig. B). In this figure the penis bulb is hemispherical in shape and retains an elongated bulbar cavity into which two sperm ducts open separately from the postero-ventral side of it. The penis papilla, which strongly protrudes from the genital pore, is a cylindrical form. The dorsal valve surrounding the basal part of the papilla becomes a small projection into the male genital antrum (Pls. 2, Fig. B, 3, Fig. C). This is apparently due to the strong muscular extension of the penis papilla. Judging from the two figures of the penis of the present new species of the Kampong Gumpang specimens (Fig. 3 C and D), the valve surrounding the basal part of the papilla may have a collapsible function in muscular elongation of the penis.

The male genital antrum is a funnel-shaped cavity which widens anteriorly and narrows posteriorly. It opens to the genital pore postero-ventrally and into the female genital antrum, or the terminal part of the bursal canal, near the genital pore. No common genital antrum is differentiated in the present new species (Fig. 3 C and others). The wall of the male genital antrum is closed with a tall, glandular epithelium and is provided with two muscle layers, one circular and the other longitudinal. Almost all parts of the epithelium are an insunk nuclei type; the terminal part of the male genital antrum has the nucleated epithelium. The epithelial cells are well-developed at the posterior half of the male genital antrum.

In the present new species, a glandular fold or a slit is differentiated on the floor of the male genital antrum at the region near the genital pore (Fig. 3 C and D; Pls. 2, Figs. A and B, 3, Figs. B and D). The secretion of the gland ducts contains eosinophilous granules.

A slight degree of local variation in the penial anatomy is seen in the present new species. Figure 3 (B) shows the sagittal view of the copulatory apparatus of a specimen belonging to the other population of the Kampong Gumpang locality (No. 1117 group from Sumatra) (see also Pl. 5, Fig. E). In the specimen the dorsal valve of the basal part of the penis papilla seems to be larger than that of the specimen shown in Figure 3 (C). In the other slides of the Specimen Lot No. 1117 group, almost all specimens have a rather strongly contracted penis somewhat pointed at its tip (Pl. 5, Figs. B-D). This seems to be the effect of formalin as fixative.³⁾ It may be said that there is no conspicuous difference of the penial anatomy among them. On the contrary, the Siborangit specimen (No. 1116 group from Sumatra, Fig. 3 A) has a small size of copulatory apparatus. Apparently, the penis is strongly contracted in this specimen.

The copulatory apparatus of two specimens from two localities in Java (Nos. 556 and 558 groups from Kaliurang) is illustrated in Figure 3 (E and F). The penis in one locality (No. 556 group; Fig. 3 E) is strongly contracted. In this specimen, therefore, both the penis papilla and the ejaculatory duct are slightly folded. In one of the specimens from the same locality, the penis papilla is highly elongated so that the dorsal valve of the penis papilla is inconspicuous (Pl. 5, Fig. A). The penis of the Kaliurang specimen in the other locality (Fig. 3 F) is moderately elongated. In this specimen the dorsal valve of the penis papilla seems to be a large swelling. Although the essential anatomical features of the penis of the specimens from Java are coincident with those of the specimens from Sumatra, a slightly short ejaculatory duct is a character of the Java specimens. Another difference in the penial anatomy between Sumatra and Java specimens is a lack of the glandular fold on the roof of the male genital antrum in the latter specimens.

The copulatory bursa is a middle-sized (specimens from the Siborangit and the Kampong Gumpang locality in Sumatra) to large (specimens from the Kampong Gumpang locality in Sumatra and from the Kaliurang localities in Java) organ and is somewhat irregularly lobed. The lumen of the bursa is lined with a tall glandular epithelium. In this lumen, in many slides examined, a mass of sperm is found enveloped in a coagulum of secretion. The bursa stalk is a rather wide and long duct with a muscular coat consisting of three layers of fibres, i.e., a slightly wide layer of longitudinal, a rather wide layer of circular, and a thin layer of longitudinal (Pl. 5, Fig. H). It runs posteriorly to the left of the penis, then curves ventrally, to open to the wall of the female genital antrum from the upper-left side of it near the genital pore. The course of the bursa stalk is the same in every specimen of the present new species from different localities. The posterior part of the bursa stalk forms a less-developed vagina. The glandular epithelium of the bursal canal has insunk nuclei. The

3) In *Dugesia japonica*, the penis papilla, the bulb and the glandular epithelium of the bulbar cavity are strongly contracted when the animal is fixed in 3% formalin solution. When the animal is fixed in 70% ethyl alcohol, the penis papilla is usually elongated but slightly contracted; the penis bulb is moderately contracted (cf. KAWAKATSU & MIYAZAKI 1972).

ovovitelline ducts are accompanied by many eosinophilic glands at the region near the vagina. Weakly eosinophilous cement glands open into the female genital antrum near the genital pore.

