Freshwater Triclads (Turbellaria) of North America, V: The Genus *Polycelis*

ROMAN KENK

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY · NUMBER 135

SERIAL PUBLICATIONS OF THE SMITHSONIAN INSTITUTION

The emphasis upon publications as a means of diffusing knowledge was expressed by the first Secretary of the Smithsonian Institution. In his formal plan for the Institution, Joseph Henry articulated a program that included the following statement: "It is proposed to publish a series of reports, giving an account of the new discoveries in science, and of the changes made from year to year in all branches of knowledge." This keynote of basic research has been adhered to over the years in the issuance of thousands of titles in serial publications under the Smithsonian imprint, commencing with *Smithsonian Contributions to Knowledge* in 1848 and continuing with the following active series:

Smithsonian Annals of Flight
Smithsonian Contributions to Anthropology
Smithsonian Contributions to Astrophysics
Smithsonian Contributions to Botany
Smithsonian Contributions to the Earth Sciences
Smithsonian Contributions to Paleobiology
Smithsonian Contributions to Zoology
Smithsonian Studies in History and Technology

In these series, the Institution publishes original articles and monographs dealing with the research and collections of its several museums and offices and of professional colleagues at other institutions of learning. These papers report newly acquired facts, synoptic interpretations of data, or original theory in specialized fields. These publications are distributed by mailing lists to libraries, laboratories, and other interested institutions and specialists throughout the world. Individual copies may be obtained from the Smithsonian Institution Press as long as stocks are available.

S. Dillon Ripley
Secretary
Smithsonian Institution

SMITHSONIAN CONTRIBUTIONS TO ZOOLOGY • NUMBER 135

Freshwater Triclads (Turbellaria) of North America, V: The Genus *Polycelis*

Roman Kenk

SMITHSONIAN INSTITUTION PRESS
City of Washington
1973

ABSTRACT

Kenk, Roman. Freshwater Triclads (Turbellaria) of North America, V: The Genus *Polycelis*. *Smithsonian Contributions to Zoology*, number 135, 15 pages, 9 figures, 1973.—Two species of *Polycelis* occur in North America, belonging to two different subgenera, *P.* (*Polycelis*) *coronata* (Girard) and *P.* (*Seidlia*) *sierrensis*, new species. They cannot be distinguished by their external appearance but only by the anatomy of their reproductive systems. *P. coronata* is represented by three subspecies, *P. c. coronata* with large penis papilla and predominantly secretory bursal duct; *P. c. borealis* Kenk with moderately developed penis papilla and nonsecretory bursal duct; and *P. c. brevipenis* Kenk with reduced penis papilla and secretory bursal duct. The anatomical features of the various forms are described and all known distributional records collected. A comparison is made of the anatomy of *P. sierrensis* with that of a closely related Japanese species, *P. auriculata* Ijima and Kaburaki.

Official publication date is handstamped in a limited number of initial copies and is recorded in the Institution's annual report, Smithsonian Year.

COVER DESIGN: *Montastrea cavernosa* (Linnaeus).

Library of Congress Cataloging in Publication Data
Kenk, Roman, 1898–
Freshwater triclads (Turbellaria) of North America, V: the genus Polycelis.
(Smithsonian contributions to zoology, no. 135)
Bibliography: p.
1. Polycelis. 2. Turbellaria—North America. I. Title. II. Series: Smithsonian Institution. Smithsonian contributions to zoology, no. 135.
QL1.S54 no. 135 [QL391.T75] 591'.08s [595'.123] 72–7410

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 45 cents (paper cover)

Contents

Freshwater Triclads (Turbellaria) of North America, V: The Genus *Polycelis*

Roman Kenk

Introduction

Information on the occurrence of the genus *Polycelis* in North America is rather meager and scattered in the literature. The first representative of this genus was discovered in 1877 by Joseph Leidy in a spring near Fort Bridger, Wyoming. Leidy himself did not report on this finding, but apparently handed his notes and collections over to Charles Girard, who in 1891 published a brief description of the species, without figures, under the name of *Phagocata coronata,* new species. In 1893, Girard expanded his preliminary account and added illustrations and some of Leidy's field observations. Hallez (1894:179) recognized the species as probably belonging to the genus *Polycelis* and stated that it might be identical with the European *Polycelis nigra* (O. F. Müller). This assumption was apparently based on Girard's (1893) inaccurate plate 5, figure 48, which actually resembles the European species in the contour of the anterior end and the marginal position of the eye spots; plate 5, figure 49, of the same animal but with greater magnification, corresponds better to the appearance of a preserved specimen of the American form. Stringer (1918:358) included *Polycelis coronata* in her key to American freshwater Turbellaria and reproduced Girard's (1893) figure 48 and description without having seen additional specimens. She also admitted the possible identity of the species with *P. nigra.* Muttkowski (1918:389) reported *"Polycelis nigra"* from Lake Mendota, Wisconsin, and in a later paper (1929:183) from streams in Yellowstone National Park, Wyoming.

The first modern study of an American *Polycelis,* including an analysis of its anatomical features, was carried out by Hyman (1931). Hyman, who had been informed by J. H. Powers that a species of *Polycelis* occurred in the Black Hills of South Dakota, visited that area herself and collected *Polycelis* in two streams, including sexually mature specimens. In their external appearance the animals conformed with Girard's (1893:173) description of the form from Fort Bridger. Therefore, Hyman considered them to be identical with Girard's species, designated them as *Polycelis coronata,* and furnished a detailed description of their anatomical characters. In later papers she indicated the distribution of the species (1951:162) to be "Black Hills of South Dakota westward to the northwest Pacific coast," and stated (1953:132) that it "probably occurs generally in the western states at suitable altitudes and temperatures." She (1963:1–2) mentioned as specific record "the vicinity of Crystal Springs in the Eastmoreland District of Portland," Oregon. In the collections of the Smithsonian Institution are nine lots of specimens (USNM 36070 through 36078) collected in 1937 by D. M. Pike in Mount Rainier National Park, Washington, and identified on the labels by Hyman as *P. coronata.* Hyman may have seen additional materials from other localities. It appears, however, that she did not examine the anatomy of any of these specimens except the ones from South Dakota.

Roman Kenk, Department of Invertebrate Zoology, National Museum of Natural History, Smithsonian Institution, Washington, D.C. 20560.

Polycelis was recorded from the Rocky Mountain National Park region in Colorado by Kenk (1952). As the structure of the reproductive system coincided with that of Hyman's (1931) specimens, the worms were assigned to the species *P. coronata*. Kenk also mentioned their occurrence on the Eastmoreland golf course in Portland, Oregon, and on Skalkaho Pass, Ravalli County, Montana, where they had been collected by Betty Locker. Specimens from these two localities had not been studied anatomically.

A new species of *Polycelis, P. borealis,* was described by Kenk (1953:168–173) from about 30 localities in southern Alaska. Six of the lots contained sexually mature animals and were examined in serial sections.

Beck (1954) reported *P. coronata* from springs and streams in seven counties of Utah. He discussed its general external morphology and natural history but did not study its anatomical characteristics. It remained for Braithwaite (1962), one of Beck's students, to make a more thorough investigation of the anatomy of the *Polycelis* from Utah, on which he reported in his unpublished Master of Science thesis. Examination of the reproductive system of specimens from one of Beck's localities (on Mt. Timpanogos, Utah County) revealed certain differences from the published anatomical accounts of the North American representatives of the genus. Braithwaite made a careful comparison of the copulatory complex of his specimens with the available descriptions of *P. coronata* from South Dakota by Hyman (1931) and of *P. borealis* from Alaska by Kenk (1953). In the absence of an adequate description of worms from Girard's type-locality, Fort Bridger, he could not settle the question whether the name *P. coronata* should be applied to the species from Utah or to that of North Dakota, or if the Utah form represented a new taxon.

Additional finds of *Polycelis* species were reported by Holmquist (1967:463) from southern Alaska, by Kennedy (1967:8) from Mono County, California, and by Ball and Fernando (1968) from Jasper National Park in Alberta, Canada. Carpenter (1969:280) recorded the presence of *P. coronata* in several springs and streams in Logan Canyon, Cache County, Utah. Two of Carpenter's localities were mentioned also in one of my recent papers (Kenk, 1970:22) in addition to *Polycelis* species of Nevada County, California.

On two field trips in 1967 and 1970, I succeeded in collecting *Polycelis* in two springs near Fort Bridger, Uinta County, Wyoming, one of which may well have been the spring in which Leidy had discovered Girard's species in 1877. The animals proved to be specifically identical with those from Utah. In a key to the North American freshwater triclads I (1972) attempted to differentiate between the various morphologically distinct units, combining the described forms under one species, *P. coronata,* with the nominate subspecies *P. c. coronata* from Fort Bridger and Utah, the subspecies *P.c. borealis* from Alaska, and introducing a new subspecies, *P.c. brevipenis,* for the form from South Dakota and Colorado. In addition I studied a *Polycelis* from the Sierra Nevada which proved to be specifically and subgenerically different from *P. coronata.*

ACKNOWLEDGMENTS.—This study was in part supported by National Science Foundation Grant GB–6016 to the George Washington University. Thanks are due also to many individuals who have served as guides or collaborators in the field work or have furnished specimens or valuable information: Reed Bluemel, Dr. Lee F. Braithwaite (Brigham Young University), Dr. C. J. D. Brown, (Montana State University), R. Andrew Cameron, Jerry H. Carpenter, Frank P. Crawley, Robert A. Dalton (Bear Lake Biological Station, Utah), Jack L. Dean (U. S. Fish and Wildlife Service, Yellowstone National Park), Peter N. D'Eliscu and Dr. M. H. Gunnell (Utah State University), Dr. John C. Harshbarger (Smithsonian Institution), Vernon M. Hawthorne (Sagehen Creek Biological Station, California), Timothy F. Hicks, Dr. Vida C. Kenk (San Jose State College), John Matrisciano, Dr. G. Wayne Minshall (Idaho State University), Robert E. Olson, Melvin B. Taylor, Michael W. Tunicliffe and Richard Whitten (Powell Laboratories, Gladstone, Oregon).

