A DESCRIPTION OF THE PLANARIAN PHAGOCATA CRENOPHILA,
NEW SPECIES, FROM UTAH

by

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# TABLE OF CONTENTS

ACKNOWLEDGMENTS ............................................. ii

LIST OF TABLES .............................................. iv

LIST OF FIGURES .............................................. iv

LIST OF PLATES ............................................... v

ABSTRACT ....................................................... vii

INTRODUCTION .................................................. 1

REVIEW OF LITERATURE ....................................... 2

MATERIALS AND METHODS ..................................... 6

- Histotechniques ............................................. 6
- Pressing ....................................................... 6
- Collecting ..................................................... 7
- Culturing ...................................................... 8
- Temperature Experiment ...................................... 8
- Current Experiment ......................................... 9
- Water Measurements ......................................... 9

RESULTS .......................................................... 10

Description ..................................................... 10

- External features ........................................... 10
- Internal features ............................................ 11

- Diagnosis ...................................................... 13
- Relationships ............................................... 13
- Key to Species and Subspecies of North American Phagocata ........................................ 14
- Distribution and Natural History .......................... 15

SUMMARY ........................................................ 21

LITERATURE CITED ............................................. 22

APPENDIX ......................................................... 24

VITA .............................................................. 37
LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Numbers and percentages of <em>P. crenophila</em> to <em>P. coronata</em></td>
</tr>
</tbody>
</table>

LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Miniature press</td>
</tr>
<tr>
<td>2. Artificial current apparatus</td>
</tr>
<tr>
<td>3. Map of Logan River and associated springs</td>
</tr>
<tr>
<td>4. Populations in upper Spring Hollow Stream from collection on January 21, 1968</td>
</tr>
</tbody>
</table>
LIST OF PLATES

PLATE I

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Type locality. Head of Spring Hollow Stream looking downstream</td>
<td>32</td>
</tr>
<tr>
<td>2</td>
<td>Smaller of two small springs near Temple Fork turnoff</td>
<td>32</td>
</tr>
<tr>
<td>3</td>
<td>Ricks Spring during winter dry season</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>Logan Cave Stream</td>
<td>32</td>
</tr>
<tr>
<td>5</td>
<td>China Row Spring on east side of highway</td>
<td>32</td>
</tr>
<tr>
<td>6</td>
<td>China Row Spring on west side of highway</td>
<td>32</td>
</tr>
</tbody>
</table>

PLATE II

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Anterior end of <em>Phagocata crenophila</em></td>
<td>34</td>
</tr>
<tr>
<td>2</td>
<td>Anterior end of <em>Polycelis coronata</em></td>
<td>34</td>
</tr>
<tr>
<td>3</td>
<td>Is through copulatory organs showing relative shapes and positions of organs, X40</td>
<td>34</td>
</tr>
<tr>
<td>4</td>
<td>Is through copulatory organs showing entrance of ovovitelline duct into male atrium, X40</td>
<td>34</td>
</tr>
<tr>
<td>5</td>
<td>Is through posterior end showing testes in ventral position, X23</td>
<td>34</td>
</tr>
<tr>
<td>6</td>
<td>Is through anterior end showing relative positions and sizes of ovary and most anterior testis, X30</td>
<td>34</td>
</tr>
<tr>
<td>7</td>
<td>xs anterior to pharynx showing relative positions of testes and nerve cords, X40</td>
<td>34</td>
</tr>
<tr>
<td>8</td>
<td>xs through penis showing several sections of vas deferens before entering ejaculatory duct, X90</td>
<td>34</td>
</tr>
</tbody>
</table>

PLATE III

<table>
<thead>
<tr>
<th>Figure Number</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>xs through anterior portion of penis showing vas deferens as they enter ejaculatory ducts, X90</td>
<td>36</td>
</tr>
</tbody>
</table>
Figure 2. xs through anterior end showing relative positions of ovaries, testes, and nerve cords, X75. 36

Figure 3. Is through penis showing ventral opening and enlarged lobe of penis, X75. 36

Figure 4. xs through penis showing ventral opening and enlarged lobe of penis, X90. 36

Figure 5. Is through copulatory organs showing penis lobe, course of ejaculatory duct, and spermatophore exiting penis, X75. 36

Figure 6. xs through bursa showing diverticula of bursa and a spermatophore, X90. 36
ABSTRACT

