

Redescription of *Dugesia azteca* (BENAZZI et GIANNINI, 1971)
Based upon the Material Collected from the Type Locality
in Mexico, with Corrective Remarks
(Turbellaria, Tricladida, Paludicola)

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Abstract

BENAZZI & GIANNINI (1971) described a Mexican species of freshwater planarian under the name of *Cura azteca* (Turbellaria, Tricladida, Paludicola). Our examination of newly-collected material from the type locality of this species (El Zarco, approximately 30 km SW of México, D. F., Mexico) proved that the species should be placed in the genus *Dugesia* GIRARD, 1850: *Dugesia azteca* (BENAZZI et GIANNINI, 1971). Redescription of this species is given in the present paper, together with some taxonomic remarks and distributional notes on 7 Mexican dugesiid planarians (including 3 troglobitic, 1 troglomorphic, and 3 epigeal water species) known to the present.

Introduction

In 1971, Drs. M. BENAZZI and E. GIANNINI described a new epigeal species of Mexican freshwater planarian, *Cura azteca*, based upon material collected by the members of the Italian Expedition to Mexico in 1969. Its type locality is El Zarco, Puerto de Las Cruces, México, D. F., Mexico (altitude, approximately 3100 m). Their original description of this species was based on four specimens preserved with alcohol.

In the summer of 1973, we had a chance to visit the type locality of *Cura azteca* and succeeded in collecting a considerable number of fully sexually mature specimens. After examination of serial sections of our material, we have come to the conclusion that this Mexican species should be placed in the genus *Dugesia* GIRARD, 1850, in the family Dugesiidae.

The purpose of this paper is to present a redescription of this little known species, together with corrective remarks on its taxonomy.

Habitat Description, Material and Methods

Habitat. The type locality of *Dugesia azteca* at El Zarco is a pond fed by mountain streams and clean, cold, spring waters, which is located approximately 30 km southwest of México City (El Zarco, fish hatchery operated by Instituto Nacional de Pesca, between México City and Toluca in state of Mexico; lat. 19°30'N. and long. 99°45'W.). It is located in an open area surrounded by deep forests in high-altitude Mexico (Fig. 1 A–C). The pond is approximately 25 m long, 20 m wide, has a maximum depth of 1 m (in the dry season). Water temperature of the pond is 12°C at the shore surface; pH 5.2. The water of the pond discharges into a narrow stream from a concrete lock (Fig. 1 B). There are many aquatic plants along the shore (especially, near the places where the streams flows into the pond (Fig. 1 C and D).

Planarians are found in the streams, on the surface of the muddy bottom and or pebbles, and on aquatic plants (Fig. 2 A). Other aquatic animals (isopods, freshwater shrimps, insects, etc.) are also common along the shoreline. The collection was made by MITCHELL and his family, KAWAKATSU, and Dr. F. E. ABERNETHY, on August 16, 1973. Cf. KAWAKATSU, 1976.

Materials and methods. The freshly-collected, live specimens were carefully examined by us and photographed in color, and then sketched on the spot. They were fixed with Bouin's fluid according to our standard fixing technique and then

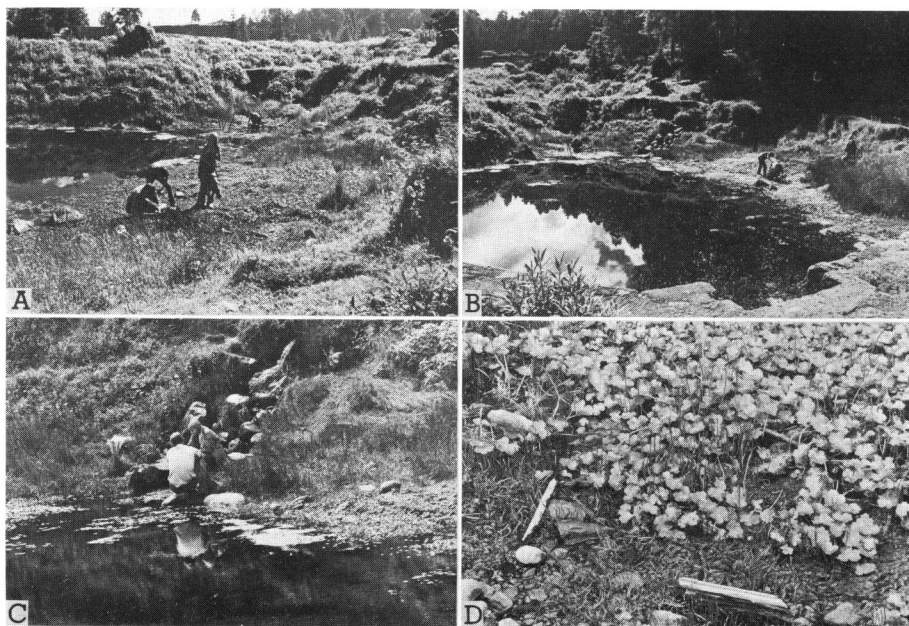


Fig. 1. Photographs showing the type locality of *Dugesia azteca* (BENAZZI et GIANNINI, 1971) at El Zarco, México, D. F., Mexico. For explanation see text.

transferred to 70% ethanol. The El Zarco collection has been designated as KAWAKATSU's Specimen Lot No. 1240. The Paraplast Plus embedded material, cut in serial sections, was stained with Delafield's hematoxylin and erythrosin.