Genus *Polycelis* Ehrenberg, 1831

The genus *Polycelis* was established by Ehrenberg (1831:2) for turbellarians with branched intestine ("Dendrocoela") which possess numerous eyes arranged in a row at the anterior end. Originally the genus contained two European freshwater

triclads, Müller's (1774:54) *Fasciola* or *Planaria nigra,* and *P. brunnea.* Later authors enlarged the genus by adding to it representatives of terricolous triclads and of polyclads which conformed to Ehrenberg's definition. Stimpson (1857:24) and Diesing (1862:508) again restricted *Polycelis* to freshwater triclads. At present the genus is placed in the family Planariidae of the Tricladida Paludicola which is characterized by having the internal muscle zone of the pharynx composed of two distinct layers of muscle fibers, a circular layer adjoining the epithelium and a longitudinal layer. The present definition of *Polycelis* is as follows: Planariidae in which the oviducts, without embracing the bursa stalk, unite to an unpaired duct which opens into the genital atrium; zone of testes extending to the level of the pharynx; male atrium without radial muscle plates; eyes numerous. Type-species, *Fasciola nigra* O. F. Müller (Kenk, 1930:294).

In 1930, I proposed to divide the genus *Polycelis* into two subgenera, *Polycelis,* sensu stricto, without adenodactyls (or muscular gland organs) and *Ijimia* Bergendal (type-species, *Polycelis tenuis* Ijima) with solid adenodactyls attached to the genital atrium (Kenk, 1930:294). Later investigations, however, particularly those of Lepori (1955), show that adenodactyls may be either present or absent in *P. tenuis.* There are also indications that *P. tenuis* and *P. nigra* may interbreed in the laboratory although this question is not finally settled (Benazzi, 1963). In any case, the subgenus *Ijimia* as based on the presence of adenodactyls can no longer be retained.

A group of species of *Polycelis* of the Asian continent and the Japanese islands shows an extraordinary thickness of the muscle coat surrounding the male atrium. I reintroduced Zabusov's (1911, appendix, page 7) subgeneric name *Seidlia* for this group (Kenk, 1953:172), with the type-species *Sorocelis sabussowi* Seidl (1911:36). Both subgenera, *Polycelis* and *Seidlia,* are represented in North America.

Subgenus *Polycelis*

Male atrium without excessively developed muscle coat.

Polycelis (P.) coronata coronata (Girard, 1891)

FIGURES 1, 2, 3, 6A, B

Phagocata coronata Girard, 1891:80.
Polycelis coronata.—Hallez, 1894:172, 179.

EXTERNAL FEATURES.—Adult specimens are 12–20 mm long and 1.5–2.5 mm wide when gliding quietly. The anterior end is truncate, with gently convex frontal margin and a pair of rather prominent auricles projecting laterally (Figure 1). These auricles, when seen from above, appear triangular, with bluntly pointed or rounded tips. During locomotion they are raised above the substrate. Behind the auricles the head narrows insignificantly, forming a "neck." Behind the neck, the lateral

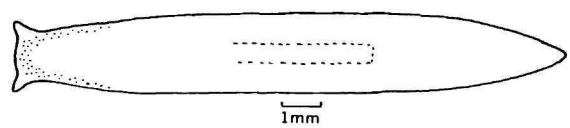

FIGURE 1.—*Polycelis coronata coronata,* outline sketch of living animal.

margins of the body gradually diverge and soon reach the maximum width. In the last third or fourth the margins converge again to meet in the rounded posterior end.

The color of the dorsal side is a variable shade of brown, from light brown to almost black, appearing somewhat mottled under magnification, with lighter areas above the pharynx and copulatory complex. The ventral side is also pigmented but somewhat lighter. The eyes (Figure 6A, B) are numerous and are arranged in a band, more than one row wide, extending along the frontal margin, the base of the auricles, and about one-fifth to one-fourth the prepharyngeal lateral margin where they taper to a single row. The band may narrow to some extent in the frontal midline or at the base of the auricles but this is not the case in all individuals. The auricular projections themselves are free of eye spots. The number of the eyes varies and increases in the course of the growth of the animal. Beck (1954:81) counted from 28 to 70 eyes on any one side of his specimens. The eyes are seen as small, reniform, black spots, lacking the white, pigment-free areas usually associated with the eyes of two-eyed pigmented planarians.

The locomotion of the species is by gliding only; no "crawling" movements have been observed. In laboratory cultures the worms are frequently seen gliding on the underside of the surface film in the aquarium, a tendency that is mentioned also by

Braithwaite (1962:22) who observed them in nature in stagnant pools during the night and early morning, while in daytime they were found on the undersurfaces of submerged objects.

ANATOMY.—The digestive system shows no peculiarities. On account of the pigmentation of the body, the branching of the intestine can rarely be analyzed in the living animal. In preserved and cleared specimens I counted 5–8 lateral branches on each side of the anterior intestinal ramus and 14–16 branches on each posterior ramus. The pharynx is rather large, its length amounting to about one-fourth the body length in adult specimens. The arrangement of the pharyngeal muscles is of the planariid type, the fibers of the internal muscle zone forming two separate layers, a circular and a longitudinal one.

REPRODUCTIVE SYSTEM.—The densely clustered, large testes are situated in a pair of short bands occupying chiefly the areas between the anterior intestinal ramus and the ventral nerve cord on either side and extending from behind the first or second lateral branch of the intestine to the insertion of the pharynx. Their position is ventral, although a few individual follicles may be pushed toward the dorsal side. The thin anterior sperm ducts or vasa deferentia run along the medial sides of the ventral nerve cords, close to the ventral integumental muscle layers. They connect with the individual testes by means of short branches, the vasa efferentia or sperm ductules. In the region of the pharynx each vas deferens expands to form the tortuous false seminal vesicle (or spermiductal vesicle), filled with sperm, which proceeds backward toward the copulatory complex.

The ovaries are located at the level of the first lateral intestinal branches, on the medial side of each ventral nerve trunk. They have no typical parovaria.

The copulatory apparatus (Figure 2) occupies the anterior half of the postpharyngeal region. The genital aperture or gonopore (gp) leads into an undivided genital atrium. The penis consists of a rounded, muscular bulb (bp) and a conical

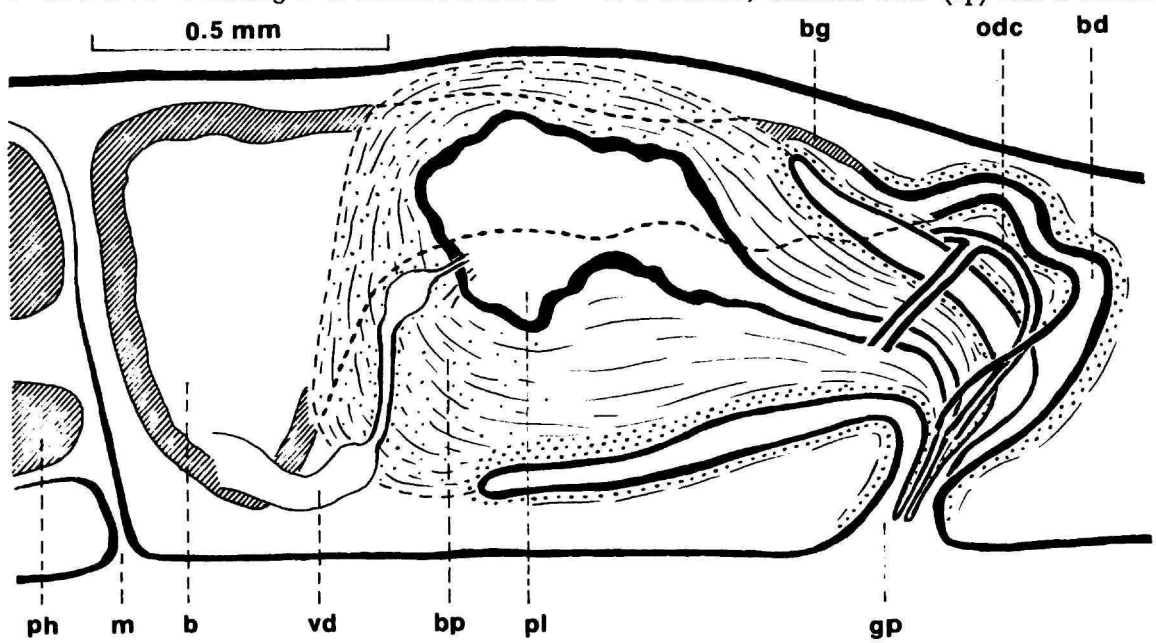

FIGURE 2.—*Polycelis coronata coronata* from Fort Bridger, Wyoming, copulatory apparatus in sagittal section. [Abbreviations for this and following figures: a=genital atrium; ac=common genital atrium; am=male atrium; b=copulatory bursa; bd=bursa duct; bg=cyanophilic gland ducts; bp=penis bulb; cy=cyanophilic glands; de=ejaculatory duct; eg=eosinophilic gland ducts; gp=gonopore; i=intestine; m=mouth; ma=muscle coat of atrium; odc=common oviduct; pa=atrial papilla; ph=pharynx; pl=penis lumen; pp=penis papilla; sg=shell glands; vd=vas deferens; vs=seminal vesicle.]