Type-series. Holotype: a set of serial sagittal sections of the Kampong Gumpang specimen from Sumatra (Specimen No. 1119 d, 4 slides) preserved in KAWAKATSU's laboratory of Fuji Women's College in Sapporo, Japan. Paratypes from Sumatra: 16 sets of serial sagittal sections (Specimen Nos. 1116 a, 1117 a-d, f, g, 1118 a, 1119 a-c, e-g, l-n). Paratypes from Java: 6 sets of serial sagittal sections (Specimen Nos. 556 a-c, 558 a, 560 a, b). These paratypes, several sets of remaining serial sections, several whole mounts of head pieces (Specimen Nos. 556 and 560 groups), and preserved specimens in alcohol are also preserved in the same laboratory.

Type Locality and Distribution. A brooklet at Kampong Gumpang, the north-western part of Kutatjane, Sumatera Atjeh, Sumatra. Collected by Dr. M. HIRANO on August 20, 1971. Distribution, Sumatra and Java, Indonesia (see "List of Localities and the Species Obtained" and Figure 1 in the text).

Taxonomic and Faunistic Remarks and Differential Diagnosis. The modern taxonomic and faunistic discussions about the known species of the genus *Dugesia* reported from Southeast Asia (i.e., countries around the South China Sea) and the Far East are found in the following papers. These are: BALL (1970), ICHIKAWA & KAWAKATSU (1964, 1967), KAWAKATSU (1965, 1967, 1970, 1971, 1972 a, b, c, d, in press), KAWAKATSU & IWAKI (1967, 1968), KAWAKATSU, IWAKI & KIM (1967), KAWAKATSU & KIM (1966, 1967), KAWAKATSU, HORIKOSHI & AKAMA (1972), and KAWAKATSU & TANAKA (1971). Several Asian *Dugesia* species are reported from the countries around the northern part of the Indian Ocean, i.e., the Andaman Islands (KABURAKI 1925), Burma (KABURAKI 1918), Ceylon (BALL 1970), India (KAWAKATSU 1969 a; KAWAKATSU & BASIL 1971), Pakistan (KAWAKATSU 1969 d), and Afghanistan (DE BEAUCHAMP 1959, 1961, 1963). Some taxonomic and faunistic discussions are also included in these papers. In addition to these studies, the taxonomy of some Asian *Dugesia* species is also discussed in the following papers recently published: BANCHETTI & DEL PAPA (1971), DAHM (1971), KAWAKATSU (1969 b, 1972 e), and MITCHELL & KAWAKATSU (In press).

Among the valid *Dugesia* species of the Oriental region and Japan, the following species have an asymmetrical penis papilla with a diaphragm in the penis lumen. They are: *Dugesia lindbergi* DE BEAUCHAMP, 1959, from Afghanistan and Pakistan (cf. KAWAKATSU 1969 d), *Dugesia indica* KAWAKATSU, 1969, from India, *Dugesia burmaensis* (KABURAKI, 1918) from Burma, *Dugesia nannophallus* BALL, 1970, from Malaya (cf. KAWAKATSU 1972 b, c), *Dugesia hymanae* (ŠIVICKIS, 1928), from the Philippines, *Dugesia japonica* ICHIKAWA et KAWAKATSU, 1964, from the southeastern part of the Far East, and the present new species *Dugesia indonesiana* KAWAKATSU, 1973, from Sumatra and Java. The valve surrounding the basal part of the penis papilla,

the character is conspicuous in the present Indonesian form, is only found in five of them, namely, in *Dugesia lindbergi*, *Dugesia batuensis*, *Dugesia hymanae*, *Dugesia japonica*, and in *Dugesia indonesiana*. In *Dugesia lindbergi* the valve of the penis papilla is less-developed only at the dorsal side of the papilla (including KAWAKATSU's unpublished data on this species from Pakistan). In *Dugesia japonica* this character is found only in some specimens of the populations from China, the Okinawa Islands, the southern part of Kyûshû and the Izu Peninsula in Japan (cf. ICHIKAWA & KAWAKATSU 1967; KAWAKATSU & IWAKI 1967; KAWAKATSU, HORIKOSHI & AKAMA 1972; KAWAKATSU & TANAKA 1971).

In comparing the present new Indonesian form, *Dugesia indonesiana*, with four related Asian *Dugesia* species (*lindbergi*, *batuensis*, *hymanae* and *japonica*), a number of essential morphological and anatomical differences are apparent. For this point BALL's (1970, pp. 288-291) character key for the Oriental species of *Dugesia* is available. *Dugesia hymanae*, the species not included in that key, was recently redescribed as a valid species (cf. KAWAKATSU 1972 d). *Dugesia indonesiana* can be separated from *Dugesia hymanae* in the details of the arrangement and number of testes, the anatomical feature of the penis and the genital antrum, and the histology of the bursa stalk.