Species Description

Order TRICLADIDA

Suborder PALUDICOLA or PROBURSALIA

Family Dugesiidae BALL, 1974

Genus *Dugesia* GIRARD, 1850

Dugesia azteca (BENAZZI et GIANNINI, 1971)

Principal literature. BALL, 1974 a, b; BENAZZI & GIANNINI, 1971; KENK, 1974; MITCHELL & KAWAKATSU, 1973a. A preliminary note on the taxonomic status of this species will be found in the footnote 1) of a paper by KAWAKATSU & MITCHELL (1982, p. 91).

External features. This is a rather large, pigmented species having a typical appearance of the long-auricled *Dugesia* species distributed in the American countries. The living, fully sexually mature specimens measured up to 20–25 mm long and 3–4 mm wide. The head is regularly triangular with a pointed tip; a pair of auricles is moderately long and pointed (Fig. 2 B and C). This characteristic head shape is lost upon fixation (Figs. 2 D; 3 A–H). There is no “neck” or narrowing of the body behind the head. The posterior end is bluntly pointed (Figs. 2 B and C; 3 A, C, E and G).

BENAZZI & GIANNINI's (1971) figure of “*Cura azteca*” on page 478 in their co-operative paper shows an oblong body form. This seems to be the typical appearance when the animals are fixed in alcohol (cf. KAWAKATSU & MIYAZAKI, 1972).

The distance between two rather small eyes, each of which surrounded by a small, non-pigmented area, is wider than one-third the width of the head at the level of eyes (Figs. 2 B–D; 3 A, C, E and G).

The uniformly pigmented pharynx is inserted slightly posterior to the middle of the body and is about one-sixth to one-seventh the body length. The genital pore opens on the midline slightly posterior to the level of the postpharyngeal region (Fig. 3 B, D, F and H).

The color of the dorsal surface is blackish-brown with numerous whitish spots. A pair of non-pigmented auricular sense organs is conspicuous (Figs. 2 B–D; 3 A, C, E and G). The ventral surface is a uniform grayish brown with numerous, small, dark brown pigments. Areas surrounded the mouth and genital pore are without pigments (Fig. 3 B, D, F and H). A pair of ovaries and of spermiducal vesicles can be seen from the dorsal surface as white, opaque organs (Fig. 3 B, D, F and H).

Internal features. The musculature of the pharynx shows the typical arrangement of the genus *Dugesia*: the internal musculature consists of two distinct layers, a