papilla. There is wide variation in the size relationships between the bulb and the papilla, due in part to the state of muscular contraction at the moment of killing, in part to the phase of sexual maturity, and possibly to characteristics of local populations. In general, the penial papilla is as large as, or larger than, the bulb, differentiating the subspecies *P.c. coronata* from *P.c. brevipenis*. The penial lumen (pl) is rather voluminous, forming in the bulb a wide expansion of irregular outline which usually narrows posteriorly and opens at the tip of the papilla. There is no sharp demarcation between the anterior widened part (seminal vesicle) and the posterior section (which corresponds to an ejaculatory duct). The musculature of the penis bulb consists of concentrically arranged layers of muscle fibers. The papilla has a circular muscle layer below the external epithelium, followed by longitudinal fibers traversing the parenchyma of the papilla. The epithelial lining of the expanded bulbar lumen consists of tall cylindrical, often club-shaped, secretory cells sometimes extending into the cavity as villus-like projections. The epithelium of the ejaculatory duct is cuboidal and nucleate, that of the outside of the papilla flattened and, at least in fully mature specimens, in part infranucleate. The two vasa deferentia enter the penis bulb anteroventrally and open into the penial lumen separately, often in an asymmetrical fashion, one more anterior or more dorsal than the other. To what extent this asymmetry is a result of muscular contraction or due to the asymmetry of the canal of the copulatory bursa is difficult to decide. At full sexual maturity the penis is supplied with copious gland ducts entering the penial bulb from the surrounding parenchyma. These ducts, filled with a granular, usually slightly eosinophilic, secretion, traverse the bulb and the papilla and open into the penial lumen. In animals from northern Montana and from Mount Rainier National Park (Figure 3), the secretions contained in the ducts were tinctorially differentiated into cyanophilic secretions (cg) emptying into the seminal vesicle and eosinophilic secretions (eg) connecting with the posterior part of the lumen. It was not possible to ascertain whether this differentiation corresponds to a particular phase in the developmental cycle of the reproductive system or is a peculiarity of the local populations.

The two oviducts or ovovitelline ducts proceed from the ovaries along the dorsal sides of the ventral nerve cords. In the region of the copulatory complex they leave the nerve cords, turn upward and medially, and unite in the space above the male atrium to form a common oviduct. The end parts of the paired oviducts and the unpaired common oviduct are equipped with strongly eosinophilic glands, the so-called shell glands (Figure 3, sg). The common oviduct opens into the end part of the genital atrium from the dorsal side. The copulatory bursa (b) is a voluminous, often very lobate sac situated between the pharyngeal pouch

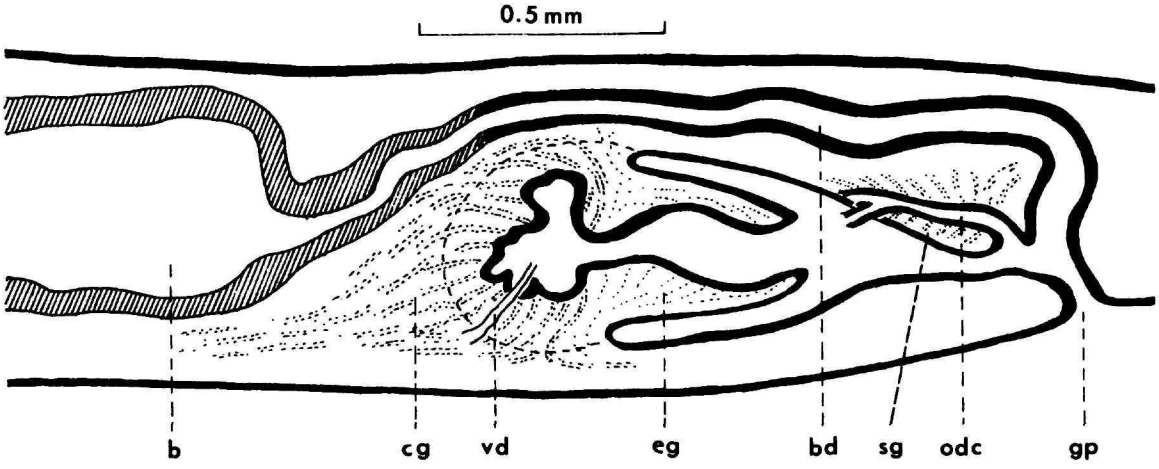

FIGURE 3.—*Polycelis coronata coronata* from Yellow Creek, Lake County, Montana; copulatory apparatus in sagittal section. [See Figure 2 for abbreviations.]

and the penial bulb in the midline of the body. Its outlet or stalk (bd) is displaced from the median, usually to the left but in some individuals to the right side of the penis. Histologically the stalk is divided into sections, a wider anterior section lined with a continuation of the tall secretory epithelium characteristic of the bursal sac (Figure 2, bg), and a narrower posterior section with nonglandular lining and a thick muscular coat consisting of circular and longitudinal fibers. The proportion between the two sections is somewhat variable, in specimens from the type-locality (Fort Bridger) the glandular section is about as long as the muscular one. The bursal stalk opens into the genital atrium close to the gonopore.

ECOLOGY AND DISTRIBUTION.—*Polycelis coronata coronata* inhabits springs and cold creeks in the western parts of the United States. Beck (1954:81) indicates that in Utah the species is confined to habitats of low water temperature, not exceeding 10°C, a statement which was confirmed by Braithwaite (1962:21) and which is valid also for other localities of its geographic range. The species is, therefore, found generally at high altitudes. No intensive studies concerning other ecological requirements (ionic composition of the water, food supply, etc.) have been made. When the animals are collected in the field, the great majority of the specimens are found to be immature. As the identification of the species and subspecies is possible only by the analysis of the reproductive system, only localities at which sexually mature individuals have been taken have been included in the following listing.

MONTANA. LAKE COUNTY: (1) Tributary of Flathead Lake, crossing State Road 35 on east side of lake, 12 road miles north of junction with U. S. Highway 93; 3 September 1967, water clear, fast, 8.7°C, pH 7.9; many specimens of various sizes (some with short postpharyngeal parts indicating recent fission), one mature, under stones. (2) Yellow Bay Creek, about 10 yards from the shore of Flathead Lake; several specimens, some mature, collected in August and September 1969 by Frank P. Crawley and shipped to me alive. (Besides this species, one specimen of *Dendrocoelopsis vaginata* Hyman).

NEW MEXICO. SANTA FE COUNTY: Stream on west slope of Sangre de Cristo Mountain, crossing State Road 475, 2.5 road miles above the north boundary of Hyde State Park, at an altitude of about 9000 feet; 17 July 1968, water clear, fast, 8.8°C, pH 7.2; many specimens of various sizes, among them some adults, under stones.

UTAH. CACHE COUNTY: Spring Hollow Stream, off U. S. Highway 89, 5 road miles east of Utah State University in Logan; samples collected at various occasions by myself (September 1967), Jerry H. Carpenter (March 1968) and Prof. M. H. Gunnell (May 1969); besides *Polycelis, Phagocata crenophila* occurs here. RICH COUNTY: Willow Springs, located 4 air miles west of Garden City; 27 September 1967, clear, fast water; many specimens, some mature, under stones. UTAH COUNTY: North Fork of Provo Canyon, on Mt. Timpanogos, in headwaters at Aspen Grove, off State Road 80; 26 September 1967, water clear, 6.7°C, pH 7.7, fast current; numerous *Polycelis,* many mature, under stones (this is the locality where Braithwaite collected his sexual specimens, see Braithwaite, 1962:24).

WYOMING. UINTA COUNTY: (1) Scoop Shovel Spring, located about 4 miles west of entrance to Fort Bridger, perhaps ⅛ mile north of Interstate Road 80 (water from this spring had been used by the inhabitants of the area for domestic purposes for many years; it is possible that this is the type-locality where Leidy collected his specimens in 1877); 30 September 1967, little water flow; many specimens, 3 mature, under stones and pieces of wood. 7 June 1970, water clear, 7.0°C, moderate current; under stones very many worms of various sizes, about one-third of them showing sexual structures, at least two with signs of recent fission (regenerating hind ends). (2) Spring about 6 miles west of Fort Bridger, on property of Reed Bluemel (who kindly took me to this spring), 1.8 miles west of Union Road exit of Interstate Highway 80 and ⅛ mile south of the highway; 30 September 1967, clear, cold water, under stones 6 *Polycelis,* one of them mature.

LIFE CYCLE.—Field observations are too scarce to permit definite conclusions as to the seasonal behavior and reproductive activity of the species. Sexually mature specimens were taken in different places in March, May, June, July, August, and September, always together with immature, presumably younger individuals. Braithwaite (1962: 21) found mature worms from June through November; he could not examine his locality during the winter months because of the snow cover. It is quite possible that the worms may reproduce sexually the year round in springs with little seasonal temperature fluctuations, but only seasonally (in winter?) in habitats in which the temperature is not constant. Egg capsules have not been observed; presumably they are spherical or ellipsoidal and unstalked.

Asexual reproduction by fission, as revealed by the presence of individuals with regenerating head or tail ends, has been observed occasionally in the field collections. Postfission specimens may be seen in a population at the same time as sexually mature specimens.

In the laboratory, *Polycelis coronata* may be maintained in cold-water cultures for extended periods of time. Five immature specimens, col-

lected 30 September 1967 near Fort Bridger, Wyoming, were kept in spring water at 14°C and fed alternatingly beef liver and *Tubifex*, which were freely taken. They developed sexual structures by December, but never laid cocoons nor underwent typical fission (only occasional divisions after mechanical injuries). The culture was concluded in May 1969.

TAXONOMIC POSITION.—The nearest relatives of *Polycelis coronata* are found in Asia. *P. tibetica* Hyman, from Kashmir and Indian Tibet, seems to have a copulatory complex similar to that of the American species, including the division of the bursa stalk into a wider secretory anterior and a narrower nonglandular posterior section (Hyman, 1934:9, pl. 1: fig. 7). *Polycelis koslowi* (Zabusov, 1911:345), also from Tibet, resembles *P. coronata* in its external and anatomical features. In *P. eburnea* (Muth, 1912) from the Aral Sea area, the reproductive system conforms with that of the American species but the arrangement of the eyes appears to be different. No detailed comparison of these species with the American form can be made at present. Should future investigations show that *P. coronata* is identical with any of the Asian species, it would nevertheless keep its name since its establishment predates the descriptions of the three other forms.