The present new form *Dugesia indonesiana*, a dark pigmented epigeal species, is easily separable from *Dugesia batuensis* described from the Batu Caves as a white hypogean species according to the differential diagnosis provided by the original author of the latter form (cf. BALL 1970, pp. 284-285). Dr. BALL's original definition of *Dugesia batuensis* was partly corrected by myself based upon the materials from the type locality and from an epigeal locality in the vicinity of Kuala Lumpur (cf. KAWAKATSU 1972 b, c). My material which I identified as an epigeal form of *Dugesia batuensis* consists of only one sexual and several asexual specimens fixed in 80% ethyl alcohol (cf. KAWAKATSU 1972 c, p. 5, Fig. 3, Pl. 2, Figs. A and B).

From the result of the comparative examination of my slides of *Dugesia batuensis* from both the type and the Kuala Lumpur localities and those of *Dugesia indonesiana*, it is clear that these two species are very closely related. There are, however, several differences in their anatomy: in *Dugesia batuensis* the long, slender penis papilla is weakly muscular with a well-developed valve at its basal part (both dorsal and ventral lips are conspicuous); the bulbar cavity has a nucleate epithelium; the bursa stalk has a very thick muscle sheath (especially on the ventral surface of the bursa stalk). The sexually mature specimens of *Dugesia batuensis* is usually smaller in size than those of *Dugesia indonesiana*. The head may be more bluntly triangular in shape in the latter.

The anatomy and the function of the valve surrounding the basal part of the penis papilla were not sufficiently described and discussed in the previous paper. BANCHETTI & DEL PAPA (1971), who described a new Kenyan species *Dugesia lanzai* which has one solid and one hollow adenodactyl, have mentioned the Malayan species as follows (p. 34): "*D. batuensis* presenta un adenodattilo disposto a formare una corona attorno alla papilla peniena e ciò la differenzia nettamente della *Dugesia*

del Kenya". As far as my observation goes, the valve surrounding the basal part of the penis papilla of *Dugesia batuensis* is not considered as a solid adenodactyl. This is the same with other four Asian species which I have examined in my slides, i.e., *Dugesia lindbergi*, *Dugesia hymanae*, *Dugesia japonica*, and the present new species *Dugesia indonesiana*. As was already described in the text, the dorsal valve of the penis papilla is supplied with many eosinophilic gland ducts in *Dugesia indonesiana*.

It is a very interesting fact in the present new species that a narrow space between the under surface of the dorsal valve and the upper surface of the dorsal lip of the penis papilla forms a glandular cavity or a hollow adenodactyl-like structure when the penis is contracted, though it is not the real adenodactyl (i.e., adenodactyl of the *Dendrocoelum lacteum* type) which is found in *Dugesia bactriana* as well as in several other species of the genus.⁴⁾

In my slides of the above mentioned Asian species re-examined, the glandular epithelium of the dorsal valve of the penis papilla containing eosinophilous granules is found in both *Dugesia batuensis* and *Dugesia hymanae*, but not clearly in *Dugesia japonica* from the Okinawa Islands. It is to be emphasized that the degree of the differentiation of the glandular ducts is highly developed in *Dugesia indonesiana*. The secretion of these gland ducts in my slides is found in the genital antrum as heavily red stained granules. The differentiation of the glandular fold on the floor of the male genital antrum is also one of the characters of *Dugesia indonesiana*.

The *Dugesia* species with an adenodactyl or with two or three in some species are now recorded from the northeastern area of the Mediterranean Sea (Italy and Crete), Northeast Africa (Kenya), the southern part of the Hindukush Mountains (Afghanistan and West Pakistan), the Far East (Japan) and the southwestern part of Australia. There is a little possibility that the glandular structure of the genital apparatus found in *Dugesia indonesiana* (and the valve surrounding the basal part of the penis papilla found in several Asian species) may have some, if not direct, phylogenetical relationship to that of the other *Dugesia* species with adenodactyls.

DE BEAUCHAMP (1929), who studied the triclad material collected by the "Musée Zoologique de Buitenzorg", recorded three paludicolan planarian species from Java. His records are: "*Planaria gonocephala* DUGÈS" from a pond of the Jardin Botanique de Buitenzorg (now Kebun Raya Bogor), Lac Ngebel (Madioen), Cascade Sarangan (Madioen), and Lac Klakah (Pasoeroean); "*Planaria pinguis* WEISS" from a pond of the Jardin Botanique de Buitenzorg; "*Planaria* sp." from a pond of the Jardin Botanique de Buitenzorg (see Fig. 1 of the present paper).