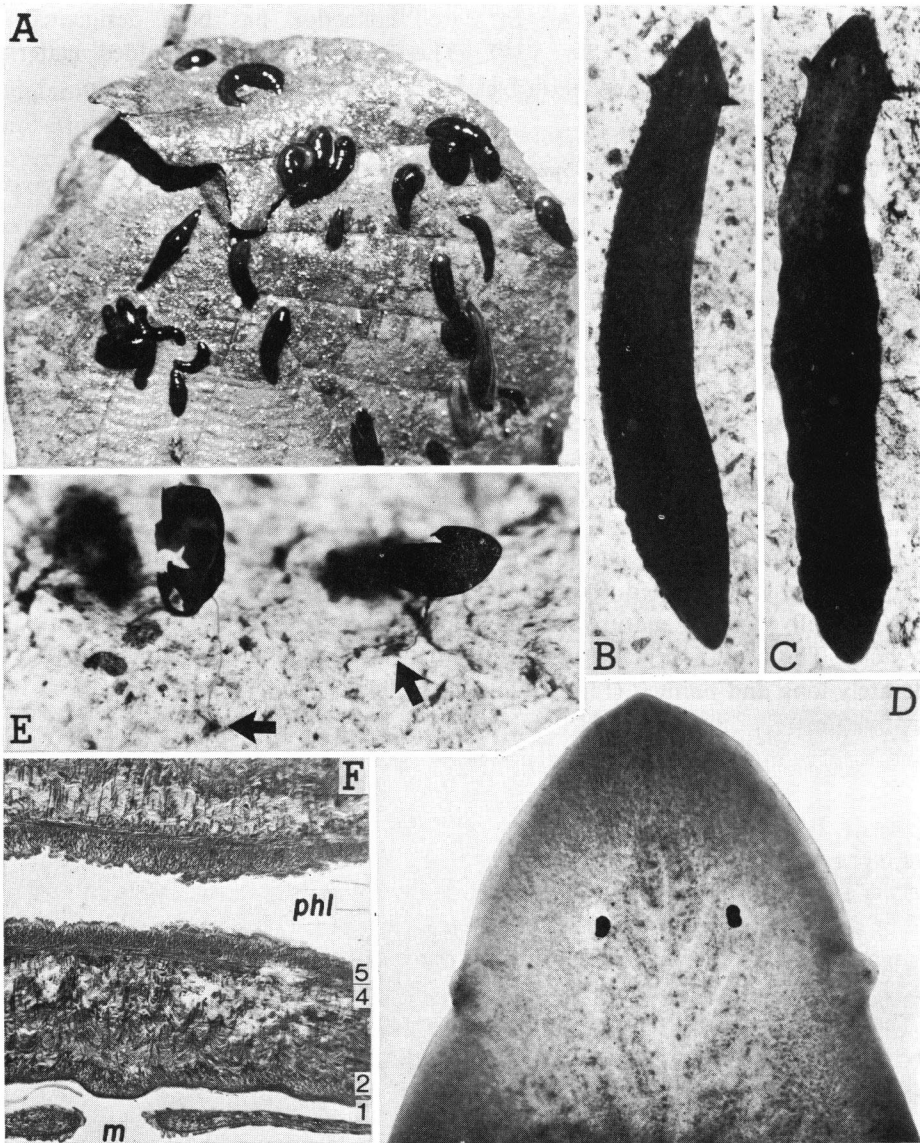


Fig. 2. *Dugesia azteca*. — A. Live specimens attached on the surface of a fallen leaf. Reproduced from a color transparency. — B and C. Dorsal view of live specimens. Reproduced from color transparencies. — D. Head of a preserved specimen (photograph taken from the whole mount; Specimen No. 1240 p). — E. Cocoon. Arrow indicates a stalk. Reproduced from a color transparency. — F. Photomicrograph of sagittal section of pharynx (Specimen No. 1240 c). m, mouth; phl, pharynx lumen; 1, longitudinal fibers of outer muscle zone; 2, circular fibers of outer muscle zone; 4, longitudinal fibers of inner muscle zone; 5, circular fibers of inner muscle zone.

thick circular layer adjacent to the epithelium of the pharynx lumen and a thinner layer of longitudinal fibers. The outer pharyngeal musculature consists of two layers, a thinner one of longitudinal fibers situated beneath the outer epithelium and a thicker layer of circular fibers beneath the longitudinal ones (Fig. 2 F). The anterior intestinal trunk has 12 to 15 branches on each side; each posterior trunk has 18 to 20 short lateral branches.

A pair of ovaries occurs in the usual ventral position between the third and fourth diverticula of the intestine (Figs. 3 B, D and F; 4 A) Yolk glands (or vitellaria) are distributed throughout the body in the surrounding parenchyma.

Testes are dorsal, rather large, numerous, and are arranged on either side of the midline in two to three longitudinal rows extending from the posterior level of the ovaries almost to the level of the genital pore (Fig. 4 B-E). They are large in size at

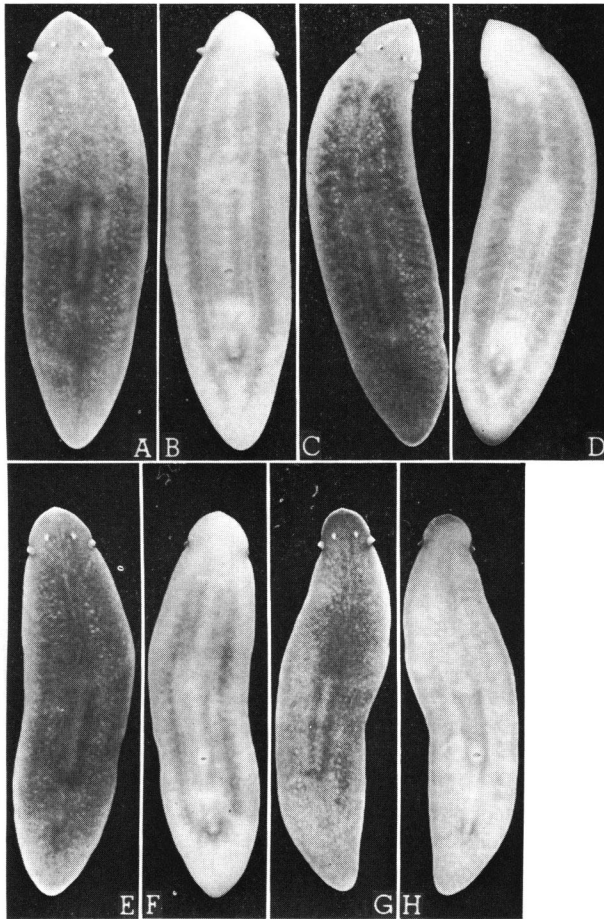


Fig. 3. *Dugesia azteca*, photographs of 4 preserved specimens (Specimen Lot No. 1240). — A, C, E and G. Dorsal view. — B, D, F and H. Ventral view.