Polycelis (P.) coronata borealis Kenk, 1953

FIGURE 4

Polycelis borealis Kenk, 1953:168.
Polycelis coronata borealis.—Kenk, 1972:27.

HOLOTYPE.—Springs on road from Palmer to Willow, Alaska; series of sagittal sections, USNM 22333.

The subspecies *P.c. borealis* was originally described from Alaska as a separate species at a time when the anatomy of the typical *Polycelis coronata* had not yet been studied. The only American *Polycelis* with which it could be compared was the form from South Dakota and Colorado. Between this and the Alaskan worms there were some differences which seemed to justify the establishment of a new species. With the rediscovery of Girard's *P. coronata*, however, these differences have in part been bridged over, and it appears now to be more practicable to unite the three forms as subspecies under the same specific name, *P. coronata*.

CHARACTERISTICS OF THE SUBSPECIES.—*P.c. borealis* cannot be differentiated from the nominate subspecies in life. A description of *P. borealis* has been presented by Kenk (1953:168–173) and need not to be repeated here. The account of the external features given for the subspecies *P.c. coronata* (p. 3) may be extended also to the present subspecies.

P.c. borealis differs from *P.c. coronata* mainly in some details of the anatomy of the reproductive system (Figure 4), specifically in the structure of the outlet or stalk of the copulatory bursa. In *P.c. coronata* this stalk is divided into two sections, an anterior wider section lined with a secretory epithelium identical with that of the lining of the bursa, and a posterior section with nonglandular lining and a thick coat of muscle fibers. The subspecies *P.c. borealis* lacks this differentiation of the bursal duct, and the entire canal is nonglandular and muscular. It is situated either on the left or on the right side of the penis.

ECOLOGY AND DISTRIBUTION.—*Polycelis coronata borealis* lives in cold streams and springs in the northwestern parts of the North American continent. Sexually mature individuals were collected in the following localities:

ALASKA (see Kenk, 1953:173). (1) Clear, fast mountain stream crossing Mount McKinley Park road, 5.5 miles from railroad station, 5 August 1950. (2) and (3) Streams on road from Palmer to Willow, 11.9 and 19.2 miles from Palmer, 9 August 1950. (4) Clear springs on road from Palmer to Willow, 20.1 miles from Palmer (type-locality of subspecies), 9 August 1950. (5) Stream on road from Anchorage to Potter, 10.6 road miles from Anchorage city limits, 12 August 1950.

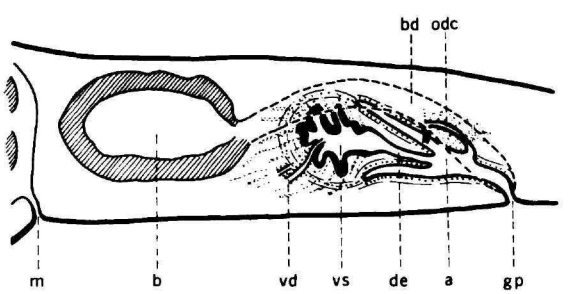

FIGURE 4.—*Polycelis coronata borealis* from type-locality on road from Palmer to Willow, Alaska; copulatory apparatus in sagittal section (after Kenk, 1953), × 61. [See Figure 2 for abbreviations.]

(6) Stream on Glenn Highway, 43.5 miles from Anchorage, 13 August 1950.

IDAHO. BINGHAM COUNTY: Headwaters of Spring Creek, situated in Fort Hall Bottoms, Fort Hall Indian Reservation, near Ferry Butte, northwest of Pocatello; springs on marshy ground; 3 June 1970, water clear, with moderate current, 10.6°C; under stones about 30 specimens collected by Dr. G. Wayne Minshall and R. Kenk, among them one mature individual.

WYOMING. YELLOWSTONE NATIONAL PARK: (1) Tributary of Obsidian Creek, at Moose Exhibit, 10.8 miles south of Mammoth Springs Junction; 18 June 1963, water clear, fast, 9.0°C; several specimens collected, two of them mature. (2) Stream at south end of Swan Lake Flat, east of road between Norris and Mammoth Springs junctions; 18 June 1963, water clear, with moderate current, 20.5°C; many specimens, some of them very large (largest 25 mm long), two mature. (3) Cascade Creek, crossing road 0.4 mile west of Canyon Village Junction; 7 September 1967, water clear, fast, 12.1°C, pH 8.1; under stones 7 immature specimens, some with signs of fission (regenerating tails); 28 September 1967 in the same locality 6 immature specimens taken under stones and placed in culture (one matured). (4) Yellowstone Lake; 4 September 1970, 6 specimens collected by Jack L. Dean off the south end of Stevenson Island on liver bait submerged the preceeding day at about 200 feet (61 m) depth, one of them mature.

LIFE CYCLE.—Reproduction of the subspecies is both sexual and asexual, by fission. Sexually mature specimens were collected in different localities in June, August, and September, but always fewer than the more numerous immature worms. This suggests that the height of the breeding season may not be in the summer months but rather during the cold season.

Four immature specimens which had been collected in Yellowstone National Park in September 1967 were placed in a laboratory culture kept at a temperature of 14°C. They were given beef liver and *Tubifex*, alternatingly, as food and underwent fission repeatedly. In September 1968 some of the worms were transferred to a culture maintained at a lower temperature (fluctuating between 1.4° and 8.4°C) in which they continued fissioning. In July 1969, when the culture was concluded, one of the seven specimens, 14 mm long, had developed reproductive organs while the others were smaller and showed various stages of postfission conditions (short tails and new heads).

Polycelis (P.) coronata brevipenis Kenk, 1972

FIGURE 5

Polycelis coronata.—Hyman, 1931:124–135.—Kenk, 1952:194–198.

Polycelis coronata brevipenis Kenk, 1972:27.

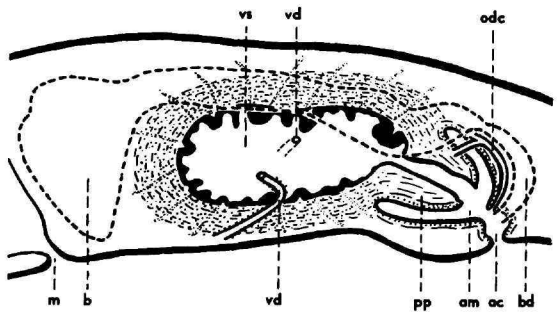

FIGURE 5.—*Polycelis coronata brevipenis* from type-locality, Glenhaven, Larimer County, Colorado; copulatory apparatus in sagittal section (after Kenk, 1952), × 60. [See Figure 2 for abbreviations.]

HOLOTYPE.—North Fork of Thompson River, 1 mile below Glenhaven, Larimer County, Colorado; series of sagittal sections, USNM 23679.

The subspecies *P.c. brevipenis* was first described from South Dakota by Hyman (1931) who assumed that it was identical with Girard's *Phagocata coronata* from Wyoming, which was known only by its external appearance. Hyman's description was later supplemented by Kenk (1952) who collected the same form in Colorado. Braithwaite (1962), while studying the anatomy of a *Polycelis* from Utah, discovered certain differences between his worms and Hyman's account of the reproductive system of the South Dakota form. As he had no comparative material from Girard's type-locality, he refrained from naming the local species from Utah and pointed out that the problem of the taxonomic status of the North American *Polycelis* was not yet settled. Kenk (1972:27), upon examining specimens from Fort Bridger, Wyoming, recognized their identity with the form from Utah and considered the animals from South Dakota and Colorado to be sufficiently different from the worms of Wyoming to justify the establishment of a new subspecies, *P.c. brevipenis*.

CHARACTERISTICS OF THE SUBSPECIES.—In life *P.c. brevipenis* is indistinguishable from the nominate subspecies (p. 3; see also Hyman, 1931:126–127; Kenk, 1952:194–195). It differs from the subspecies *P.c. coronata* in the shape and structure of the male copulatory organ (Figure 5). The penis bulb is elongated, very muscular, and much larger than the short and rather broad penis papilla. The penis lumen is likewise elongated, its bulbar section (seminal vesicle) is lined with a cuboidal,

nonglandular epithelium. The two vasa deferentia enter the seminal vesicle from the sides, often asymmetrically. Many gland ducts containing a slightly eosinophilic secretion penetrate the muscular layers of the penis bulb and empty into the seminal vesicle. The bursal stalk shows the same division into an anterior glandular and a posterior muscular section as in the case of the nominal subspecies.

ECOLOGY AND DISTRIBUTION.—*P.c. brevipenis,* like the two other subspecies of *P. coronata,* is an inhabitant of cold streams and mountain lakes and has, so far, been recorded only from South Dakota and Colorado, but it is probably more widely distributed in the mountainous regions of the western states. The following localities yielded sexually mature specimens:

COLORADO (cf. Kenk, 1952:196). LARIMER COUNTY: Localities in Rocky Mountain National Park: (1) Poudre Lake, (2) Thompson River in Moraine Park, (3) Chiquita Creek on Fall River Road, and (4) Glacier Creek (tributary of Thompson River), 24–27 September 1951. (5) North Fork of Thompson River, 1 mile below Glenhaven (type-locality of the subspecies), 28 September 1951.

SOUTH DAKOTA. Stream near Deadwood (Lawrence County?), in the Black Hills, 30 August 1929 (see Hyman, 1931:130).