The occurrence of *Dugesia gonocephala* s. str. (DUGÈS, 1830) in the countries of Southeast Asia and the Far East is very doubtful because the species is only known from Europe and Africa (cf. ICHIKAWA & KAWAKATSU 1964; KAWAKATSU 1971;

4) *Dugesia bactriana* DE BEAUCHAMP, 1959, has three hollow adenodactyls. There is no conspicuous difference of the genital anatomy between the Afghanistan material and the Pakistan material which I examined in my slides (KAWAKATSU's unpublished data).

MARCUS 1953). From DE BEAUCHAMP's illustration the Buitenzorg specimen of "*Planaria pinguis*" is very similar to the Australian *Cura pinguis* (WEISS, 1910) in general appearance (especially the arrangement of the sensory spots in both forms; cf. KAWAKATSU 1969 c, d). I expressed my opinion in my previous articles (op. cit.) that DE BEAUCHAMP's population might have originated by artificial introduction of the Australian population into Java water with some aquatic plants. Although the Java locality of "*Planaria pinguis*" is a pond of the Botanical Garden of Bogor, DE BEAUCHAMP's species from Java may be identical with *Dugesia indonesiana*. The sensory spots located at the margin of the head are commonly found in some Asian and Australian species of *Dugesia*. Since this character shows a wide local variation, it is not adequate for a taxonomic significance. DE BEAUCHAMP's "*Planaria gonocephala*" and "*Planaria* sp." from Java waters may also be considered identical with *Dugesia indonesiana*.

I have examined a number of non-sexual specimens from a small stream in the Tjibodas Botanical Garden (Specimen Lot No. 1121 group). The animal are large in size but slender (Fig. 2 G, Pl. 1, Fig. C). Judging from their external appearance, it is quite possible that this population may be that of *Dugesia indonesiana*.

Dugesia indonesiana, the present new species, is distinguished from the Malayan form, *Dugesia batuensis*, chiefly for the external appearance (especially the head shape and the body size) and for the details of the anatomy of the copulatory apparatus. Although these two species are readily separable by their morphological and anatomical differences, it is possible that when more is known of the *dugesias* of the Southeast Asian countries and adjacent regions, *Dugesia indonesiana* will be regarded as a subspecies of *Dugesia batuensis*. With due consideration for this point, I have given a rather narrow definition for the present new species.

Dugesia indonesiana differs from the other members of the genus in the combination of the following characters: living animals moderate to large in size (may attain 15 to 30 mm in length), slender, and colored dark brownish gray above, with numerous, distinct blackish pigment granules, lighter below but with numerous indistinct pigment spots; head of an equilateral triangle form with blunt auricles; two eyes; sometimes with visible sensory spots at the anterior margin of the head (irregularities may occur); external muscle layers of the pharynx consist of outer longitudinal and inner circular fibers; marginal adhesive zone well-developed; small to middle-sized, numerous dorsal testes lie in two to three rows on either side and extend to near the posterior end; penis bulb very large, semispherical or semiovoidal in shape and strongly muscular with a wide flask-shaped cavity (most of its glandular epithelium have insunk nuclei) into which sperm ducts enter separately from the posterior end; highly asymmetrical penis papilla large, conical form and highly muscular with a diaphragm in the penis lumen; narrow ejaculatory duct opens at the ventral side of the penis papilla; with a valve at the basal part of the penis papilla (ventral lip of the valve is small and inconspicuous) and the epithelial cells of the dorsal valve are highly glandular which contain heavily eosinophilous granules; with a glandular fold on

the floor of the male genital antrum (irregularities may occur); copulatory bursa middle-sized to large, with a rather wide and long bursal canal which opens into the female genital antrum near the genital pore; bursa stalk with a rather thin muscular coat consisting of three layers of fibres; the posterior terminal portion of the bursa stalk forms a less-developed vagina into which ovovitelline ducts enter separately.

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Note Added in Proof. Mr. Genchû ÔGAWARA, of Rakutô High School, Kyôto, my co-researcher in the field of turbellarians, visited several Southeast Asiatic countries from December 26, 1972 to January 6, 1973. He kindly made efforts to collect planarians in the pond of the Kebun Raya Bogor in Jakarta, but unfortunately without success.

Plate 1

- A, B and C. Photographs of three preserved specimens of *Dugesia indonesiana* spec. nov.
A: Specimen Lot No. 556 group (Kaliurang in Java). B: Specimen Lot No. 560 group (Kopeng in Java). C: Specimen Lot No. 1121 group (the Tjibodas Botanical Garden in Java).
- D and E. Enlarged photomicrographs of the head of preserved specimens of *Dugesia indonesiana* spec. nov. D: Specimen No. 556 d (whole mount; Kaliurang in Java). E: Specimen No. 560 k (whole mount; Kopeng in Java).
- F. Sagittal section of a part of the prepharyngeal region showing the arrangement of testes (Specimen No. 556 a; Kaliurang in Java). i, intestine; t, testes; vnc, ventral nerve cord.