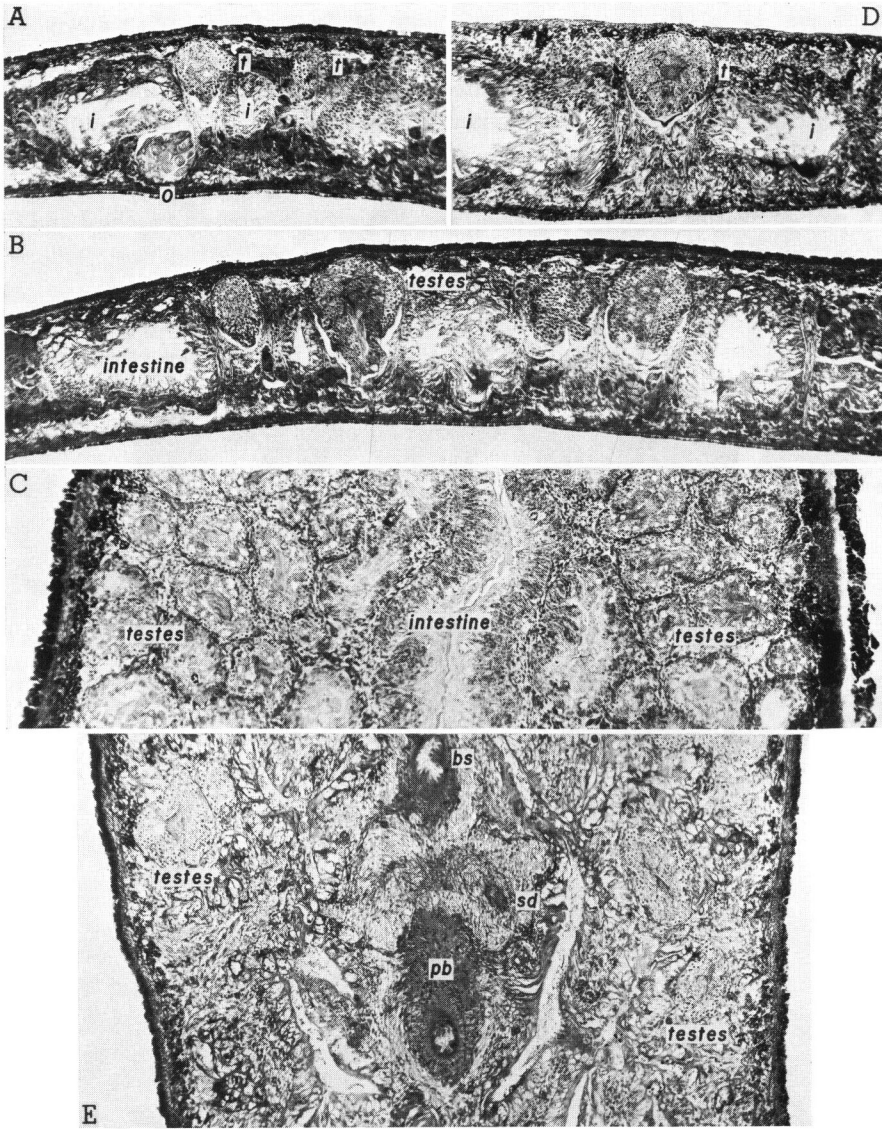


Fig. 4. *Dugesia azteca*, photomicrographs of sagittal sections (A, B and D) and horizontal sections (C and E). — A. Anterior part of the prepharyngeal region. Ovary and dorsal testes (No. 1240 e). — B. Part of the prepharyngeal region. Dorsal testes (No. 1240 c). — C. Part of the prepharyngeal region. Testes (No. 1240 m). — D. Part of the postpharyngeal region. Dorsal testes (No. 1240 c). — E. Part of the postpharyngeal region. Testes and copulatory apparatus (No. 1240 l). bs, bursal stalk; i, intestine; o, ovary; pb, penis bulb; sd, sperm duct; t, testis.

the prepharyngeal region and some of them occupy almost all the dorsoventral space of parenchyma between the intestinal diverticula (Fig. 4 B). At the pharyngeal and postpharyngeal regions, rather small testes occur in two or three vertical layers. Total number of testes in the larger specimens is estimated to be between 200 and 300. Two sperm ducts form the moderately developed spermiducal vesicles on either side of the middle part of the pharynx and the penis bulb (Fig. 3 B and D).

BENAZZI & GIANNINI (1971, p. 478) wrote the arrangement of testes in "*Cura azteca*" as follows: "I follicoli testicolari, che meritano particolare attenzione ai fini diagnostici, sono posti dorsalmente e tutti prefaringei. Il più anteriore si trova ad una distanza di mm 1,60 dall'estremo cefalico, tra il terzo e il quarto ramo secondario

