

The Freshwater Planaria from South Brazil

By

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Introduction

Although the freshwater planarian fauna of Brazil was studied extensively by the late Dr. E. MARCUS and his school of São Paulo, the material from South Brazil has not been given full investigations. For the past several years, the second and the third authors (HAUSER and FRIEDRICH), who studied the morphogenesis and physiological problems on triclads, employed an unidentified species of *Dugesia* collected from the vicinity of São Leopoldo as an experimental animal. This species was identified with *Dugesia schubarti* (MARCUS, 1946) by the first author (KAWAKATSU) who studied both live and preserved specimens which were sent to him from the second and the third authors. KAWAKATSU also had a chance to examine several slides of the serial sections of the type-series of this species (i.e., “*Curtisia schubarti*”) by courtesy of Dr. E. DU BOIS-REYMOND MARCUS.

The purpose of the present paper is to present a redescription of this little known South American species, together with some ecological and chorological problems of the animal. Whole mounts (KAWAKATSU's Specimen Lot Nos. 1287, 1380 and 1381 groups) and the series of sections (KAWAKATSU's Specimen Lot No. 1314 group) of the material were prepared in KAWAKATSU's laboratory (stained with Delafield's haematoxylin and erythrosin). Some additional serial sections for histological study were also prepared in HAUSER's laboratory. The anatomy and histology of the animals were studied by KAWAKATSU and HAUSER; the ecology of the species in the São Leopoldo population was chiefly studied by HAUSER and FRIEDRICH in cooperation with the members in their laboratories (the collection data, see the section “Ecological Notes and Laboratory Observations”).

Morphology and Taxonomy

Order TRICLADIDA

Suborder PALUDICOLA or PROBURSALIA

Family Planariidae

Genus *Dugesia* GIRARD, 1850*Dugesia schubarti* (MARCUS, 1946)*Principal literature.*

- Curtisia schubarti* MARCUS, 1946, in Univ. São Paulo, Bolet. Fac. Filos., Ciênc. e Let., Zoologia, (11), pp. 142–145, 173, 240–345 (+ pls. 26, fig. 154, 27, figs. 156–157, 28, figs. 160–161, 32, fig. 6. Original description.
- Cura schubarti* (MARCUS, 1946), in MARCUS, 1955, South African Animal Life, 1, pp. 111–112. Taxonomic key.
- Cura schubarti* (MARCUS, 1946), in BALL, 1969, Canad. J. Zool., 47, p. 61. Taxonomic remarks.
- Curtisia schubarti* MARCUS, 1946, in PEREIRA, 1970, Ciências e Cultura, 22, pp. 211–212. Karyological study. Chromosome no., $n=4$ and $2n=8$.
- Dugesia? schubarti* (MARCUS, 1946), in BALL, 1971, Amer. Mus. Novitates, (2472), p. 17. Taxonomic remarks.
- Dugesia (Girardia) schubarti* (MARCUS, 1946), in BALL, 1974, HYMAN Mem. Vol., Biol. Turbellaria, pp. 376–377. Taxonomic remarks.
- Dugesia schubarti* (MARCUS, 1946), in KENK, 1974, Smithsonian Contr. Zool., (183), p. 27. Taxonomic remarks.
- Neppia schubarti* (MARCUS, 1946), in BALL, 1974, Life Sci. Contr. Royal Ontario Mus., (99), pp. 21–22. Taxonomic remarks.
- Neppia schubarti* (MARCUS, 1946), in GOURBAULT & BENAZZI, 1975, Canad. J. Genet. Cytol., 17, p. 351. Karyological remarks.

External characters. This is a middle to large-sized and pigmented species with a typical appearance of long-auricled dugesias distributed in the Americas. The general appearance of both living and preserved specimens of this species is shown in photographs in Fig. 1 (A–M).

Usually, the sexually mature specimens from the São Leopoldo population examined by the authors measures up to 25 to 30 mm in length and 3 to 4 mm in width. But a number of large specimens measuring 35 to 40 mm long are also seen in the population. In the normally gliding animal, the anterior end of the markedly triangular shaped head is highly pointed as like as a thorn (Fig. 1 C). The auricles are well-developed, long and pointed (Fig. 1 A–M). Behind the auricles, the body first narrows slightly, then gradually widens, reaching its widest at the level of pharynx and copulatory apparatus. The body then tapers to a bluntly pointed posterior end (Fig. 1 A–B, F–K).

The ground color of the dorsal side of the animal is very blackish brown. It is mottled with numerous, small, indistinct white-yellowish brown spots. The midline