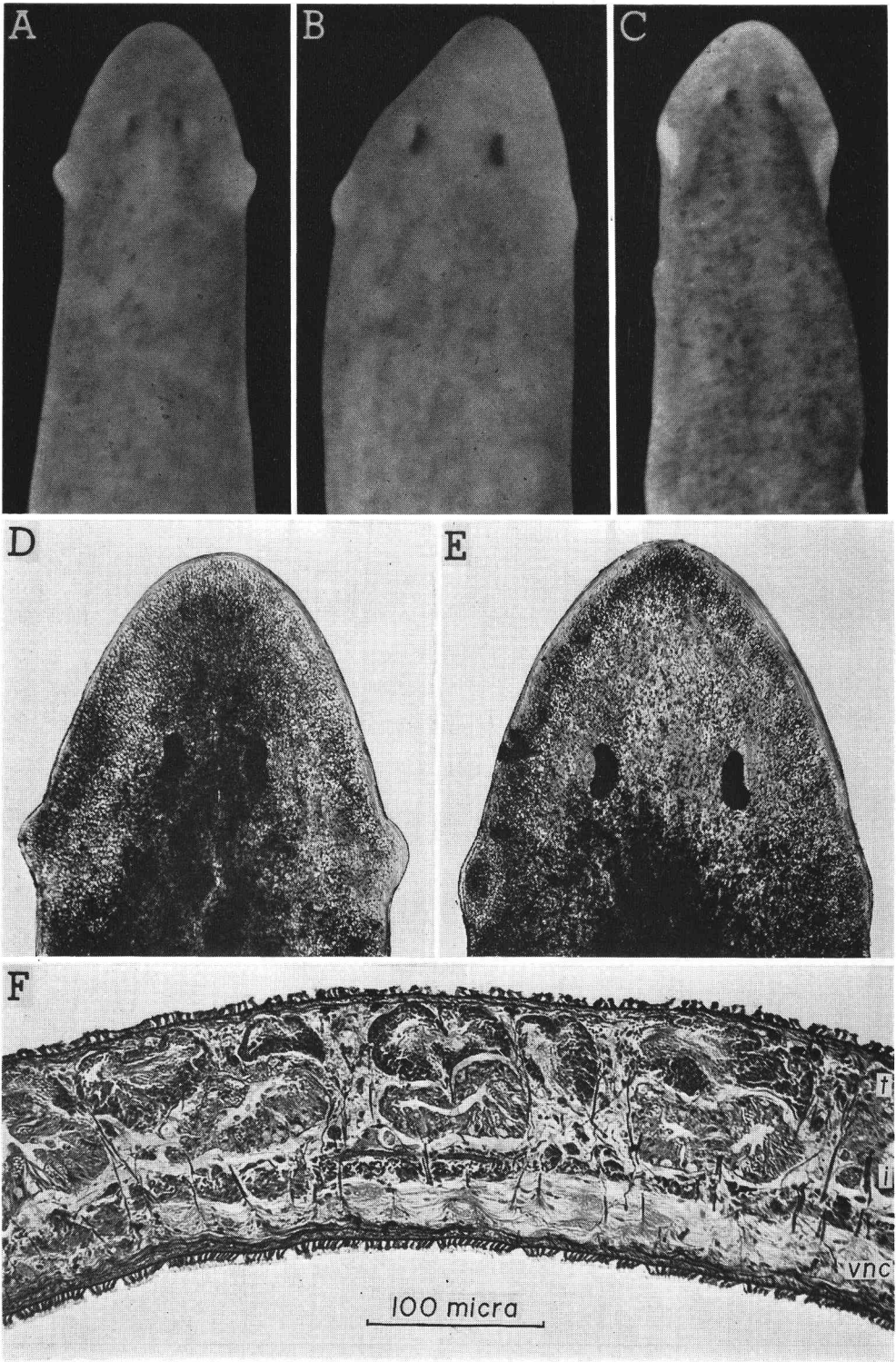


Plate 2

A and B. Photomicrographs showing the parts of the copulatory apparatus of *Dugesia indonesiana* spec. nov. from Kampong Gumpang in Sumatra. A: mid-sagittal section (Specimen No. 1119 d; holotype). B: mid-sagittal section through elongated penis (Specimen No. 1119 a). bc, bulbar cavity; cb, copulatory bursa; ed, ejaculatory duct; gf, glandular fold on the floor of the male genital antrum; gp, genital pore; ma, male antrum; od, ovovitelline duct; pb, penis bulb; ph, pharynx; pp, penis papilla; sd, sperm duct; vp, valve at the basal part of the penis papilla (dorsal lip).