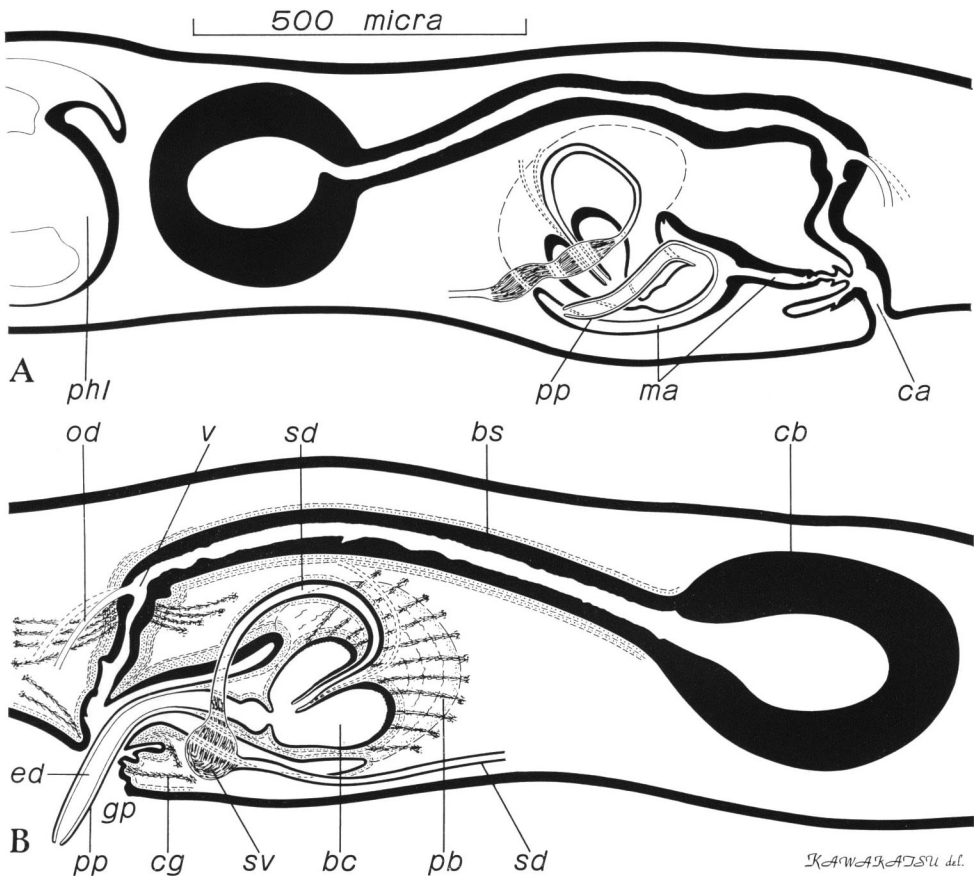
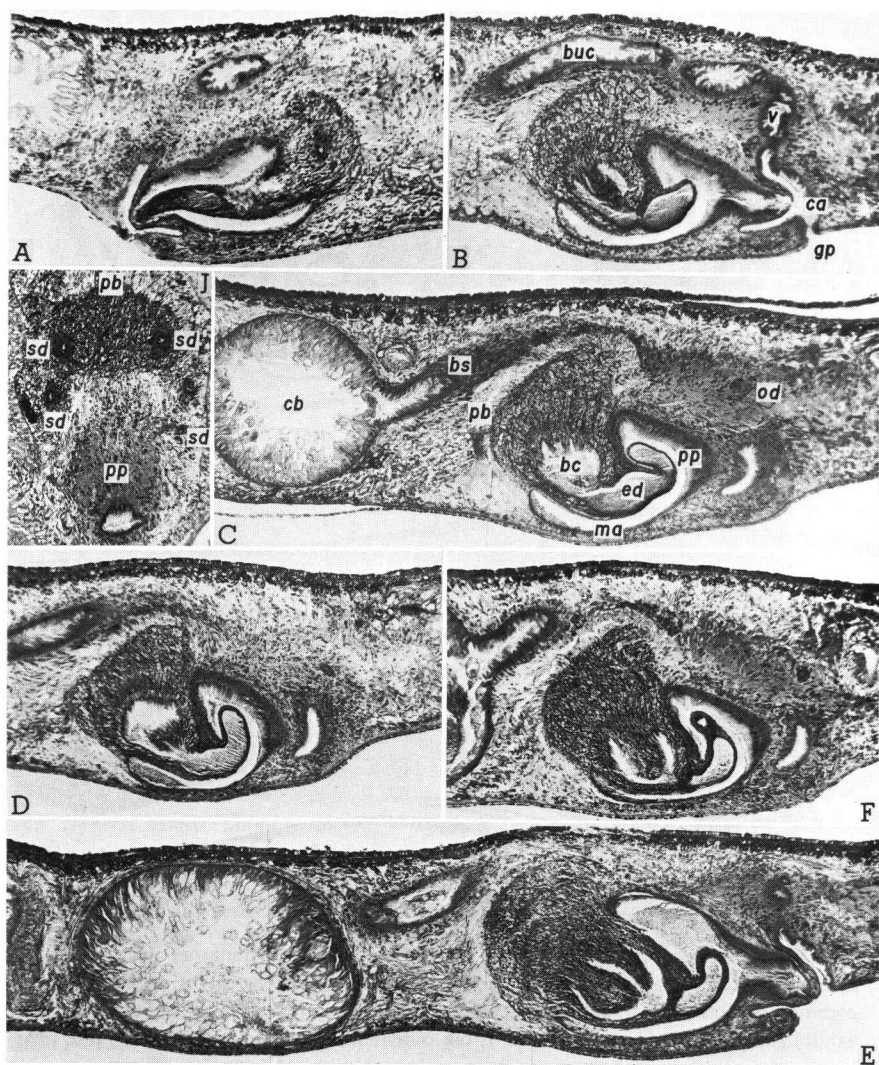