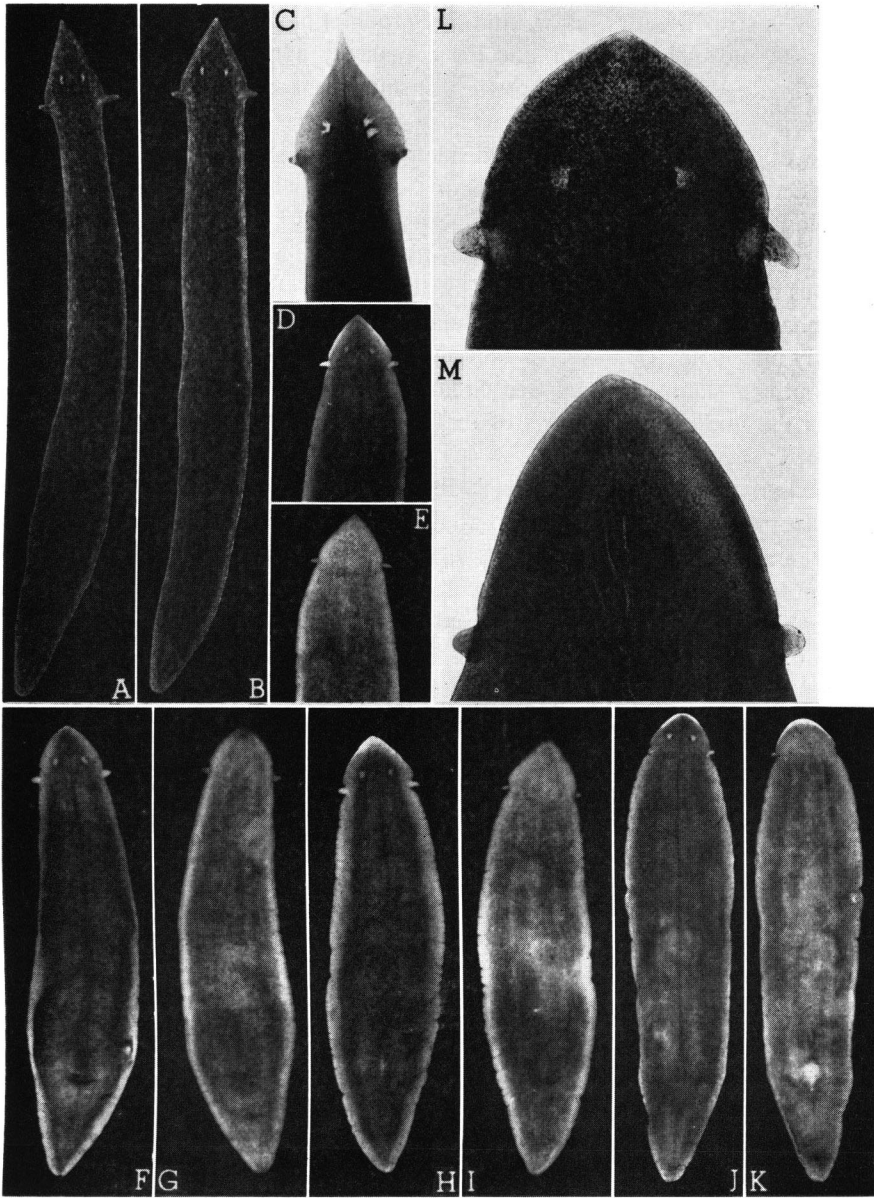


Fig. 1. *Dugesia schubarti* (MARCUS, 1946) from the São Leopoldo locality in South Brazil. — A and B. Two living sexually immature specimens (Specimen Lot No. 1287 group). — C. Head of a sexually mature specimen with three eyes. — D–K. Four preserved sexually mature specimens (Specimen Lot No. 1314 group). — E. Ventral view of the specimen D. — G. Ventral view of the specimen F. — I. Ventral view of the specimen H. — K. Ventral view of the specimen J. — L and M. Head of two preserved specimens (photographs taken from the whole mounts; Specimen Lot No. 1381 group). — L. A sexually mature specimen without stain (Specimen No. 1381 b). — M. A sexually mature specimen stained with borax-carmin (Specimen No. 1381 a).

of the body is striped with a clear, thin, longitudinal black band. The body margin and the areas above the pharynx and the copulatory apparatus are of a lighter hue. The ventral side is light grayish brown with numerous blackish brown pigments or granules (Fig. 1 E, G, I and K).

Two eyes are situated on the dorsal side of the head; the distance between them is slightly wider than one-third the width of the head at the level of the eyes. Each eye is enclosed in a reniform, pigment-free ocular areas (Fig. 1 A–D, F, H, J, L, and M). The non-pigmented auricular sense organ of a boomerang-shape is large and conspicuous on each postero-lateral side of the auricles (Fig. 1 L).¹⁾

The pharynx is inserted, in sexually mature animals, somewhat behind the middle of the body and is nearly one-sixth as long as the body length. Around the opening of the mouth, a small, pigment-free circular area is observed. The genital pore is situated in the midline at the level of the middle of the postpharyngeal region (Fig. 1 G, I and K; see also Fig. 2 A).

The external characters described above of the authors' material of *Dugesia schubarti* from São Leopoldo are essentially the same as those of MARCUS's (1946) original description and figures of "*Curtisia schubarti*". His largest specimen measures 20 mm in length and 2.5 mm in width. MARCUS' color painting of the animal (*op. cit.*, pl. 32, fig. 6) may look natural and is coincident with the result of the authors' observation.

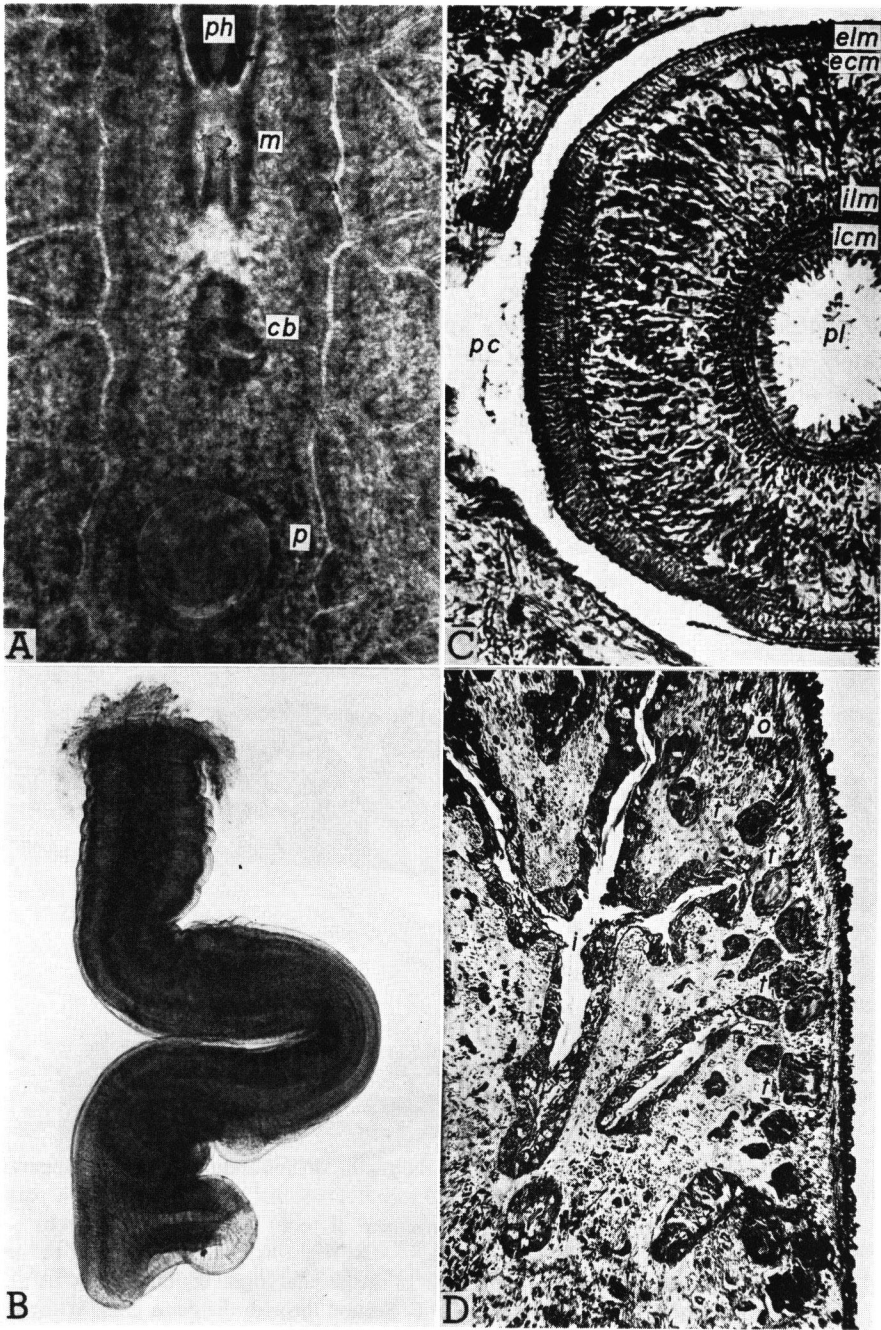
Internal characters. The four sexual specimens fully matured, fixed with "Susa" fluid, were sectioned sagittally, transversally and horizontally.²⁾ The dorsal epithelium is thicker than the ventral. The marginal adhesive zone is well developed.