LIFE CYCLE.—Hyman stated that many of the worms collected in August in the stream near Deadwood were sexually mature, that no cocoons were found in the field, and that there were no indications of the occurrence of fission. Kenk (1952:196) reported that among 39 specimens taken in Glacier Creek in September, 17 were asexual, showing no signs of reproduction, 20 showed evidence of recent fission, and only 2 were sexually mature. In other localities, the great majority of the collected animals were also asexual. These data are too meager to permit any conclusions concerning the seasonal distribution of the reproductive activity.

Subgenus *Seidlia* Zabusov, 1911

Male atrium surrounded by a very thick muscle coat.

Polycelis (Seidlia) sierrensis, new species

FIGURE 6c, 7, 8

HOLOTYPE.—Deep Creek, Placer County, California; series of sagittal sections, USNM 46053.

EXTERNAL FEATURES.—Mature animals are up to 22 mm long and about 2 mm wide. Head truncate, with slightly bulging frontal margin and a pair of bluntly pointed auricles extending from the lateral edges anterolaterally (Figure 7). After a slight narrowing or neck behind the auricles, the body margins first diverge, then run parallel throughout the greater part of the body length. Behind the copulatory apparatus the body narrows again and forms a pointed to rounded posterior end.

The dorsal side is dark brown; the areas above the pharynx and the copulatory complex are somewhat lighter. Ventral side grayish brown, with white spots indicating the sites of the mouth and the gonopore. The numerous eyes (Figure 6c) form a band along the margin of the head and the anterior part of the prepharyngeal region. This band may be interrupted at the base of the auricles.

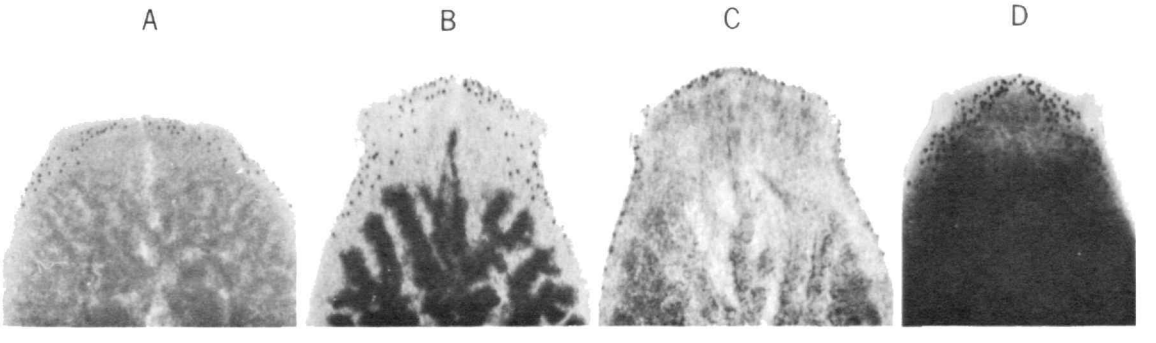

FIGURE 6.—Anterior ends of preserved animals, showing arrangement of eyes: A, *Polycelis coronata coronata* from Fort Bridger, Wyoming, × 30; B, *P. c. coronata* from Provo Canyon, Utah, × 17; C, *P. sierrensis* from Nevada County, California, × 17; D, *P. auriculata* from Hidaka, Hokkaido, Japan, × 17.

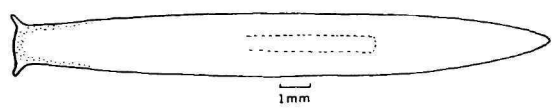

FIGURE 7.—*Polycelis sierrensis,* outline sketch of living animal.

On the head it is more than one row wide, but it narrows posteriorly to a single row. The number of the eyes varies within wide limits. There are fewer eyes in smaller (younger?) individuals than in larger ones. In adult specimens 36 to 108 eyes were counted on either side of the head, not necessarily symmetrically arranged.

The pharynx is rather long, about one-fourth the length of the body. Its insertion or root is at, or somewhat anterior to, the middle of the body. The copulatory complex occupies two-thirds of the postpharyngeal region.

As seen from this description, *P. sierrensis* cannot be distinguished from *P. coronata* in life with certainty. In *P. sierrensis,* the band of eyes may be narrower and slightly more marginal than in *P. coronata,* but this is not the case in all individuals.

REPRODUCTIVE SYSTEM.—The testes are ventral and are arranged in a pair of rather short bands in the posterior half of the prepharyngeal region, situated on either side of the anterior intestinal ramus and extending laterally as far as the ventral nerve cords. The ovaries are located at the level of the first or second lateral intestinal branches, somewhat anterior to the testicular bands.

The copulatory complex (Figure 8) shows the genital atrium divided into a small posterior common atrium (ac) and a larger anterior male atrium (am), the two subdivisions communicating by means of a narrow canal which, in fully mature animals, runs in the axis of a conical papilla (pa) projecting into the male atrium; this atrial papilla or diaphragm is developed only at full maturity. The common atrium connects with the genital aperture (gp), the outlet (bd) of the copulatory bursa (b), and the common oviduct (odc). The male atrium, which is lined with a cuboidal epithelium, is surrounded by a very thick, massive muscular layer (ma) consisting chiefly of circular fibers interspersed with less numerous longitudinal fibers. The penis has a rounded bulb and a conical papilla (pp). The bulb contains a large cavity (pl) with villus-like processes projecting from the wall. Posteriorly, toward the penis papilla, the cavity narrows and its wall becomes smooth, forming what may be compared to an ejaculatory duct. The cavity opens at the tip of the penis papilla.

The two vasa deferentia, which at the sides of the pharynx have enlarged to spermiductal vesicles, turn upward and medially at the level of the penis

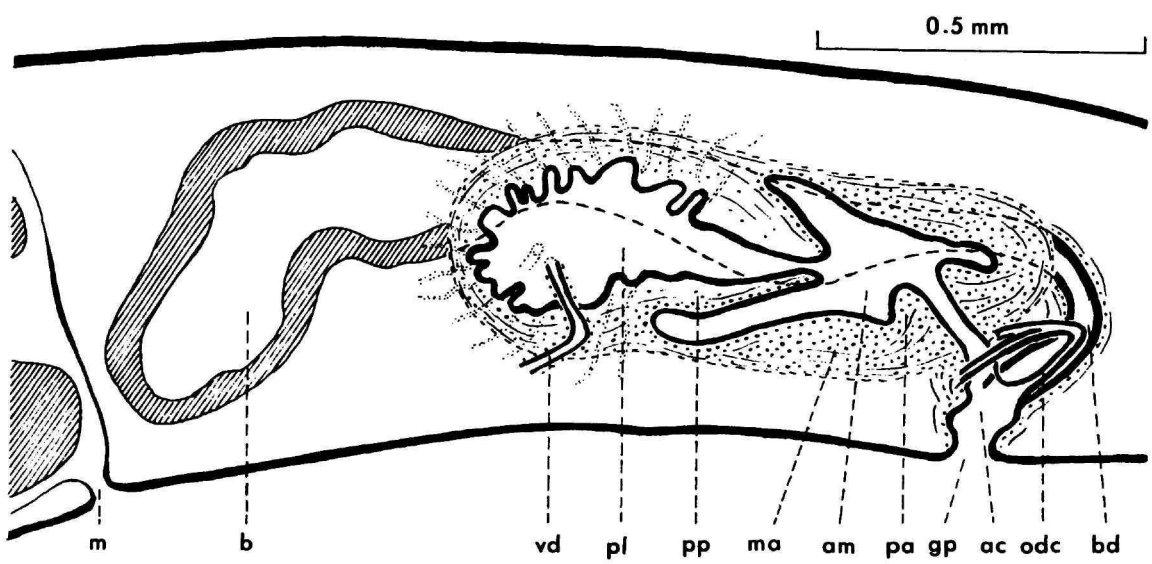

FIGURE 8.—*Polycelis sierrensis* from type-locality, Deep Creek, south of Truckee, California; copulatory apparatus in sagital section. [See Figure 2 for abbreviations.]

bulb, approach the bulb, enter it from the sides, and open separately into the bulbar lumen. The lumen also receives many ducts originating from unicellular glands located in the parenchyma surrounding the penis. The two oviducts unite in the space above the common genital atrium, forming a short common oviduct (odc) which empties into the common atrium from the dorsal side. The end parts of the paired oviducts and the common oviduct receive many outlets of eosinophilic glands.

The copulatory bursa (b) is a large, lobate sac without prominent lateral extensions. Its duct (bd) runs posteriorly, normally on the right side of the midline (only exceptionally above the penis). The secretory epithelium lining the bursa extends some distance into the anterior part of the bursal duct.