Fig. 5. *Dugesia azteca*, semidiagrammatic sagittal view of the copulatory apparatus. — A. Specimen No. 1240 c. — B. Specimen No. 1240 j. bc, bulbar cavity; bs, bursal stalk; ca, common genital antrum; cb, copulatory bursa; cg, cement gland; ed, ejaculatory duct; gp, genital pore; ma, male genital antrum; od, ovovitelline duct; pb, penis bulb; phl, pharynx lumen; pp, penis papilla; sd, sperm duct; sv, spermiducal vesicle; v, vagina.

dell'intestino; seguono altri due (o tre) follicoli posti tra il quarto e il quinto ramo, ed infine un ultimo tra il quinto e il sesto ramo intestinale. Tutti i follicoli sono in piena spermatogenesi." Thus, he classified his specimens as a member of the genus *Cura* STRAND, 1942. This is quite different from our observation of the new material.

Sagittal views of the copulatory apparatus of two specimens of *Dugesia azteca* from the type locality are shown in Fig. 5 (A and B), and pertinent photomicrographs of the apparatus are shown in Fig. 6 (A–J).

The penis consists of a large, hemiglobose bulb and an elongate, conical-shaped papilla of a symmetrical form, of which middle and terminal sections form a finger-



like tube (Figs. 5 A and B; 6 A and G). The bulb is moderately muscular in nature and contains a wide bulbar cavity (seminal vesicle). The recurved course of the sperm ducts which open into the bulbar cavity separately, is characteristic in this species. Each of them forms a long, narrow, thin walled tube from a level near the middle part of the pharynx to the posterior level near the base of the penis papilla. Then, it forms one or two swellings containing a mass of sperms (spermiducal vesicle). Anterodorsally, the spermiducal vesicle continues as a long, slightly wide and curved tube (posterior part of the sperm duct); anteroventrally and medially, it runs into the penis bulb, and finally opens into the anterior part of the bulbar cavity from its lateral side (Figs. 5 A and B; 6 A and J). The wall of the posterior part of the sperm duct is covered with a nucleate epithelium, below which there are two muscle layers, a thin circular one and the outer, thin longitudinal one.

The bulbar cavity is lined with a glandular epithelium of a nucleate type (it is thicker in the anterior part than in the posterior one). The muscular coat surrounding the anterior part of the bulbar cavity consists of a muscle layer of intermingled circular and longitudinal fibers; in the posterior part, it consists of an inner, thin circular layer and an outer, thin longitudinal layer. The bulbar cavity continues to the penis

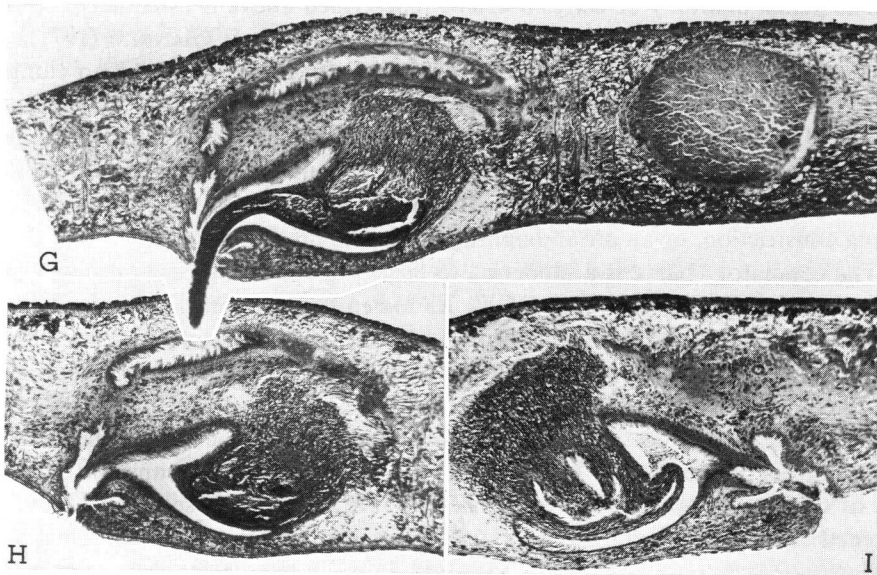


Fig. 6 (on pp. 44-45). *Dugesia azteca*, photomicrographs of sagittal sections (A-I) and horizontal section (J) of the copulatory apparatus. — A. Penis (No. 1240 a). — B and C. Penis (No. 1240 c). — D. Penis (No. 1240 d). — E. Penis (No. 1240 e). — F. Penis (No. 1240 i). — G and H. Penis (No. 1240 j). — I. Penis (No. 1240 k). — J. Penis (No. 1240 l). bs, bursal stalk; buc, bursal canal; ca, common genital antrum; cb, copulatory bursa; ed, ejaculatory duct; gp, genital pore; ma, male genital antrum; od, ovovitelline duct; pb, penis bulb; pp, penis papilla; sd, sperm duct; v, vagina.

papilla as a rather wide, tubular cavity, the ejaculatory duct, which opens a tip of the papilla. A slight degree of constriction is found at the beginning of the ejaculatory duct (Figs. 5 A and B; 6 B-I). The lining epithelium and the surrounding musculature of the anterior section of the ejaculatory duct are the same as those of the posterior part of the bulbar cavity.