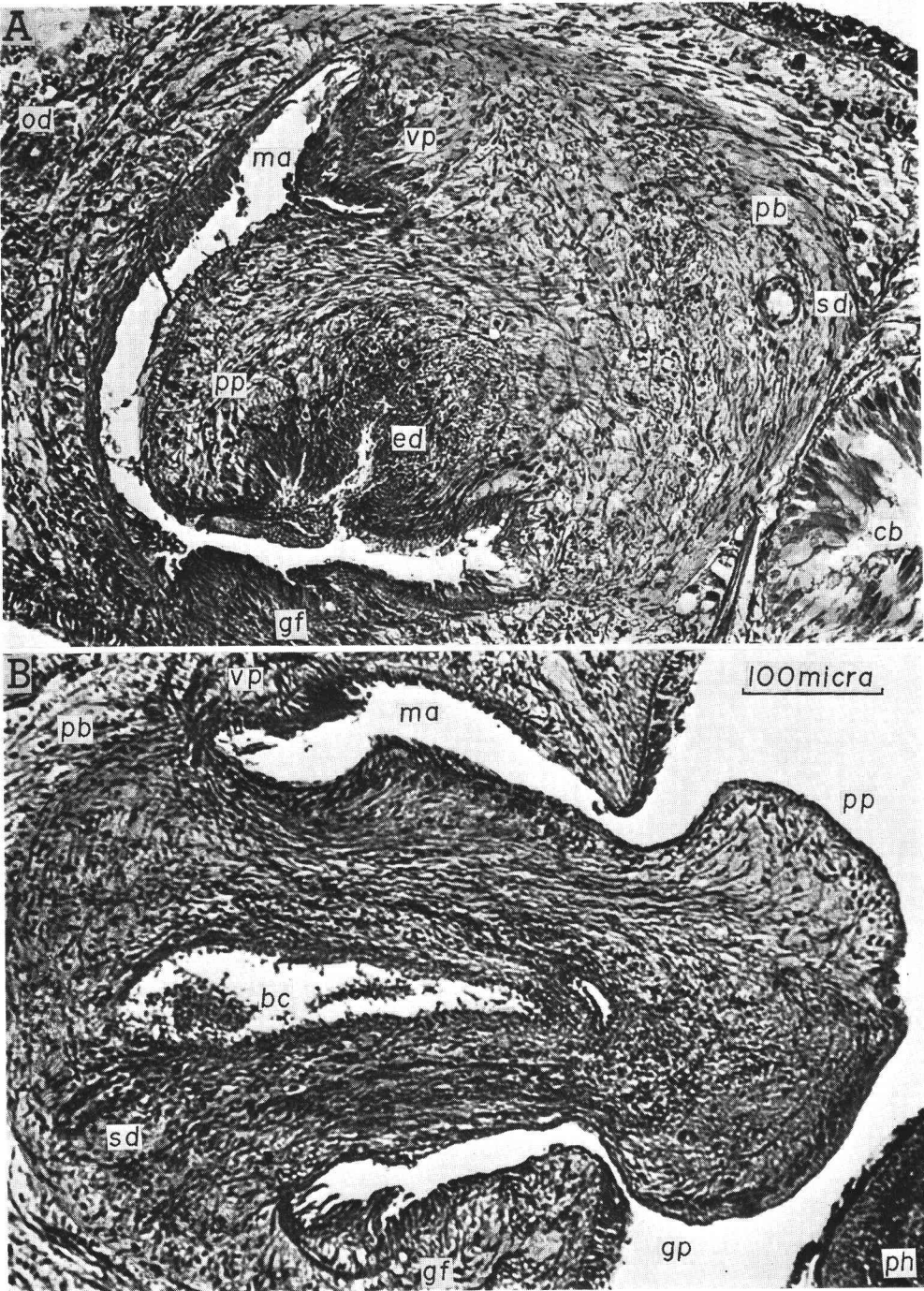


Plate 3

A, B, C and D. Photomicrographs showing the dorsal lip of the valve at the basal part of the penis papilla (A and C) and the glandular fold on the floor of the male genital antrum (B and D) of *Dugesia indonesiana* spec. nov. from Kampong Gumpang in Sumatra. The same magnifications. See Pl. 2, Figs. A and B. A and B: Specimen No. 1119 d. C and D: Specimen No. 1119 a. ed, ejaculatory duct; gf, glandular fold on the floor of the male genital antrum; gp, genital pore; ma, male antrum; pp, penis papilla; vp, valve at the basal part of the penis papilla (dorsal lip).