ECOLOGY AND DISTRIBUTION.—*Polycelis sierrensis* was collected in cold springs and streams in the region of the Sierra Nevada of California and Nevada. The few observations on the physicochemical conditions of its habitats do not permit definitive conclusions concerning the ecological requirements of the species. The temperature range of the water was between 6.2° and 16.5°C, with an average of 9.2°C (12 measurements); the pH between 6.1 and 7.7, average 7.0 (11 measurements); and the oxygen content between 7 and 10 parts per million, average 9 ppm (4 measurements). It must be pointed out, however, that these observations were made in the warmer seasons of the year, from late May to September, and that no data are available on the seasonal fluctuations of these parameters. Other factors which may influence the occurrence of the species, such as the chemical composition of the water, the available food supply, etc., have not been studied. Sexually mature individuals were taken in the following localities:

CALIFORNIA. MARIPOSA COUNTY: Fern Spring, in Yosemite National Park, on road connecting State Roads 140 and 41. Limnocrene with considerable water flow and several seepage springs above it; 3 July 1967, water temperature 6.4° and 6.8°C, pH 6.1 and 6.2; several specimens under stones, one of them mature, one with regenerating head. 5 July 1968, temperature 7.3°C, 17 specimens of various sizes, 2 mature. NEVADA COUNTY: Spring near Sagehen Creek Biological Station, tributary of Sagehen Creek, furnishing water to the station. Situated about 2 miles west of State Road 89, north of Truckee; 23 September 1967, water clear, fast, temperature 6.3°C, pH 7.5, under stones 3 specimens; 10 July 1968, 6.5°C, pH 7.5, oxygen 10 ppm, many specimens under stones, some mature; 28 and 29 May 1970, temperature 6.3°C, pH 7.5, oxygen 9 ppm, about 50 *Polycelis* under stones and on bait (beef liver) exposed over night, some mature. Besides this species, less numerous *Phagocata crenophila* Carpenter. PLACER COUNTY: (1) McKinney Creek near its mouth on the west shore of Lake Tahoe, close to the El Dorado County line; 21 June 1967, clear, fast water, 9.0°C, pH 7.1, about 10 specimens under stones, 2 mature. (2) Tahoe City, overflow of spring furnishing water to the local California Fish and Game facility, on State Road 28, 1.7 road miles northeast of junction with State Road 89; 23 September 1967, water clear, fast, temperature 6.7°C, pH 6.8, 6 immature *Polycelis* under stones; 10 July 1968, 6.2°C, pH 6.6, oxygen 10 ppm, several *Polycelis* under stones, 2 of them mature; 28 and 29 May 1970, 10.0°C, pH 7.0, oxygen 7 ppm, many mature and immature specimens under stones and on liver bait. Besides *Polycelis, Phagocata crenophila* occurs here. (3) Deep Creek, at crossing of State Road 89 south of Truckee (type-locality of *Polycelis sierrensis*); 23 September 1967, water clear, fast current, temperature 10.6°C, pH 7.7, 4 immature post-fission specimens under stones; 10 July 1968, 3 specimens, 2 of them mature.

NEVADA. WASHOE COUNTY: Marlette Creek, along State Road 28, about ½ mile north of Ormsby County line; 11 July 1968, water clear, fast, 16.5°C, pH 7.4, 2 specimens under stones, 1 mature.

LIFE CYCLE.—The few sexually mature specimens collected from May to September allow no conclusions regarding the breeding season of the species. Generally they were taken together with more numerous asexual specimens some of which in individual cases showed signs of active fission. No egg capsules were seen in the field. No attempt was made to culture the species in the laboratory. Presumably it could be maintained in cold-water cultures, with liver as food, since it has been successfully attracted by beef liver used as bait.

TAXONOMIC POSITION.—*P. sierrensis* is rather closely related to a Japanese species, *P. auriculata* Ijima and Kaburaki (1916). Through the courtesy of Dr. Masaharu Kawakatsu of Fuji Women's College in Sapporo, Japan, who kindly sent me several living specimens of *P. auriculata* from Hidaka, Hokkaido, I was able to compare the two species in greater detail. Externally *P. auriculata* is similar to *P. sierrensis* by its general shape, size, and pigmentation. There is a difference in the arrangement of the eyes which in *P. auriculata* form a wider, horseshoe-shaped band which does not reach as far backward as in *P. sierrensis* (Figure 6C,D). In the copulatory apparatus the differences mainly concern the atrial papilla or diaphragm and the shape of the copulatory bursa (Figures 8 and 9). In *P. auriculata* the atrial papilla (pa) is much

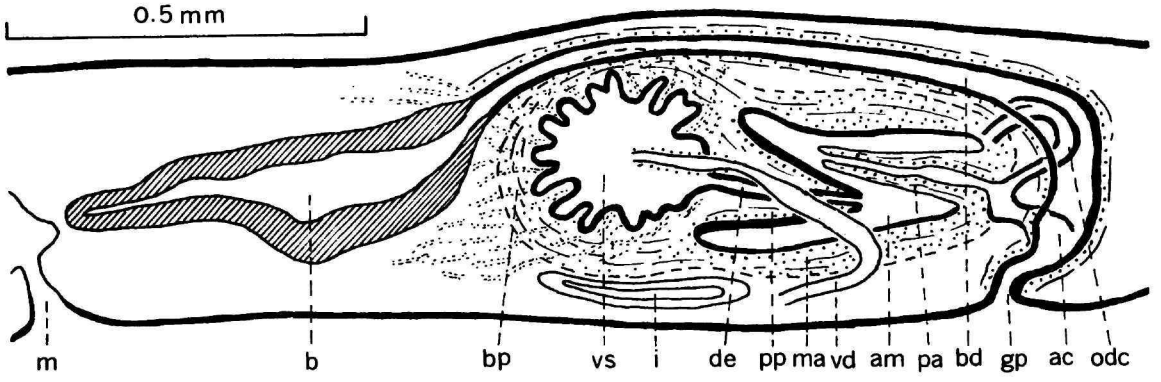

FIGURE 9.—*Polycelis auriculata* from Hidaka, Hokkaido, Japan, copulatory apparatus in sagittal section. [See Figure 2 for abbreviations.]

larger and more pointed than in *P. sierrensis*. The copulatory bursa (b) is smaller and forms a pair of anterolateral extension or horns (see Ijima and Kaburaki, 1916:168; Kaburaki, 1922:40), while in *P. sierrensis* it is a large, lobate sac. Another peculiarity which I noticed in the three specimens of *P. auriculata* studied was the formation of an intestinal anastomosis (i) below the copulatory complex, observed also by Okugawa (1938:177), which was absent in *P. sierrensis*. This anastomosis or transversal commissure is lined with the normal intestinal epithelium and lacks a special muscular coat such as is seen in a related species from Japan and Kamchatka, *P. schmidti* [=*Rjabuschinskya schmidti* Zabusov (1916:276); *Polycelis ijimai* Kaburaki (1922:45)]. This commissure may not be a specific characteristic of *P. auriculata*, since anastomoses between the two posterior intestinal rami are frequently observed in other species as well and are subject to great individual variation. Kaburaki (1922:40, fig. 12), in his figure of the digestive system of *P. auriculata* indicates such an anastomosis behind the copulatory apparatus. Another species related to *P. sierrensis* is *P. sabussowi* (Seidl) from Turkestan which has an almost identical structure of the copulatory organs but lacks the atrial papilla (see Kenk, 1936).

Polycelis species

Because of the scarcity of sexually mature specimens in the collections of *Polycelis* and the lack of external characters which might distinguish the individual taxa, many of the lots taken in the field could not be identified to species. Unfortunately this is true for the great majority of the locality records of the genus in North America. In some cases the presence of identifiable specimens in the vicinity of a given locality may give a hint as to the taxonomic identity of the immature forms but would not preclude the risk of misidentification. I am, therefore, listing here all distributional records known to me which need further study.

ALASKA. (1) to (7) Six streams and one lake on road from Palmer to Willow (Kenk, 1953:173). (8) to (13) Six streams on Glen Highway, between Anchorage and Glenallen (Kenk, 1953:173). (14) and (15) Two streams on road from Anchorage to Potter (Kenk, 1953:173). (16) to (25) Nine Streams and one lake on Richardson Highway, between Glenallen and Valdez (Kenk, 1953:173). (26) Stream 9 miles north of Seward (Holmquist, 1967:463). (27) Near Johnson Pass, 66 miles from Anchorage (Holmquist, 1967:463).

CALIFORNIA. EL DORADO COUNTY: Tributary of South Fork of American River, crossing U. S. Highway 50, 5.9 road miles east of Pacific House; 23 June 1967, water clear, fast, 10.1°C, pH 7.3, many specimens under stones. MARIPOSA COUNTY: (1) Tributary of Yosemite Creek, on Yosemite Falls Trail, Yosemite National Park; 3 July 1967, 5 specimens. (2) Wildcat Creek, Yosemite National Park, crossing Big Oak Flat Road, 2.3 miles west of junction with State Road 140; 3 July 1967, water clear, fast, 14.6°C, pH 7.2, 3 specimens under stones. MONO COUNTY: (1) Convict Creek in Long Valley, at an altitude of 7200 feet (Kennedy, 1967:8). (2) Stream on Tioga Road (State Road 120) at timberline near Tioga Pass; 18 October 1970, 7 specimens collected by Dr. Vida C. Kenk. NEVADA COUNTY: Sagehen Creek at Sagehen Creek Biological Station, 1.7 road miles west of State Road 89, north of Truckee; 9 July 1968, water clear, fast, temperature 18.1°C, pH over 7.6, oxygen 7 ppm, many specimens, some with signs of fission; 29 May 1970, 13.0°C,

pH 7.6, many small specimens. SANTA CLARA COUNTY: Springs of Black Creek, on east slope of Black Mountain, southwest of Los Gatos; bottom silt with stones; 3 June 1967, water temperature 11.0° and 11.5°C, pH 6.7, 12 immature specimens under stones; 25 June 1967, 6 specimens. SANTA CRUZ COUNTY: (1) Tributary of San Lorenzo River, crossing State Road 9 at Brookdale; 4 June 1967, water clear, fast, 11.2°C, pH 8.0, one specimen under a stone. (2) Fall Creek, about ½ mile west of Felton, San Lorenzo River Valley; 4 June 1967, water clear, fast, 11.6°C, pH 8.3, one specimen under a stone. (3) Fall Creek, above fork leading to old mine; 4 July 1968, water clear, fast current, temperature 13.4°C, pH 7.9, 3 worms under stones. (4) Small spring on right bank of tributary of Fall Creek which leads to old mine; 4 July 1968, water clear, moderate current, temperature 12.3°C, pH 7.4, 2 immature *Polycelis* under stone and fallen leaf. (5) Tributary of Fall Creek, at site of old mine; 4 July 1968, water clear, fast, 12.3°C, 3 specimens under stones. TULARE COUNTY: (1) East Fork of Redwood Creek, in Sequoia National Forest, crossing State Road 198, 2.2 road miles east of Bearskin Meadow Road; 27 June 1967, water clear, fast, 16.1°C, pH 6.9, 4 immature specimens under stones. (2) Stream crossing State Road 198, 0.9 mile south of Camp Kaweah in Sequioa National Park; 28 June 1967, water clear, fast, 12.2°C, pH 7.2, 4 *Polycelis* under stones. (3) Tributary of Kaweah Creek, Sequoia National Park, crossing State Road 198, 2 miles west of Lodgepole; 28 June 1967, water clear, fast, 9.9°C, pH 6.0, 4 asexual worms under stones. (4) Tributary of Halstead Creek, crossing State Road 198, 3.7 miles west of Lodgepole, Sequoia National Park; 28 June 1967, water clear, fast, 12.9°C, pH 7.1, one immature specimen under stone. TUOLUMNE COUNTY: (1) Stream crossing Tuolumne Grove Road in Yosemite National Park, 2.3 road miles west of junction with Big Oak Flat Road; 3 July 1967, water clear, fast, 11.1°C, pH 6.2, 4 specimens on fallen branch. (2) Small seepage spring on right bank of stream crossing Tioga Road (State Road 120), 5.6 road miles west of junction with Big Oak Flat Road; 3 July 1967, water 8.4°C, pH 6.0, 2 immature specimens.