The very long penis papilla is weakly muscular and is protruded into the male genital antrum, which has a deep, cup-shaped form. In some slides examined, the tip of the finger-shaped, tubular papilla is protruded from the genital pore as shown in Figs. 5 (B) and 6 (G). In many other slides, the tip of the papilla is coiled in the male antrum (Figs. 5 B; 6 B-F, I). In those specimens preserved in the latter condition, the posterior part of the male antrum forms a narrow, tubular cavity, which is sharply separated from the common antrum by a striking constriction, or an atrial diaphragm (Figs. 5 B; 6 B, C, E, H and I). The dorsal part of the penis papilla and the roof of the male antrum are lined with a tall, glandular, nucleate epithelium, below which there are two muscle fibers, a thick circular one and an outer, slightly thick longitudinal one. The lining epithelium and the muscle coat of the ventrobasal part of the papilla and the floor of the male antrum are thinner than those of the dorsal side.

The penial anatomy of *Dugesia azteca* redescribed above is essentially coincident with the original description of "*Cura azteca*" by BENAZZI & GIANNINI (1971). The penis papilla in their figures (op. cit., p. 479, fig. 1, pl. I, fig. 2) shows an elongated, conical shape. Their specimen may have been strongly contracted. These authors mentioned the presence of a "diverticolo dell'atrio comune" (see fig. 2 on page 479 and figs. 2 and 3 in pl. I). This character is also found in our specimens (it accompanies erythrophilous glands; see Fig. 5 B). We mentioned this character as "a striking constriction, or an atrial diaphragm", in the present paper.

The copulatory bursa is a moderate to large organ of a globose or an ellipsoidal form (Figs. 5 A and B; 6 C, E and G). Its lumen is lined with a tall, glandular epithelium. The bursa stalk, a rather wide and long duct of almost uniform diameter, runs posteriorly from the copulatory bursa and opens into a narrow common genital antrum at closely near position of the genital pore (Figs. 5 A and B; 6 A, B, G and H). The dorsal and both lateral sides of the anterior three-fourth's of the stalk have a muscular coat consisting of a thin layer of inner circular fibers and an outer, thin layer of longitudinal ones; the ventral side of the stalk in this section has a slightly thickened muscle coat consisting of intermingled circular and longitudinal fibers. The posterior one-fourth section of the stalk forms a less-developed vagina and accompanies a thick muscular coat consisting of inner thick circular fibers and an outer, slightly thickened longitudinal one. The two ovovitelline ducts accompanying erythrophilous glands open separately into the vagina (Figs. 5 A and B; 6 C). The glandular epithelium of the bursal canal has nuclei along its entire course. Weakly erythrophilous cement glands open into the common genital antrum near the genital pore.

Several cocoons, or egg capsules, were obtained from the type locality when we collected the animals. The globose cocoon, having a stalk, measures up to 2.5–3 mm in diameter (Fig. 2 E).

Material. Fifteen sets of sagittal, horizontal and transverse sections (Specimen Lot No. 1240 a–o) and whole mouths. Some of the sections and of the preserved, sexually mature specimens are deposited in the Department of Zoology, National Science Museum, Tokyo (NSMT-PI 2937). Several preserved specimens were sent to Dr. Roman KENK of the National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A., as reference material. The remaining sections and the specimens in 70% ethanol are retained by the authors' laboratories in Sapporo (Biological Laboratory, Fuji Women's College), Japan and in Lubbock (Texas Tech University), Texas, U.S.A.

Locality. A pond and mountain streams associated with it, near México, D.F., Mexico. More detailed collection data, see the foregoing section, "Habitat, etc."

Taxonomic remarks and differential diagnosis. Up to the present, over 30 species of the genus *Dugesia* (s.l.) are known from North, Central, and South Americas. The literature and some explanatory notes on these species will be found in a recent paper by KAWAKATSU, HAUSER, FRIEDRICH, OKI, TAMURA & YAMAYOSHI (1983). This paper includes an original description of *Dugesia anderlani* KAWAKATSU et HAUSER, 1983, from South Brazil.

Among these American *Dugesia* species, only two species are known that, have long (or moderately long) auricles and the dorsal testes extending posteriorly to the level of the copulatory apparatus. They are: *Dugesia schubarti* (MARCUS, 1946) from the southeastern area of Brazil (cf. MARCUS, 1946; KAWAKATSU, HAUSER & FRIEDRICH, 1976, 1980; KAWAKATSU, HAUSER, FRIEDRICH & SOUZA LIMA, 1982) and *Dugesia arizonensis* KENK, 1975, from Arizona in the United States.