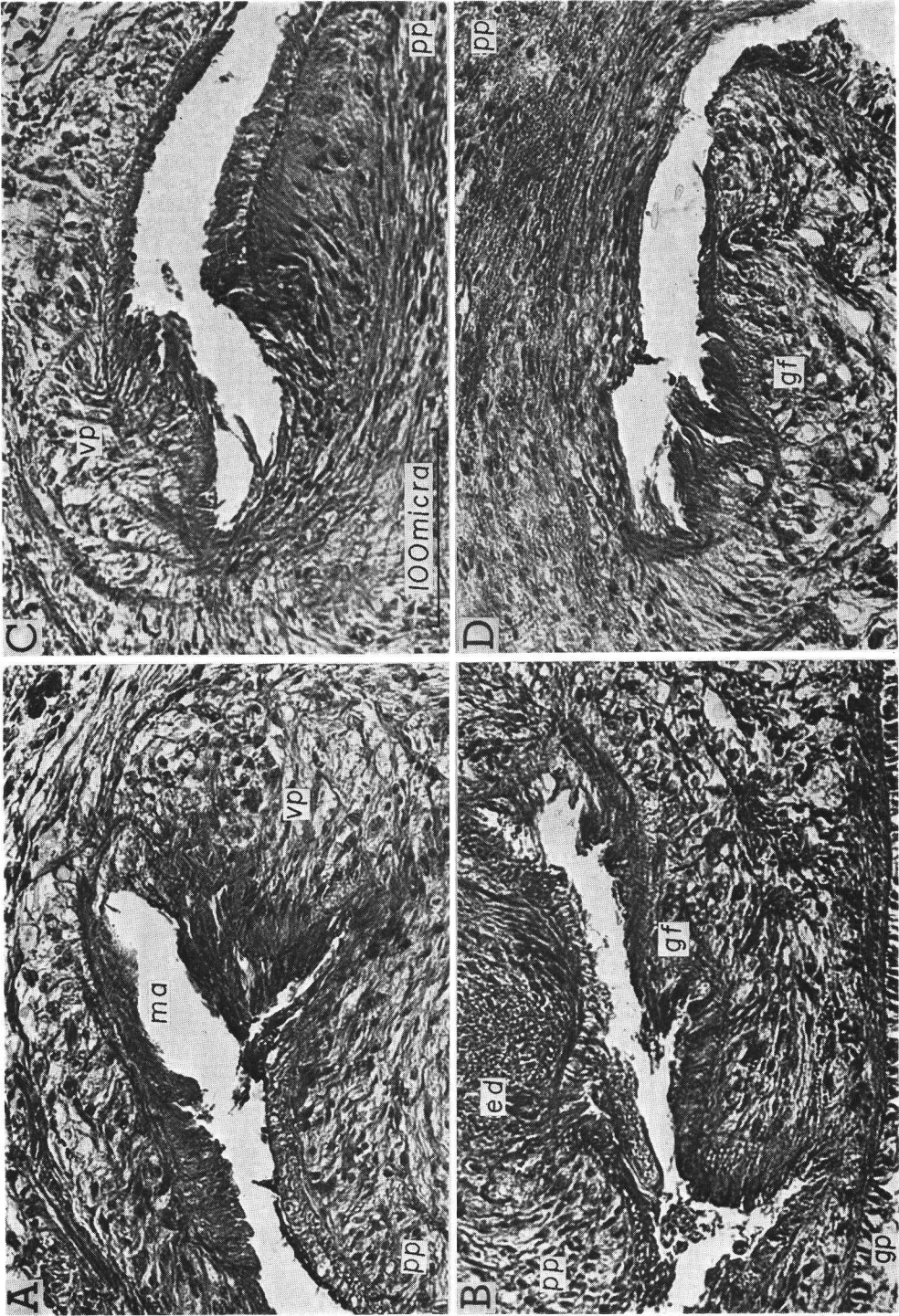


Plate 4

A and B. Photomicrographs showing the parts of the copulatory apparatus of *Dugesia indonesiana* spec. nov. from Kaliurang in Java. A: near mid-sagittal section (Specimen No. 556 a). B: mid-sagittal section (Specimen No. 556 a). bc, bulbar cavity; cb, copulatory bursa; ma, male antrum; pb, penis bulb; pp, penis papilla; sd, sperm duct; sv, spermiducal vesicle; vp, valve at the basal part of the penis papilla (dorsal lip).