The species has a pigmented pharynx. A pale grayish-brown pigment covers the greater part of its surface (it is located in a subepithelial position) (Fig. 2 B). This pigment layer of the pharynx was also observed in young animals. In histological sections the pharynx is typical of the family Planariidae, i.e., the inner musculature of

1) Judging from the external appearance of the animals examined, there are some possibilities that the asexual specimens from the São Leopoldo population (Fig. 1 A and B) are the different species.

2) Modification of Heidenhain's No. 2 fluid and Romeis' "Susa" fluid (i.e., Ludford's fluid): mercury chloride 4.5 g+sodium chloride 0.5 g+dist. water 80 ml+40% formalin 20 ml+acetic acid glacial 4 ml+trichloroacetic acid 2 g (cf. HAUSER, 1969, pp. 144–145). Judging from the chemical components of this fixative, the penis papilla of the animals examined seems to be moderately contracted (cf. KAWAKATSU & MIYAZAKI, 1972).

Fig. 2. Photomicrographs of *Dugesia schubarti* from the São Leopoldo locality. — A. Photomicrograph of the copulatory apparatus (Specimen No. 1381 a; whole mount). — B. Photomicrograph of the pharynx (Specimen Lot No. 1381 b; whole mount). — C. Cross section of the pharynx (Specimen No. 1314 d). — D. Horizontal section of the right anterior part of the body showing the arrangement of ovary and testes (Specimen No. 1314 c). cb, copulatory bursa; ecm, external circular muscle layer; elm, external longitudinal muscle layer; i, intestine; icm, internal circular muscle layer; ilm, internal longitudinal muscle layer; m, mouth; o, ovary; p, penis; pc, pharyngeal chamber; ph, pharynx; pl, pharynx lumen; t, testis.



the pharynx consists of two distinct layers, a thick circular layer adjoining the epithelium of the pharynx lumen and the thinner outer longitudinal one. The outer musculature of the pharynx consists of two layers, i.e., an external thin longitudinal fibers and a slightly thick circular fibres (Fig. 2 C). As far as KAWAKATSU's observation goes, the pharynx tissues of the animals examined are infected by a nematode species (cf. KAWAKATSU, 1970). The anterior intestinal trunk bears 12 to 15 branches on each side; each posterior trunk has 15 to 20 short lateral branches.

A pair of ovaries recognizable from the ventral side occurs between the third and the fourth intestinal diverticula (Figs. 2 D, 3 B). Two ovovitelline ducts converge at the posterior level of the copulatory apparatus and then bend upwards and open separately into the posterior part of the bursal canal. Numerous yolk glands (or vitellaria) are distributed throughout the body in the surrounding parenchyma.

Numerous, rather small-sized testes are situated dorsally. They are arranged on

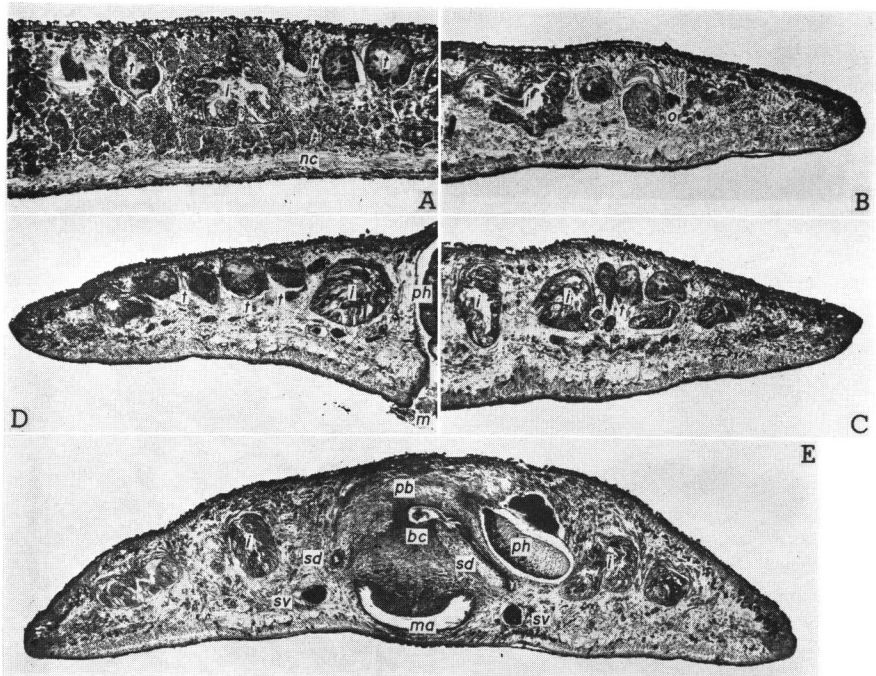


Fig. 3. Photomicrographs showing the parts of the genital organs and the copulatory apparatus of *Dugesia schubarti* from the São Leopoldo locality. — A. Saggital section of a part of the prepharyngeal region showing the arrangement of testes (Specimen No. 1314 b). — B-E. Cross sections (Specimen No. 1314 c). — B. Right-half of the section at the level of the ovary. — C. Right-half of the section of the prepharyngeal region. — D. Left-half of the section at the level of the mouth. — E. Section through the penis bulb, at the level of entry of the sperm ducts.