A Description of the Planarian Phagocata Crenophila, New Species, from Utah

by

Jerry H. Carpenter, Master of Science

Utah State University, 1968

Major Professor: Professor Merrill H. Gunnell
Department: Zoology

A new species of planaria in the genus Phagocata was found in several springs and spring-fed streams in Logan Canyon, Cache County, Utah. This species was named Phagocata crenophila because it greatly prefers to live in springs and it seems to be adapted behaviorally to this type of habitat. Serial sections and whole mounts were made by standard methods in order to study the anatomical features which are necessary for identification of planarians. The distinguishing features of this species are the following: testes ventral and extending from near the brain to near the posterior end, ejaculatory duct opening ventrally from the penis, penis short and rounded with a prominent finger-like lobe at the tip, two eyes situated far back on the truncated head, and color usually dark gray. Comparisons to similar species are made, and a new key to the species and subspecies of the genus Phagocata is proposed.

Several experiments were performed on cultured lab animals in order to determine their reactions to temperature and to current. Most animals which were kept in a refrigerator at 16°C. survived for a month or more. Several short experiments were performed using an artificial current created in 1000 ml. beakers by an electric magnetic stirrer. These
tests indicate a fairly great tolerance of relatively high temperatures (16°C.), but a greater ability of P. crenophila to orient into a current and to resist being swept away by a strong current than Polycelis coronata with which it lives naturally.

The ecology of each spring or stream in which the new species is found is discussed briefly. Observations throughout the year indicate that P. crenophila prefers cold, fast flowing head waters of streams with substrates composed of rocks and moss. P. crenophila may be able to better survive the strong current or the winter dry periods at Ricks Spring than P. coronata, thus resulting in a greater proportion of the former species in this spring. In other springs, populations of P. crenophila appear to be limited, at least partially, by the large populations of P. coronata.
INTRODUCTION

In February of 1967 a few specimens of a planarian which was unfamiliar to the author were found in upper Logan River. Preliminary investigations were then undertaken to learn more about this species. A review of the literature and correspondence with specialists of this group indicated that this species was new to science. This species closely resembles eight other North American planarians in general shape, but each of these has slight differences in eye position, pigmentation, size, and/or habitat. In addition, none of the similar species had ever been reported farther west than Colorado. However, it was not until late summer of 1967 that planarians in sexual condition were obtained. Serial sectioning of mature specimens confirmed my suspicion that this is a new species in the genus Phagocata. It was given the name Phagocata crenophila. This is the tenth species in this genus known to occur in North America. Since very few new planarians have been discovered in recent years, this finding is of considerable interest.

Although planarians have been the subject of much laboratory research on regeneration, relatively few studies have been performed in planarian ecology. It is the purpose of this investigation, therefore, to describe this new planarian, its habits, and the factors which influence its local distribution.
REVIEW OF LITERATURE

In order to determine the taxonomic position of this new species, several references were necessarily examined. Before mature individuals were obtained, various standard references were used to key out the species using external characteristics. Pennak (1953) and Ward and Whipple (1963) contain keys which are arranged slightly differently, and by using the two keys together the writer was able to determine that this new species most closely resemble *Planaria dactyligera*, which is reported only from springs in Virginia. Letters and questionnaires were sent to various authorities in the field and to zoologists in the western U. S. to determine if any species fitting the description of the new one has been described from the West since the keys from Pennak and Ward and Whipple had been written. All responses were negative.

When mature specimens were available later in the year, the morphology of the new species was compared to drawings, photographs, and verbal descriptions of all similar species in North America. These references and comparisons are described in the section entitled Diagnosis.

As stated in the Introduction, relatively few studies have been performed on the ecology of planarians. However, a few studies have been good guidelines for the present study. Macan (1961) discusses the factors which can limit the range of fresh-water animals: (1) oviposition behavior of female, (2) isolation, (3) predation, (4) competition, (5) organic substances, (6) water movement, (7) substrate, (8) dessication, (9) temperature, (10) oxygen, (11) salinity, (12)
calcium, (13) other chemicals, and (14) H+ ion. Various studies have indicated the importance or unimportance of all these factors.

Chandler (1966) found that a good substrate composed of calcium carbonate and silt probably was needed (or at least preferred) for oviposition by Phagocata gracilis gracilis in Indiana. "The worms in some way deposit their capsules under the encrustation, thus protecting them effectively from the current, indeed a unique adaptation in running water" (Chandler, 1966, p. 52). However, large amounts of calcium carbonate have not been found in streams inhabited by the new species (Phagocata crenophila); in most localities the substrates are composed of fairly large rocks covered by aquatic moss (Fontinalis). Apparently oviposition by P. crenophila occurs under the rocks and perhaps in the moss. Substrate is of great importance in other ways, also, by influencing rate of flow, oxygen, content, and type of food available. This is probably one of the main factors limiting P. crenophila to small mountain springs and streams.