COLORADO (see Kenk, 1952:196). BOULDER COUNTY: (1) to (4) Four streams in the St. Vrain Creek Basin, crossing State Road 7. GRAND COUNTY: (1) Onahu Creek, crossing U. S. Highway 34. (2) Tonahutu Creek, above opening into Grand Lake. LARIMER COUNTY: (1) Thompson River east of Estes Park. (2) Fall River at Estes Park. (3) Roaring River (tributary of Fall River).

MONTANA. GALLATIN COUNTY: (1) Small spring on campus of Montana State University, Bozeman; 1 September 1967, water clear, moderate current, 11.7°C, pH 7.4, many immature specimens under stones; February and April 1969, 43 specimens collected and sent by Dr. C. J. D. Brown, none mature. (2) Trout Brook, tributary of East Gallatin River, north-northwest of Bozeman; 2 September 1967, water clear, fast current, 9.6°C, pH 7.8, 6 animals under stones. (3) Spring north of Belgrade, tributary of Thompson Creek, outlet crossing county road 4.3 miles north of junction of U. S. Highway 10 and Montana Secondary Road 347; 4 September 1967, 2 immature *Polycelis;* 4 June 1970, 14.0°C, 3 *Polycelis* under stones; *Dendrocoelopsis vaginata* Hyman also occurs here. LAKE COUNTY: East shore of Flathead Lake, below mouth of a creek off State Road 35, 12 road miles north of junction with U. S. Highway 93; 3 September 1967, one specimen under a stone. MISSOULA COUNTY: Spring and creek, tributary of Rattlesnake Creek, 1 mile from Clark Fork River; 21 May 1968, water slightly muddy, 10°C, 4 immature *Polycelis* collected by F. P. Crowley, together with *Dendrocoelopsis vaginata* Hyman. RAVALLI COUNTY: Skalkaho Pass, east of Hamilton, collected by Miss Betty Locker (see Kenk, 1952:196). YELLOWSTONE NATIONAL PARK (Montana sector): Warm Creek, crossing road from Northeast Entrance to Tower Falls Junction, 1.2 miles west of entrance gate; 23 June 1963, water clear, fast, 7.6°C, 4 *Polycelis* under stones, some with regenerating tails.

NEW MEXICO. BERNALILLO COUNTY: Stream in Cienega Canyon, on east slope of Sandia Mountains, in Cibola National Forest; 16 July 1968, water clear, fast, 12.6°C, pH 8.6, very numerous *Polycelis* of various sizes, some with indications of preceding fission, none fully mature.

OREGON. CLACKAMAS COUNTY: Spring in Willamette Park, Willamette (12 miles south of Portland); 12 September 1967, water clear, moderate current, 12.1°C, pH 6.2, many specimens, all asexual, some with signs of fission. KLAMATH COUNTY: (1) Goodbye Creek, Crater Lake National Park, above bridge which leads from the Park Service headquarters to State Road 62; 13 September 1967, water clear, fast, 5 immature specimens under stones. (2) Anne Spring, at south entrance of Crater Lake National Park; 13 September 1967, water clear, 3.1°C, pH 7.0, 11 specimens under stones, some with regenerating tail ends. MULTNOMAH COUNTY: Woodbury Spring, in Crystal Springs area of Eastmoreland district of Portland; 12 September 1967, water clear, 11.2°C, pH 6.3, on liver bait many *Polycelis,* all immature (besides this species, also *Phagocata oregonensis* Hyman and *Dendrocoelopsis vaginata* Hyman). The occurrence of *Polycelis* in this area is also mentioned by Hyman (1963:2) and Kenk (1970:31).

SOUTH DAKOTA. Brook near the State Game Lodge in the southern part of the Black Hills (Hyman, 1931:124).

UTAH. BEAVER COUNTY: Springs and streams in Puffer Lake area (Beck, 1954:82). CACHE COUNTY. Rick's Spring in Logan Canyon, on U.S. Highway 89, 16.6 road miles east of Utah State University in Logan; 27 September 1967, water clean, fast, cold, many specimens under stones, some of them mature but not studied (see also Beck, 1954:82; Braithwaite, 1962:24). *Phagocata crenophila* Carpenter occurs in the same locality. Springs and streams in Dagget, Emery, San Juan, Sanpete, Tooele, Utah, Wasatch, and Wayne counties (Beck, 1954:82; Braithwaite, 1962:24).

WASHINGTON. Streams in Mt. Rainier National Park, Lewis and Pierce counties (USNM 36070 through 36078).

WISCONSIN. DANE COUNTY: Springs near Lake Mendota (Muttkowski, 1918:389, as *"Polycelis nigra"*).

WYOMING. TETON COUNTY: (1) Stream crossing Jackson Hole highway (U.S. Highway 26), 0.5 mile south of Spread Creek bridge, Grand Teton National Park; 24 June 1963, water clear, 11.6°C, *Polycelis* in fission under stones. (2) Outflow of fish tanks of Jackson National Fish Hatchery, off U.S. Highway 89, 3½ road miles north of Jackson; 29 September 1967, moderate current, water clear, cold, one *Polycelis* under a stone. YELLOWSTONE NATIONAL PARK: Twenty-two springs

and streams in various parts of the Park; 17-25 June 1963, 7-8 September 1967, and 6 June 1970, water temperature 5.4°-17.3°C, (average 10.3°, 18 measurements), pH 7.7-8.6 (average 8.2, 4 measurements), worms frequently showing signs of asexual reproduction. Muttkowski (1929:183) reported "*Polycelis nigra*" from various streams in the Park. Specimens from Lava Creek were also collected and sent to me by Jack L. Dean.

CANADA. ALBERTA: Snaring River, Jasper National Park (Ball and Fernando, 1968:213).

The American species and subspecies of *Polycelis* are probably allopatric in distribution, with some possible sympatry in marginal areas. If this is the case, individual unidentified populations may be assigned, with some confidence, to known forms occuring in the same geographic area. Thus, all records from Alaska, northern Wyoming, and Alberta may refer to *P. coronata borealis,* populations of Montana, New Mexico, and Utah to *P.c. coronata,* and those of Colorado and South Dakota to *P.c. brevipenis.* It is possible that all *Polycelis* from California are *P. sierrensis.* These questions will have to be settled by additional collecting, preferably during the height of the breeding season (in winter?).

Conclusion

The genus *Polycelis* is represented in North America by two species belonging to two subgenera, *P. (Polycelis) coronata* (Girard) and *P. (Seidlia) sierrensis,* new species, inhabiting the western half of the continent. *P. coronata* occurs as three subspecies, *P.c. coronata, P.c. borealis,* and *P.c. brevipenis,* differing in the detailed structure of the copulatory apparatus. The North American forms cannot be distinguished by external characters alone, nor can they be identified in immature stages.

Literature Cited

Ball, I. R., and C. H. Fernando
1968. On the Occurrence of *Polycelis* (Turbellaria, Tricladida) in Western Canada. *Canadian Field-Naturalist,* 82:213–216.

Beck, D. E.
1954. Distributional and Natural History Notes on *Polycelis coronata* (Girard) in Utah. *Utah Academy of Sciences Arts and Letters, Proceedings,* 31:79–82.

Benazzi, M.
1963. Il Problema Sistematico delle *Polycelis* del Gruppo *nigra-tenuis* alla Luce di Richerche citologiche e genetiche. *Monitore Zoologico Italiano,* 70–71:288–300.

Braithwaite, L. F.
1962. The Taxonomic Problem of *Polycelis* in the United States. 32 pages. Unpublished M.S. Thesis, Brigham Young University.

Carpenter, J. H.
1969. A New Planarian from Utah, *Phagocata crenophila* n. sp. (Turbellaria, Tricladida). *Transactions of the American Microscopical Society,* 88:274–281.

Diesing, K. M.
1862. Revision der Turbellarien, Abtheilung: Dendrocoelen. *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften, Mathematisch-naturwissenschaftliche Classe,* Abtheilung 1, 44:485–578.

Ehrenberg, C. G.
1831. Animalia Evertebrata Exclusis Insectis. In Hemprich and Ehrenberg, *Symbolae Physicae,* series 1. Berolini.

Girard, C.
1891. Deux espèces nouvelles de Planaires Américaines. *Le Naturaliste (Paris),* series 2, 13 (98):80.
1893. Recherches sur les Planariés et les Némertiens de l'Amérique du Nord. *Annales des Sciences Naturelles, Zoologie,* series 7, 15:145–310, plates 3–6.

Hallez, Paul
1894. *Catalogue des Rhabdocoelides, Triclades & Polyclades du Nord de la France.* Second edition, 239 pages, 2 plates. Lille.