bc, bulbar cavity; i, intestine; m, mouth; ma, male antrum; nc, nerve cord; o, ovary; pb, penis bulb; ph, pharynx; sd, sperm duct; sv, spermiducal vesicle; t, testis.

either side of the midline in three to four longitudinal zones extending from the posterior level of the ovaries to the nearly posterior level of the penis bulb (Fig. 2 D, 3 A, C and D). On examination of the sagittal, transverse and horizontal sections, their total number can be estimated at almost 300 or more. In this species the sperm ducts form the moderately developed spermiducal vesicle and are packed with sperm on either side of the postpharyngeal region between the mouth and the anterior level of the penis bulb (Fig. 3 E). On the side of the penis bulb, each of them narrows to a slender duct and opens into the bulbar cavity separately at its antero-lateral side (Fig. 3 E). The authors' observation on the reproductive system of *Dugesia schubarti* from the São Leopoldo population is essentially the same as that of "*Curtisia schubarti*" (cf. MARCUS, 1946, pp. 244–245, pl. 28, fig. 156).

Figure 4 (A and B) shows a sagittal view of the copulatory apparatus of the São

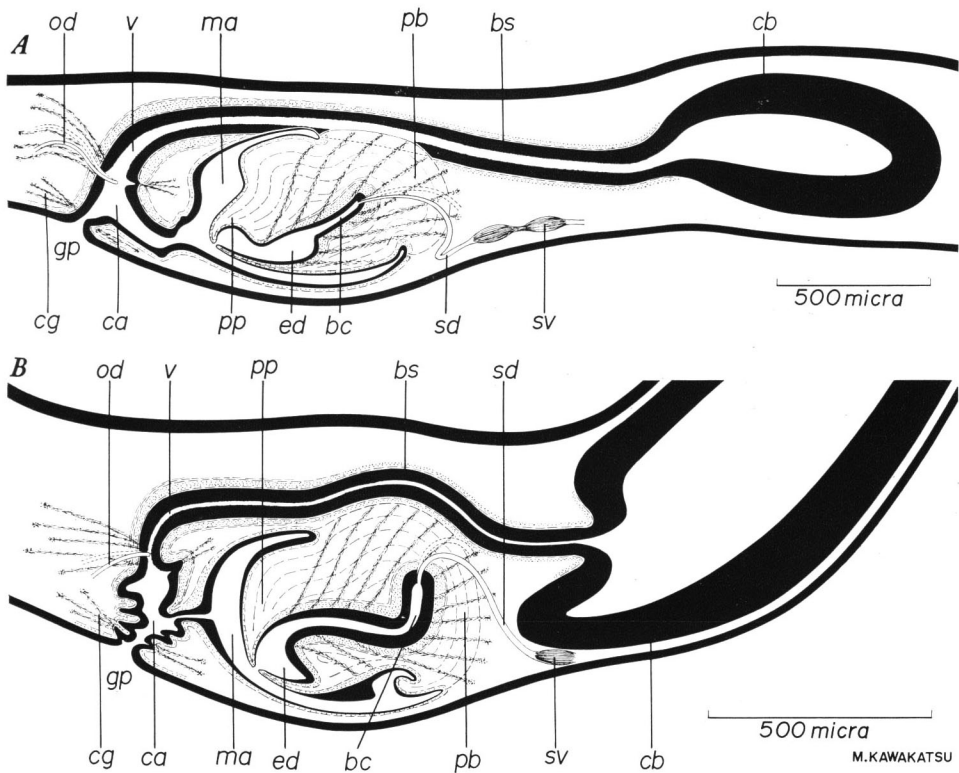


Fig. 4. Diagrams showing the sagittal view of the copulatory apparatus of *Dugesia schubarti* from the São Leopoldo locality (A, Specimen No. 1314 b) and the type-locality (B, one of the paratypes).

bc, bulbar cavity; bs, bursa stalk; ca, common antrum; cb, copulatory bursa; cg, cement gland; ed, ejaculatory duct; gp, genital pore; ma, male antrum; od, ovovitelline duct; pb, penis bulb; pp, penis papilla; sd, sperm duct; sv, spermiducal vesicle; v, vagina.

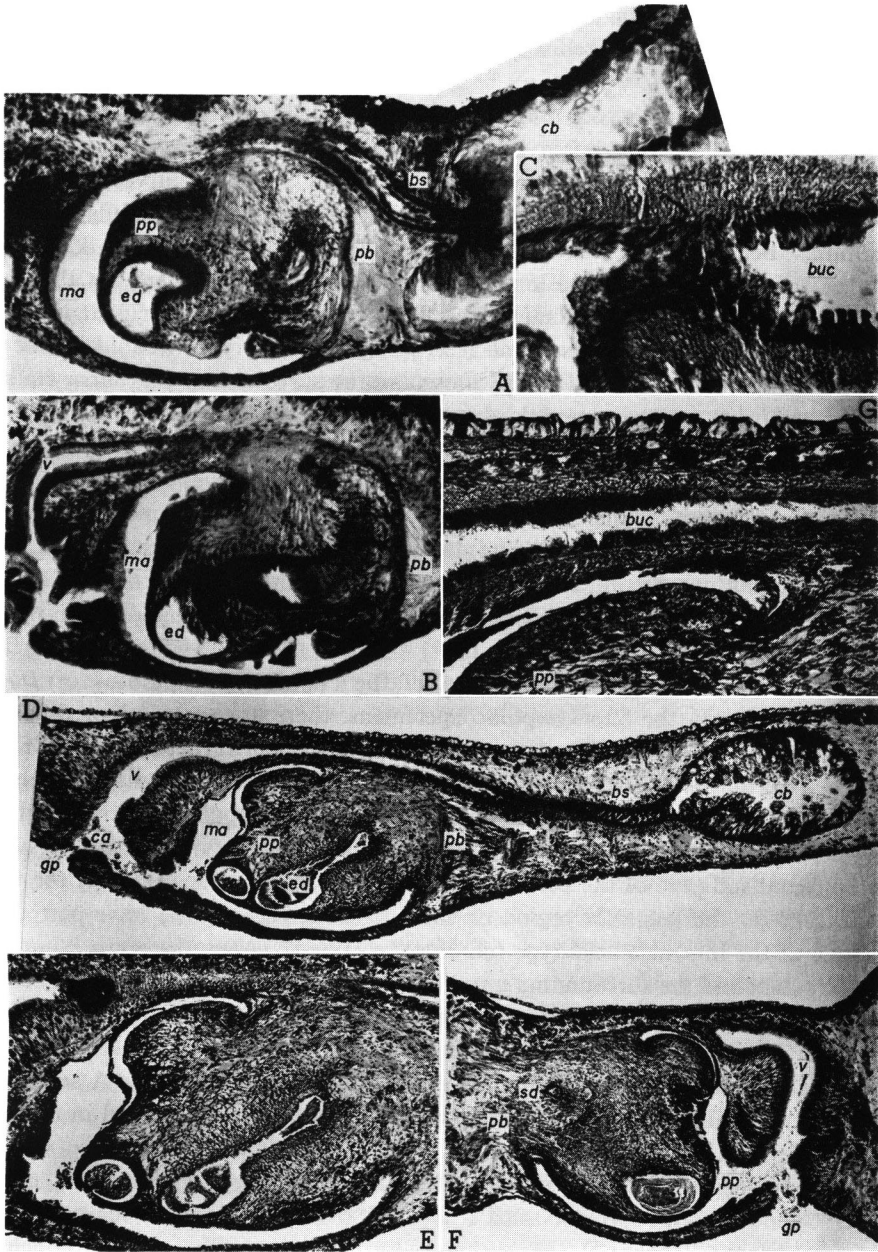
Leopoldo specimen (A) and of "*Curtisia schubarti*" which was redrawn by KAWAKATSU from one of the paratypes (B; sagittal sections are retained in Dr. E. DU BOIS-REYMOND MARCUS' laboratory in São Paulo). Photomicrographs of the parts of the copulatory apparatus of several specimens from both the São Leopoldo and the type-localities are also shown in Fig. 3 (E) and 5 (A-G).