Isolation could play a part in the distribution of planarians. For instance, if different drainage systems are not connected, planarians would have great difficulty in getting from one to another. However, transportation of egg capsules via birds or humans is possible. The small geographic ranges of many planarians (Hyman, 1951a), however, indicate that overland transportation is relatively rare in most species.

Predation by other organisms is uncommon since the surface secretions of planarians appear to be distasteful (Hyman, 1951b). Their worst enemies are other planarians since they are highly cannibalistic. In this respect competition may be of great importance. Chandler (1966)
found that where the ranges of two species of planarians in a stream overlapped, the proportions of the species varied depending on the food availability. Beauchamp (1932) also found competition to be of great importance in the local distributions of planarians.

Dissolved organic matter, especially when in high amounts, is important to some planarians. But mountain streams would, of course, be low in organic matter (especially of animal origin) because of the lack of human pollution.

The rate of water movement is of great importance to planarians. "Planarians that habitually live in flowing water usually exhibit a positive rheotaxis response to current, for obviously without such a reaction they could not maintain themselves in their habitat" (Hyman, 1951b, p. 213). The degree to which a species is dependent on the current is variable. *Crenobia alpina*, which inhabits European streams, apparently needs a current to find its food (Hyman, 1951b). *P. crenophila* does seem to prefer fast running water, but it can be cultured without a current. Some investigators, especially Beauchamp, have found the rheotactic response of *Planaria alpina* varies with the strength of the current and with the physiological condition of the worm. A weak stimulus results in a positive response while a strong stimulus results in a negative response in order to escape (Beauchamp, 1937). Individuals which are developing sexually are positively rheotactic, but they are negatively rheotactic after maturing (Beauchamp, 1933). After many maturing individuals reach the head of a stream, overcrowding results in starvation of many individuals; starved animals and those having already laid cocoons become negatively rheotactic and move downstream to where food is available and where the starved worms can rejuvenate and again move
upstream (Beauchamp, 1933).

Dessication can obviously affect planarians, since they normally have no surface protection against evaporation. Phagocata velata and Phagocata vernalis, however, fragment and encyst during summer dry periods (Kenk, 1944). Resistance to dessication may be important in the ecology at Ricks Spring which dries up during winter months.

There is no doubt that low temperatures are necessary for many planarians. Beck (1954) noted that Polycelis coronata dies before temperature of the surrounding water reaches 20°C and that it prefers temperatures around 10°C. Some planarians are able to detect slight changes of 2°C to 3°C in temperature (Hyman, 1951b). Laboratory experiments indicate low temperatures are necessary in the culturing of P. crenophila.

A reasonable amount of oxygen is necessary for planarians, but in moving water the oxygen level probably does not often drop to a dangerous level. Chandler (1966) indicates that in his studies dissolved oxygen at no time dropped to levels so low as to be a serious limiting factor for planarians. He also says, "There is apparently no distributional relationship for chloride, magnesium, or specific conductance" (Chandler, 1966, p. 43). Hyman (1951b, p. 198) says, "Turbellarians are in general indifferent to the pH of their environment, enduring without evident effect wide change in this factor."

In short, the factors of greatest importance in the distribution of most planarians are competition, water movement, substrate, and temperature. The degree to which they influence P. crenophila are briefly discussed in the section on distribution and natural history.
MATERIALS AND METHODS

Histotechniques

To determine the exact taxonomic position and the morphological details of this species, serial sections and whole mounts of sexually mature specimens were made. Preparing the sections was a long and complicated process which involved killing with 2 per cent nitric acid, fixing in FAA, dehydrating, imbedding, sectioning with a microtome, affixing to slides, hydrating, staining with Harris' hematoxylin, dehydrating, counter-staining with eosin Y, and mounting with Permount mounting fluid. Preparation of whole mounts involved killing with 2 per cent nitric acid, fixing in corrosive sublimate, rinsing, pressing in 70 per cent EtOH, staining with borax carmine, destaining in weak HCl, dehydrating, and mounting with Permount.