Holmquist, C.
1967. *Dendrocoelopsis piriformis* (Turbellaria Tricladida) and Its Parasites from Northern Alaska. *Archiv für Hydrobiologie,* 62:453–466.

Hyman, L. H.
1931. Studies on the Morphology, Taxonomy, and Distribution of North American Triclad Turbellaria, III: On *Polycelis coronata* (Girard). *Transactions of the American Microscopical Society,* 50:124–135.
1934. Report on Triclad Turbellaria from Indian Tibet. *Memoirs of the Connecticut Academy of Arts and Sciences,* 10:5–12, plates 1–2.
1951. North American Triclad Turbellaria, XII: Synopsis of the Known Species of Fresh-Water Planarians of North America. *Transactions of the American Microscopical Society,* 70:154–167.
1953. Turbellaria (Flatworms). In Robert W. Pennak, *Fresh-Water Invertebrates of the United States,* pages 114–141. New York: Ronald Press Company.
1963. North American Triclad Turbellaria, XVI: Fresh-Water Planarians from the Vicinity of Portland, Oregon. *American Museum Novitates,* 2123:1–5.

Ijima, I., and T. Kaburaki
1916. Preliminary Descriptions of Some Japanese Triclads. *Annotationes Zoologicae Japonenses,* 9:153–171.

Kaburaki, T.

1922. On Some Japanese Freshwater Triclads; with a Note on the Parallelism in Their Distribution in Europe and Japan. *Journal of the College of Science, Imperial University of Tokyo,* 44(2):1–71, 1 plate.

Kenk, R.

1930. Beiträge zum System der Probursalier (Tricladida Paludicola), III: Versuch einer natürlichen Gruppierung der Probursalier. *Zoologischer Anzeiger,* 89:289–302.

1936. Bemerkung zur Trikladenfauna Turkestans. *Zoologischer Anzeiger,* 115:76–80.

1952. Fresh-Water Triclads (Turbellaria) of the Rocky Mountain National Park Region, Colorado. *Journal of the Washington Academy of Sciences,* 42:193–198.

1953. The Fresh-Water Triclads (Turbellaria) of Alaska. *Proceedings of the United States National Museum,* 103:163–186, plates 6–8.

1970. Freshwater Triclads (Turbellaria) of North America, II: New or Little Known Species of *Phagocata. Proceedings of the Biological Society of Washington,* 83:13–34.

1972. Freshwater Planarians (Turbellaria) of North America. *Biota of Freshwater Ecosystems, Identification Manual,* no. 1. (In press.)

Kennedy, H. D.

1967. Seasonal Abundance of Aquatic Invertebrates and Their Utilization by Hatchery-Reared Rainbow Trout. *Technical Papers of the Bureau of Sport Fisheries and Wildlife, United States Department of the Interior,* 12:1–41.

Lepori, N. G.

1955. La Differenziazione specifica di *Polycelis nigra* Ehrenberg e *Polycelis tenuis* Iijima (Tricladida, Paludicola) e la loro Distribuzione geografica in Europa. *Atti della Società Toscana di Scienze Naturali,* series B, 62:50–71.

Müller, Otho Fridericus

1774. *Vermium Terrestrium et Fluviatilium, seu Animalium Infusoriorum, Helminthicorum et Testaceorum, non Marinorum, Succincta Historia.* 1(2):–80. Havniae et Lipsiae.

Muth, A.

1912. Beiträge zur Kenntnis der Gattung *Sorocelis* Grube. *Mitteilungen des Naturwissenschaftlichen Vereines für Steiermark,* 48:381–410.

Muttkowski, R. A.

1918. The Fauna of Lake Mendota: A Qualitative and Quantitative Survey with Special Reference to the Insects. *Transactions of the Wisconsin Academy of Sciences Arts and Letters,* 19:374–482.

1929. The Ecology of Trout Streams in Yellowstone National Park. *Roosevelt Wild Life Annals,* 2:154–240.

Okugawa, K. I.

1938. [On *Sorocelis sapporo* and some other Probursalia (Paludicola)]. *Dobutsugaku Zasshi,* 50:177.

Seidl, H. H.

1911. Beiträge zur Kenntnis centralasiatischer Tricladen. *Zeitschrift für wissenschaftliche Zoologie,* 98:31–67, plates 5–7.

Stimpson, W.

1857. Prodromus Descriptionis Animalium Evertebratorum quae in Expeditione ad Oceanum, Pacificum Septentrionalem a Republica Federata Missa, Johanne Rodgers Duce, Observavit et Descripsit, I: Turbellaria Dendrocoela. *Proceedings of the Academy of Natural Sciences of Philadelphia,* 9:19–31.

Stringer, C. E.

1918. The Free-Living Flatworms (Turbellaria). In Henry Baldwin Ward and G. C. Whipple, *Fresh-Water Biology,* pages 323–364. New York: John Wiley & Sons.

Zabusov, I. P. [also Sabussow, H., or Zaboussoff, H.]

1911. Izsliedovaniia po Morfologii i Sistematikie Planarii Ozera Baĭkala. I. Rod *Sorocelis* Grube (Untersuchungen über die Morphologie und Systematik der Planarien aus dem Baikalsee. I. Die Gattung *Sorocelis* Grube). *Trudy Obshchestva Estestvoispytatelei pri Imperatorskom Kazanskom Universitetie,* 43(4):1–422, 11 plates. Dobavlenie [Appendix], 10 pages.

1916. *Rjabuschinskya schmidti* n. g. n. sp., novyĭ vid i rod Tricladida Paludicola iz Kamchatki (*Rjabuschinskya schmidti* n. g. n. sp., Espèce et Genre nouveau des Tricladida Paludicola du Kamtchatka). *Russkii Zoologicheskii Zhurnal,* 1:273–286.

Addendum

While this paper was in press, an additional record of *Polycelis* came to the author's attention: K. Elgmork and O. R. Saether (1970), Distribution of Invertebrates in a High Mountain Brook in the Colorado Rocky Mountains. *University of Colorado Studies, Series in Biology,* 31:1–55, 1 folding table. Elgmork and Saether reported *Polycelis coronata* from North Boulder Creek and tributary in Boulder County, Colorado (p. 27).

☆ U. S. GOVERNMENT PRINTING OFFICE: 1973—484-322/36

Publication in Smithsonian Contributions to Zoology

Manuscripts for serial publications are accepted by the Smithsonian Institution Press, subject to substantive review, only through departments of the various Smithsonian museums. Non-Smithsonian authors should address inquiries to the appropriate department. If submission is invited, the following format requirements of the Press will govern the preparation of copy.

Copy must be typewritten, double-spaced, on one side of standard white bond paper, with 1½" top and left margins, submitted in ribbon copy with a carbon or duplicate, and accompanied by the original artwork. Duplicate copies of all material, including illustrations, should be retained by the author. There may be several paragraphs to a page, but each page should begin with a new paragraph. Number consecutively all pages, including title page, abstract, text, literature cited, legends, and tables. The minimum length is 30 pages, including typescript and illustrations.

The *title* should be complete and clear for easy indexing by abstracting services. Taxonomic titles will carry a final line indicating the higher categories to which the taxon is referable: "(Hymenoptera: Sphecidae)." Include an *abstract* as an introductory part of the text. Identify the *author* on the first page of text with an unnumbered footnote that includes his professional mailing address. A *table of contents* is optional. An *index*, if required, may be supplied by the author when he returns page proof.

Two *headings* are used: (1) text heads (boldface in print) for major sections and chapters and (2) paragraph sideheads (caps and small caps in print) for subdivisions. Further headings may be worked out with the editor.

In *taxonomic keys,* number only the first item of each couplet; if there is only one couplet, omit the number. For easy reference, number also the taxa and their corresponding headings throughout the text; do not incorporate page references in the key.

In *synonymy,* use the short form (taxon, author, date:page) with a full reference at the end of the paper under "Literature Cited." Begin each taxon at the left margin with subsequent lines indented about three spaces. Within an entry, use a period-dash (.—) to separate each reference. Enclose with square brackets any annotation in, or at the end of, the entry. For *references within the text,* use the author-date system: "(Jones, 1910)" and "Jones (1910)." If the reference is expanded, abbreviate the data: "Jones (1910:122, pl. 20: fig. 1)."

Simple *tabulations* in the text (e.g., columns of data) may carry headings or not, but they should not contain rules. Formal *tables* must be submitted as pages separate from the text, and each table, no matter how large, should be pasted up as a single sheet of copy.

Use the *metric system* instead of, or in addition to, the English system.

Illustrations (line drawings, maps, photographs, shaded drawings) can be intermixed throughout the printed text. They will be termed *Figures* and should be numbered consecutively; however, if a group of figures is treated as a single figure, the components should be indicated by lowercase italic letters on the illustration, in the legend, and in text references: "Figure 9*b*." If illustrations (usually tone photographs) are printed separately from the text as full pages on a different stock of paper, they will be termed *Plates,* and individual components should be lettered (Plate 9*b*) but may be numbered (Plate 9: figure 2). Never combine the numbering system of text illustrations with that of plate illustrations. Submit all legends on pages separate from the text and not attached to the artwork. An instruction booklet for the preparation of illustrations is available from the Press on request.

In the *bibliography* (usually called "Literature Cited"), spell out book, journal, and article titles, using initial caps with all words except minor terms such as "and, of, the." For capitalization of titles in foreign languages, follow the national practice of each language. Underscore (for italics) book and journal titles. Use the colon-parentheses system for volume, number, and page citations: "10(2):5-9." Spell out such words as "figures," "plates," "pages."

For *free copies* of his own paper, a Smithsonian author should indicate his requirements on "Form 36" (submitted to the Press with the manuscript). A non-Smithsonian author will receive 50 free copies; order forms for quantities above this amount with instructions for payment will be supplied when page proof is forwarded.