The genital pore leads into a wide cavity which represents the common genital antrum. It continues into a rather wide terminal part of the bursal canal postero-dorsally and into the male genital antrum anteriorly. The walls of the floor of the common antrum and that of the male antrum are closed with a tall, glandular epithelium of a nucleate type, below which occur two layers of muscle layers, one circular and the other thin longitudinal. The wall of the roof of the common antrum (as well as the posterior one-third or more of the bursal canal, of which its distal part forms a less-developed vagina) is provided with three layers of muscles, i.e., the inner thin longitudinal, the middle thick circular and the outer thin longitudinal. The epithelial cells of the wall of the common antrum is much taller than those of the male antrum.

The penis has a considerably large, hemispherical bulb embedded in the parenchyme and a very large papilla of a conical shape projecting into the male genital antrum (Figs. 4 A, 5 D-F). Both the bulb and the papilla are strongly muscular in nature. The penis bulb contains a narrow, tubular cavity, the bulbar cavity or the seminal vesicle. Its beginning or the basal part forms a slightly wide, bifid cavity and receives sperm ducts from each of the antero-lateral sides (Fig. 3 E). The bulbar cavity continues to the penis papilla as a rather wide ejaculatory duct and opens at its tip. It is located more or less on the ventral side in the papilla (Figs. 4 A, 5 D-F). The penis lumen (the bulbar cavity and the ejaculatory duct) is lined with a glandular epithelium of a nucleate type. Below this epithelium there are two layers of muscles, the inner thick layer of circular fibres and the outer rather thick layer of longitudinal ones. The musculatures are well developed at the region of the bulbar cavity. The penis bulb is pierced by numerous gland ducts (penis glands), the secretion of which contains eosinophilous granules.

The penis papilla of this species is slightly asymmetrical in shape. As is shown in Figs. 4 (A) and 5 (D-F), the dorsal lip of the papilla is larger than the ventral ones.

Fig. 5. Photomicrographs showing the parts of the copulatory apparatus of *Dugesia schubarti* from the type-locality (A-C) and the São Leopoldo locality (D-G). — A and B. Sagittal sections of the copulatory apparatus of two specimens of the paratypes. — C. Enlarged photomicrograph of the posterior part of the bursa stalk of the specimen B (paratype). — D. Near mid-sagittal section of the copulatory apparatus (Specimen No. 1314 b). — E. Near mid-sagittal section of the penis showing the opening of the ejaculatory duct of the same specimen (enlarged). — F. Near mid-sagittal section of the penis (Specimen No. 1314 a). — G. Enlarged photomicrograph of the posterior part of the bursa stalk (Specimen No. 1314 b).
bc, bulbar cavity; bs, bursa stalk; buc, bursal canal; ca, common antrum; ed, ejaculatory duct; gp, genital pore; ma, male antrum; pb, penis bulb; pp, penis papilla; sd, sperm duct; v, vagina.



The outer wall of the papilla is covered with a usual glandular epithelium of a nucleate type, below which there are two layers of muscle fibres, one circular and the other longitudinal.

The copulatory bursa is a middle-sized to large organ. It is lined with a tall, glandular epithelium. The bursa stalk, a narrow and very long duct of almost a uniform diameter, runs posteriorly close to the midline and then curves ventrally and opens into the common genital antrum. Its cavity is lined with a glandular, nucleated epithelium. Below this epithelium of the anterior half of the bursa stalk, there are two layers of muscle fibres, one longitudinal and the other circular. In this region the outer thin layer of longitudinal muscle fibres which is conspicuous at the region of the posterior half of the bursa stalk (see, foregoing description) could not be seen in the authors' slides examined. The musculatures surrounding the bursa stalk become thicker in its posterior one-third region than in the anterior (Fig. 5 G). The distal part of the bursa stalk receives many ducts of eosinophilic shell glands which open into the cavity of the less-developed vagina. In this species a glandular fold or a slit is differentiated on the antero-lateral side of the common antrum (Figs. 4 A, 5 D and F). The secretion of the gland ducts contains eosinophilous granules. Two ovovitelline ducts are accompanied with many eosinophilic glands at the region of their openings (Fig. 5 D and F). Faintly eosinophilous cement glands open into the common antrum near the genital pore.

Concerning the foregoing description of the copulatory apparatus of *Dugesia schubarti* based upon the São Leopoldo specimens, there are some minor differences between the authors' material and that of "*Curtisia schubarti*" described by MARCUS (1946, pp. 143–145, 173, 244–245, pl. 28, fig. 157). His materials from the vicinities of São Paulo and Rio de Janeiro are different from the São Leopoldo material in the following histological and anatomical characters of the copulatory apparatus. Namely, both the free distal part of the penis papilla and the posterior one-third of the bursal canal (except for the posterior region or the less-developed vagina) have partially an epithelium of the in-sunk nuclei type (cf. HAUSER, 1966). Also, the epithelium of the ejaculatory duct and the surrounding musculature are more developed in the specimens of the São Paulo and the Rio de Janeiro populations than those of the São Leopoldo specimens. The bifid cavity in the penis lumen is more developed in the former material (see MARCUS, 1946, p. 245, pl. 28, fig. 156) than in the latter. A small valve located at the basal part of the ventral lip of the penis papilla was found in the specimens of the paratypes examined (Figs. 4 B, 5 A and B).