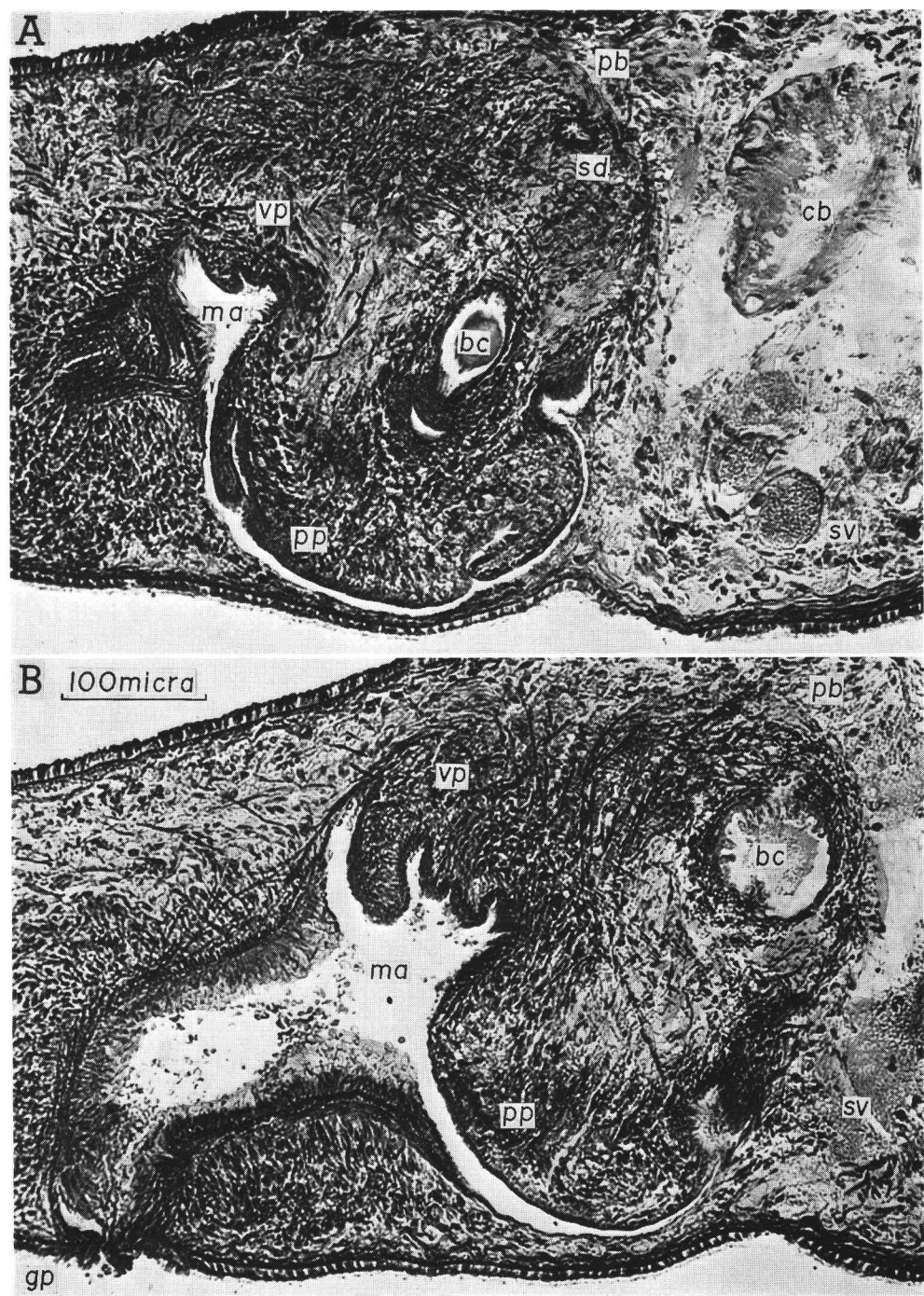


Plate 5

- A-F. Photomicrographs showing the sagittal views of the copulatory apparatus of *Dugesia indonesiana* spec. nov. from Sumatra and Java. The same magnifications. A: Specimen No. 556 b (Kaliurang in Java). B: Specimen No. 1117 b (Kampung Gumpang in Sumatra). C: Specimen No. 1117 d (Kampung Gumpang in Sumatra). D: Specimen No. 1117 f (Kampung Gumpang in Sumatra). E: Specimen No. 1117 g (Kampung Gumpang in Sumatra). F: Specimen No. 1118 a (Kampung Gumpang in Sumatra).
- G and H: Enlarged photomicrographs showing the parts of the copulatory apparatus of *Dugesia indonesiana* spec. nov. The same magnifications. G: part of the penis papilla (Specimen No. 1119 e). Notice the strongly stained granules with eosin. H: near mid-sagittal section through the part of the bursa stalk (Specimen No. 560 b). buc, bursal canal; ed, ejaculatory duct; pp, penis papilla; vp, valve at the basal part of the penis papilla (dorsal lip).