Externally, *Dugesia schubarti* has a highly pointed anterior end and paired, very long auricles. Its penial anatomy is very different from that of *Dugesia azteca*. *Dugesia arizonensis* has a head with a pointed tip and very long auricles (see KENK, 1975, p. 114, figs. 1 and 2). The latter species has the testes in the semidorsal position, extending posteriorly to the level of the copulatory apparatus; a rounded penis bulb and a symmetrical, elongate, pointed penis papilla; a recurving of the sperm ducts before entering the penis; the possession of a wide bulbar cavity; and the separation of the male antrum from the common antrum by the atrial diaphragm (see KENK, 1975, p. 116, fig. 3, 0. 117, fig. 5). All these characters in the genital anatomy of *D. arizonensis* show great resemblance to those of *D. azteca*. However, the latter can easily be separable from the former by the differences in external appearance, the details of the histology of the genital organs, and genital anatomy (the shape of the penis papilla, the position of the openings of the sperm ducts, the low position of the opening of the bursal canal, etc.).

Dugesia azteca is the seventh dugesiid species recorded from Mexico. Three of seven species are the white, eyeless, troglobitic forms inhabiting cave waters:

Dugesia barbarae MITCHELL et KAWAKATSU, 1973, *Dugesia typhlomexicana* MITCHELL et KAWAKATSU, 1973, and *Dugesia mckenziei* MITCHELL et KAWAKATSU, 1973. Only *D. mckenziei* has a pair of very small eyes. The fourth species is a troglophilic form: *Dugesia guatemalensis* MITCHELL et KAWAKATSU, 1973 (see also KAWAKATSU & MITCHELL, 1981a). *D. guatemalensis* has a slight resemblance to *D. azteca* in the external appearance, in having the symmetrical, conical, long, pointed penis papilla, the position of the opening of the sperm ducts, etc. However, both species can easily be separated by the difference in arrangement of dorsal testes, the course of the sperm ducts, the shape and the histology of the penis papilla, the anatomy of the genital antra, etc. The localities of these four troglotic and troglophilic species are indicated in a recent paper by REDDELL (1981, p. 71, fig. 3). The two remaining species are epigeic forms: *Dugesia dorotocephala* (WOORWORTH, 1897) and *Dugesia tigrina* (GIRARD, 1850). The former is common in the northeastern and central areas of Mexico (cf. KAWAKATSU & MITCHELL, 1981 b; see also BALL, 1971). The range of the latter in Mexico (cf. KENK, 1974) is not yet well known. According to Dr. R. KENK (pers. comm.), the only record of the occurrence of *Dugesia tigrina* in Mexico that is known to him is in the paper by RIOY & HERRERA (1951, p. 575). They recorded the occurrence of "*Euplanaria maculata*" from ponds and canals in the vicinity of the towns of Lerma, San Mateo Atenco, and Tultepec (on the road from México City to Toluca, 59 km from México City; alt. 2573 m).

Dugesia azteca differs from the other members of the genus in the following characters: living animal moderately large in size (20–25 mm long and 3–4 mm wide) and blackish-brown colored with numerous whitish spots; head triangular with moderately long auricles; two rather small eyes; external pharyngeal musculature of outer longitudinal and inner circular layers; dorsal testes rather large, in two or three longitudinal rows on either side extending the level of the genital pore; penis bulb large, hemiglobose and moderately muscular with a wide bulbar cavity; symmetrical penis papilla very long, elongate, conical and weakly muscular; ejaculatory duct rather wide and tubular; sperm ducts forming the spermiducal vesicles at the anterior level near the genital pore, recurved, and opening into the anterior part of the bulbar cavity separately; copulatory bursa moderate to large in size, with a rather wide bursal canal opening into the narrow common genital antrum near the genital pore; the posterior one-fourth of the bursa stalk forming a less-developed vagina into which ovovitelline ducts enter separately; male genital antrum separated from the common antrum by atrial diaphragm (this character is unclear when the penis papilla is elongated); all epithelia of the copulatory apparatus are nucleate; cocoon spherical and stalked.

Acknowledgements

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Note added in proof: Since this manuscript went to the press, the following relational papers were published.

HIRANO, M., & M. KAWAKATSU, 1983. Freshwater algae from the Southern United States and México. I. Diatoms. *Bull. Fuji Women's Coll.*, (21) (II): 113–134 (pls. I–X).

KAWAKATSU, M., J. HAUSER & S. M. G. FRIEDRICH, 1983. Morphological, etc. V. *Dugesia tigrina* (GIRARD, 1850) from Município Botucatu, Estado de São Paulo, and *Dugesia schubarti* (MARCUS, 1946) from the vicinity of São Paulo (Turbellaria, Tricladida, Paludicola). *Ibid.*, (21) (II): 147–163.

———, R. W. MITCHELL & S. INOUE, 1984. A freshwater planarian from South Chile collected by the members of two Japanese limnobiological expeditions into Chile: *Cura patagonica* (BORELLI, 1901) (Turbellaria, Tricladida, Paludicola). *J. Fac. Agric., Hokkaido Univ.*, **61** (4): 377–398.