The above-described histological details in the copulatory apparatus of "*Curtisia schubarti*" coincide with the results of KAWAKATSU's observation of the paratype of that species (Figs. 4 B, 5 A–C). From this the authors can hardly avoid the conclusion that *Dugesia schubarti* which may be distributed in rather a wide geographical area along the Serra do Mar shows a slight degree of local variation in its anatomy and histology.

Material. Several whole mounts (Specimen Lot Nos. 1287 and 1381 groups)

and four sets of serial sections (Specimen Lot No. 1314 a–d) were chiefly used for this study. Three sets of serial sections (No. 1314 b, c and d) and one whole mount (No. 1381 a) will be deposited in the Department of Zoology, National Science Museum, Tokyo; the remaining slides and additional preserved specimens in alcohol (Specimen Lot Nos. 1380 and 1381 groups) are retained in KAWAKATSU's laboratory of Fuji Women's College in Sapporo, Japan. Additional materials including both slides and preserved specimens are also retained in HAUSER's laboratory of Universidade do Vale do Rio dos Sinos, São Leopoldo, Rio Grande do Sul, Brazil.

Taxonomic and faunistic remarks and differential diagnosis. Up to the present a considerable number of species of the genus *Dugesia* (s.l.) GIRARD, 1850 (cf. HYMAN, 1939, 1951) have been recorded from the continental Americas and the Caribbean islands. All of the species are listed in MITCHELL & KAWAKATSU (1973, pp. 658–660), except for several forms recently described from these geographical areas (see also BALL, 1969 a, 1974; KENK, 1972, 1974, 1975).

The following is a revised list of the American species of *Dugesia*.

North America:— *Dugesia tigrina* (GIRARD, 1850) from the entire United States and Canada; *D. microbursalis* (HYMAN, 1931) from the northeastern United States (probably a synonym of *D. tigrina*; cf. KENK, 1974, 1975); *D. dorotocephala* (WOODWORTH, 1897) from the entire United States and Mexico (cf. MITCHELL & KAWAKATSU, in press) and Guatemala (?) (cf. BALL, 1971); *D. arizonensis* KENK, 1975, from the western United States (Arizona); *D. typhlomexicana* MITCHELL et KAWAKATSU, 1973, *D. barbarae* MITCHELL et KAWAKATSU, 1973, *D. guatemalensis* MITCHELL et KAWAKATSU, 1973 (cf. MITCHELL & KAWAKATSU, in press), and *D. mackenziei* MITCHELL et KAWAKATSU, 1973, from Mexico; *D. polychroa* (SCHMIDT, 1861) from the St. Lawrence River system in East Canada and the northeastern United States (a European immigrant; cf. BALL, 1969 b; KENK, 1972, 1974).

Caribbean islands and South America:— *Dugesia antillana* KENK, 1941, from Puerto Rico; *D. aurita* (KENNELL, 1888) from Trinidad (a problematic species); *D. arimana* HYMAN, 1957, from Trinidad, St. Vincent and Caracas in Venezuela (including KAWAKATSU's unpublished data); *D. festai* (BORELLI, 1898) from Curaçao, Caracas in Venezuela, the Andes of Bolivia, Peru, Ecuador, and Colombia (including KAWAKATSU's unpublished data); *D. cubana* CODREANU et BALCESCO, 1973, from Cuba; *D. longistriata* (FUHRMANN, 1914), *D. paramensis* (FUHRMANN, 1914), *D. polyorchis* (FUHRMANN, 1914) (a problematic species; a synonym of *D. festai* ?), and *D. cameriae* (FUHRMANN, 1914) from Colombia; *D. chilla* MARCUS, 1954 (syn. ?*D. veneranda* MARTINS, 1970), *D. rincona* MARCUS, 1954, *D. dimorpha* (BÖHMIG, 1902), and *D. sanchezi* HYMAN, 1959, from Chile; *D. iheringii* (BÖHMIG, 1887) (a problematic species), *D. nonatoi* MARCUS, 1946, *D. arndti* MARCUS, 1946, *D. hypoglauca* MARCUS, 1948, *D. schubarti* (MARCUS, 1946), and *D. tigrina* (GIRARD, 1850) (syn. ?*D. jimi* MARTINS, 1970) from Brazil; *D. anceps* (KENK, 1930) from Paraguay and Argentina; *D. andina* (BORELLI, 1895) from Argentina.

Among about 29 species of *Dugesia* of the Nearctic and the Neotropical regions

listed above, the following forms bear a striking resemblance to *D. schubarti* not only in its external appearance but also in the anatomy of the reproductive system. They are: *D. antillana*, *D. arimana*, *D. paramensis*, *D. cameriae*, and *D. hypoglauca*. Externally, *Dugesia schubarti* and these five species have a head of the long-auricled shape. Anatomically, they have the dorsal testes and a slightly asymmetrical penis papilla. *Dugesia schubarti* is, however, easily separable from the above-mentioned five Caribbean and South American forms by the following details of the genital anatomy: possessing a vary large, highly muscular penis (both bulb and papilla) with a narrow bulbar cavity of a slightly bifid form at its basal part (each sperm duct opens into this part) and a rather wide ejaculatory duct; the penis lumen is surrounded by a thick muscular coat consisting of inner circular and outer longitudinal fibres. Moreover, the restricted distribution of testes is unique only in *Dugesia schubarti*.

Although the classification system of the genera *Dugesia* (s.l.) GIRARD, 1850, and *Cura* (s.l.) STRAND, 1942, and their related genera and/or subgenera is warmly discussed by BALL (1974 a, b, c), the problem has not been settled yet (see also Dr. KENK's "Indes" of the genera and species of the paludicolen triclads of the world in 1974). BALL (1974 c) placed *Dugesia schubarti* in his new genus *Neppia* BALL, 1974. If the new generic diagnosis is applied in a strict sense (*op. cit.*, p. 18), *Dugesia schubarti* should be excluded from "*Neppia*" in the following points: a highly acute triangular form of head with a long, slender, pointed auricles, a pigmented pharynx, unusual distribution of testes, a slightly asymmetrical penis papilla, variations of the musculature of bursa stalk, and with a stalked cocoon of a spherical shape (see next paragraph).

Dugesia schubarti differs from the other members of the genus in the following characters: living animal moderate to large in size (it may attain 40 mm or more in length) and dark colored with numerous, distinct, white-yellowish brown spots and usually with a mid-dorsal longitudinal black band; head highly triangular with long, slender and pointed auricles; two eyes (irregularities may occur); pharynx is pigmented and its external muscle layers consist of thin longitudinal fibres and rather thick circular fibres; dorsal testes lie in 3 to 4 rows on either side and extend to near the posterior level of the penis bulb; penis bulb large, hemispherical in shape and strongly muscular with a narrow tubular cavity (its anterior part forms a bifid cavity) into which sperm ducts enter separately from the antero-lateral side of it; slightly asymmetrical penis papilla large and conical, contains a rather wide ejaculatory duct which is surrounded by thick muscle layers consisting of inner thick circular fibres and outer rather thick longitudinal ones; copulatory bursa moderate to large, with a long and slender bursa stalk, its cavity opening into the common genital antrum; the posterior terminal portion of the bursa stalk forms a less-developed vagina into which ovovitelline ducts enter separately; the surrounding muscle layers of the bursa stalk consist of an inner thin longitudinal, a middle thick circular and an outer thin longitudinal in its posterior part (some local variations may occur in the thickness of the musculatures surrounding the bursa stalk and in the histological detail of the epithelia covering the bursal

canal and the penis papilla); cocoon spherical in shape with a stalk.

Distribution. *Dugesia schubarti* occurs in epigeal water localities in the following areas: Serra de Mantiqueira, Itatiaia, Estado do Rio de Janeiro (alt. 900–1,830 m); Umarama, Município de Campos de Jordão, Estado de São Paulo (alt. 1,750 m); Serra da Cantareira, Cidade de São Paulo (alt. 900 m); Monte Alegre, about 100 kilometers north of Cidade de São Paulo (alt. 700 m) (cf. MARCUS, 1946, p. 145); Estação Biológica de Boracéia, Município de Salesópolis, São Paulo (cf. PEREIRA, 1970); Dois Irmãos, near São Leopoldo, the southern part of the Serra do Mar, Rio Grande do Sul (alt. 450–700 m) (the authors' material was obtained here).

The distance between Rio de Janeiro and São Leopoldo attains about 1,200 kilometers. It is highly probable that the species commonly inhabits the areas of the Serra da Mantiqueira, the Serra da Cantareira and the Serra do Mar in the southern part of Brazil.

Ecological Notes and Laboratory Observations

A series of experiments (food deprivation, feeding behavior and regeneration) have already been carried out with *Dugesia schubarti* from the São Leopoldo population both in HAUSER's laboratory in the Instituto de Ciências Positivas, Universidade do Vale do Rio dos Sinos, São Leopoldo, Rio Grande do Sul, Brasil, and in Dr. ANDER LAN's laboratory of the Zoologisches Institut, Universität Innsbruck, Österreich (FRIEDRICH stayed in that laboratory during the years from 1973 to 1975). Some ecological and histological studies were also carried out by HAUSER when he stayed in the Jesuitenkolleg, Innsbruck, as a visiting professor (1975–1976; the laboratory work has been carried out in the Zoologisches Institut der Universität Innsbruck). None of the data have been published yet. Only ecological ones on this species will be given here.

The ecological nature of the São Leopoldo locality is as follows. It is a brook (a small tributary of the Sinos River) located near the provincial centre of Dois Irmãos in the vicinity of São Leopoldo (Lat. 30° S and Long. 51° W) (alt. about 700 m). The water of the stream is rich, clear, and the current is comparatively rapid. The bed of the stream is covered with pebbles. The station where planarians were obtained is shaded by many trees. An enormous number of specimens of *Dugesia schubarti* are found in the stream throughout the year (ca. 35 cm in depth; water temperature, about 13°C in late May). Planarians are also found at the lower station of the stream (alt. about 450 m).³⁾

The animals used for HAUSER's experiments in Innsbruck were collected toward

3) The animals used for KAWAKATSU's study were collected from these localities in the following seasons: July 1974 (Specimen Lot No. 1287 group); May 1975 (Specimen Lot No. 1314 group; fixed in "Susa" fluid); May 1976 (Specimen Lot Nos. 1380 and 1381 groups; fixed in Bouin's fluid). Two asexual specimens sent alive to the laboratory of KAWAKATSU were killed by SUGINO's method and fixed in NOZAWA's fluid (Specimen Lot No. 1287 group) (cf. KAWAKATSU & MIYAZAKI, 1972).

the late in August, 1975 (late winter at that latitude). Both many sexually mature specimens (commonly 25 to 30 mm in length) and a considerable number of small-sized specimens without sexual organ could be obtained. Some of the sexual specimens attain over 30 mm in length. About 30 living sexual specimens were brought into aquarium of HAUSER's temporary laboratory in Innsbruck on September 5, 1975. Those animals seem to be fully adjusted to the new water (a clean spring water). The remaining animals have been cultured in FRIEDRICH's laboratory in São Leopoldo.

Most of the animals in HAUSER's laboratory are divided into two main culture groups, viz., a lot of high water temperature culture (ca. 20°C) and a lot of low temperature culture (14–15°C; nearly the same degree of water temperature of the locality when the animals were collected). The animals are placed in plastic containers, and fed with pieces of earthworms, a clot of chicken blood, crushed chicken liver, and sometimes boiled egg-yolk (three times per week in September and October and then twice per week since November). The culture water is renewed in 6 hours after feeding. The animals of the two lots seem normal under the culture condition of standing water.

In the lot of the high temperature culture (over 20°C), the animals grew rapidly. In November of 1975, two specimens of this lot reached over 50 mm in length; the other specimens in this lot were about 40 mm in length. Sometimes the copulation of the animals were found in the culture pans, but no cocoon-deposition was observed. Moreover, in late November, degeneration of the genital pore was found in some specimens without fission. From early December, the animals were starved during five weeks. Then, the animals became smaller in size. At the end of this starvation period, their body length was reduced to 30 to 35 mm. They were fed once again after the middle of January, 1976, and they soon recovered their body length. Although every kind of food was accepted, at first the animals refused egg-yolk after the long period of starvation.

In the lot of low temperature culture (14–15°C), frequent copulations of the animals were observed. They grew slowly and reached 33 to 38 mm in length in late December. Only two animals laid cocoons at night of November 20, 1975. Several hours were required for the deposition. The fresh cocoon was of a yellowish color, then it turned into reddish brown and at last to a chocolate brown color. The cocoon was spherial in shape (2 to 3 mm in diameter) and with a thin stalk. Under the same laboratory condition, 18 young planarians in total were hatched out from these two cocoons on December 8, 1975. They were 3 to 5 mm in length, very active, and accepted foods after four days of the hatching. After about three weeks (late December) they reached 15 to 18 mm in body length. As far as HAUSER's observation goes, they had not the copulatory organs as of the end of March, 1976.

In the natural habitat of *Dugesia schubarti*, neither sexual nor fissioned specimens were found during summer and autumn (December to April). Many large-sized specimens occur even in these seasons. Otherwise, many sexually mature specimens and their cocoons are usually found during winter to early spring (late May to early

September). Experimentally, the animals show a considerable degree of regenerative capacity. They can endure the culture of water temperature at 8 to 10°C; at 4°C, they are disintegrated within 24 hours. The data of the seasonal variation of the water temperature and of the fluctuation of the population size and structure about both sexual and asexual specimens in the natural habitat are not sufficient, but it should be stressed that *Dugesia schubarti* seems to be a non-fissioning, eurythermic form inhabiting rather warm running waters.

A comparison between the breeding seasons of freshwater planarians distributed in the Northern Hemisphere and in the Southern Hemisphere is interesting. There are only incomplete and fragmentary data covering the life-cycle of planarians distributed in the temperate zone of the Southern Hemisphere. In the tropical zone, J. O. and B. M. YOUNG (1974) observed the changes in the size-structure of a population of *Dugesia* sp. (?) over a course of a year in a stream in Nairobi, Kenya. The animals of that population reproduce only agamically.

According to various literature, the cocoon-production of many *Dugesia* species distributed in the Northern Hemisphere is observed in winter, spring and early summer. The fissioning planarians reproduce asexually by fission during the summer season. Contrary to these fissioning planarians, JENKINS and BROWN (1963) reported that the animals of *Dugesia dorotocephala* (WOODWORTH, 1897) from springs in Oklahoma reproduce cocoons the year around, both in the natural habitat and in the laboratory. A constant water temperature is maintained through the year in her locality.

Dugesia japonica ICHIKAWA et KAWAKATSU, 1964, a polymorphic form and widely distributed in a vast geographical area of the Far East including the Japanese Islands, reproduces both sexually and asexually. Usually, in many populations of this species in central Japan, one to two cocoons are laid by one animal in the period from late winter to spring (February to May). After the breeding season, a high rate of mortality is observed in many populations (cf. KAWAKATSU, 1965, 1967, 1974; KAWAKATSU, YAMADA & IWAKI, 1967). TANAKA (1965) observed that about 300 specimens of *Dugesia japonica* collected from the Adaniya locality of Okinawa (Lat. 26°15'N and Long. 128°45'E) in South Japan laid about 200 or more cocoons in the period from December 24, 1964, to March 27, 1965. Cocoons are usually laid at night when the water temperature falls at 10 to 13°C. His observation is coincident with HAUSER's of the cocoon-laying habitat in *Dugesia schubarti*.

It is a well-known fact in many freshwater planarians that the mode of their reproduction is strongly controlled according to the seasonal ups and downs of the water temperature in the natural habitat (cf. KAWAKATSU, 1965, 1967). The genital organs of the animal may induce under the proper low temperature condition. On the contrary, the high temperature may reduce them and accelerate its asexual reproduction. The breeding season of *Dugesia schubarti* distributed in the southern part of Brazil which is located in the temperate zone of the Southern Hemisphere is winter to early spring as is that of many other *Dugesia* species distributed in the temperate zone of the Northern Hemisphere. However, the months of the breeding season of

the animals inhabiting each temperate zone are different according to the opposite climate of the Northern and the Southern Hemispheres.

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Summary

A poorly known Brazilian species of the genus *Dugesia* (Turbellaria, Tricladida, Paludicola), *Dugesia schubarti* (MARCUS, 1946) (olim *Curtisia schubarti*), is redescribed in the present paper. This species has dorsal testes extending from the posterior level of ovaries to the nearly posterior level of the penis bulb and a slightly asymmetrical penis papilla. The species is distributed in the areas of the Serra de Mantiqueira, the Serra da Cantareira, the Serra do Mar, and Rio Grande do Sul in the southern part of Brazil. Some anatomical and histological variations may occur in this species. The species is a non-fissioning planarian and its breeding season is winter to early spring (late May to early September in Brazil). Its cocoon is spherical in shape with a thin stalk.

Resumo

Descreve-se neste trabalho uma espécie pouco conhecida do Gênero *Dugesia*: *Dugesia schubarti* (MARCUS, 1946). A espécie é caracterizada pela distribuição dorsal dos testículos tendo o início na margem posterior de ovário e terminando nas margens anteriores do bulbo de penis. Esta espécie foi encontrada na Serra de Mantiqueira, na Serra de Cantareira e na Serra do Mar. Ultimamente foi encontrado no Rio Grande do Sul. Foram observadas variações histológicas e anatómicas nos diversos indivíduos. A espécie pertence ao grupo de planárias não autofissionantes. Seu período da reprodução é no inverno nos meses de maio até setembro. Seu cocon é redondo, brilhante e liso e possui um fino pedúnculo.

Zusammenfassung

Eine wenig bekannte Spezies der Gattung *Dugesia*, *Dugesia schubarti* (MARCUS,

1946) wird in dieser Arbeit näher beschrieben. Diese Art ist charakterisiert durch dorsale Hoden, die sich vom hinteren Niveau der Ovarien annähernd bis zum hinteren Rand vom Penisbulbus erstrecken. Die Penispapille ist schwach asymmetrisch. Eine Verbreitung der Art wurde von der Area de Serra Mantiqueira, Serra do Cantareira und der Serra do Mar beschrieben. Jetzt wurde dieselbe Spezies auch in Rio Grande do Sul in Südwestbrasilien gefunden. Es können histologische und anatomische Variationen in den einzelnen Exemplaren gefunden werden. Die Art gehört zu den sich nicht spontan teilenden Spezies. Ihre Fortpflanzungszeit wurde im Winter von Mai bis September beobachtet. Sie legen einen runden glänzenden Kokon, der einen dünnen Stiel besitzt.

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