Pressing

While most of the above processes are standard for histological study, the pressing procedure used for the whole mounts is unique and could possibly be of use in many types of slide preparations. Flattening the planarian gradually is necessary so that the tissues and organs are not injured or displaced. This technique may also be used for squeezing excess mounting medium out of freshly mounted slides. A micrometer caliper is forced into a piece of styrofoam used for a base, which will later fit into a rectangular staining dish (Figure 1). The planarian is placed between two cover slips, which are then placed between two
depression slides held apart slightly by two pieces of sponge rubber. The micrometer caliper points (anvils) are placed in the depressions (which are on the outer side of the slides) so that the micrometer will not slip off the slides. Pins may also be used to hold the slides in place on the styrofoam base. The sponge rubber is used to balance the pressure, while the cover slips are used so that when the pressure is released from the slides, the planarians will remain compressed. The micrometer caliper serves as a miniature, but precise, vise which can be tightened or loosened very gradually over several hours to several days. The styrofoam base is submerged in 70 per cent EtOH in the staining dish. A piece of plastic wrap over the top of the dish slows evaporation.

Collecting

Many collecting trips were made during 1967 and early 1968 to obtain information on the natural history and ecology of this new species. Two methods were used for collecting the planarians. When the weather was not inclement, planarians were picked from the rocks in the streams and springs. This gave a rapid estimate of the numbers and conditions of the planarians. When the weather was unfavorable or when large samples were desired, raw beef was used to attract the worms. Bait left in the water for over an hour was often covered with several hundred planarians.

In the laboratory the new species was separated from Polycelis coronata (Girard, 1891), which is always present with the new species.

1There is some controversy over the name of this species. Girard first collected Polycelis coronata from Boulder, Colorado, in 1891, and Hyman described the internal anatomy from specimens from South Dakota. Braithwaite claims the anatomy of the Utah Polycelis is different from
The two species can be separated rather easily by sucking up the planarians of one species (one at a time) with a rubber syringe and squirting them into separate containers. One can distinguish the two species without aid of a microscope by the shape of the head (truncate with inconspicuous auricles on the new species and very prominent auricles on *P. coronata*). Under the microscope another difference becomes obvious: the new species has two eyes while *P. coronata* has many eyes around the anterior and lateral margins of the head (Plate II, Figures 1 and 2).

**Culturing**

In order to keep these planarians alive for any length of time, it is necessary to take certain precautions. Since the worms die at room temperature, they must be kept under refrigeration. Most of the planarians were reared in a styrofoam ice chest kept in a walk-in cold room maintained at 4°C. Beef liver or blood clots were provided as food once or twice a week. The water was changed after each feeding by adding spring water kept at 4°C.

**Temperature Experiment**

Several experiments were performed in the laboratory in order to learn more about the factors influencing the distribution of planarians. To test their response to temperature, a few were placed in jars in a

Hyman's description and proposes the name *Polycelis becki*. Kenk claims that the Utah specimens are the same as those he collected from Boulder, Colorado, in 1967, and that these may or may not be the same as those from South Dakota (Kenk, 1968). The name *P. coronata* will be used throughout this study.
refrigerator with temperature controls. In this way it was possible to
determine a planarian's ability to survive at various temperatures.

Current Experiment

To test response to water currents, a 1000 ml. beaker, a magnet, and
a magnetic stirrer (Figure 2) were used. The force of the current can
easily be regulated with this apparatus.

Water Measurements

Measurements of the streams and springs were determined by standard
techniques. A Beckman Model G pH meter was used for H+ ion concentration,
and a metal thermometer was used for temperature readings.
External features

*P. crenophila* resembles most other members of this genus in general shape (Plate II, Figure 1). The maximum length is 18 mm. with a width of 2.0 mm. Most individuals are much smaller, averaging about 12 mm. in length and 1.5 mm. in width when mature; however, much smaller individuals are very common at certain times of the year. During undisturbed movement, the truncated anterior end is somewhat variable in shape. The frontal margin is slightly convex; the lateral lobes (or auricles) are rounded and project only slightly laterally so that they are hardly detectable. Posterior to these lobes the body narrows very slightly, then gradually widens until the greatest width is attained in the pharyngeal region. Posterior to the pharynx the body gradually narrows, and the end is more or less rounded. The color of the dorsal side is usually a variable shade of gray, often with a brownish hue, and appears uniform but somewhat cloudy to the unaided eye. However, there is much variation in color; some appear black (especially if the habitat substrate is very dark) while others (especially very young ones) lack body pigment on part or all of the dorsal surface. Pigment is lacking in the small ocular spaces lateral to the eyes, which gives most individuals the cross-eyed appearance typical of many species. Pigment often is also lacking around the anterior margins of the head. The ventral surface is usually considerably lighter than the dorsal surface. The mouth and,
in mature specimens, the genital pore appear as round light spots. The pharynx and copulatory apparatus appear as creamy white areas in dorsal view. The distance between the two eyes is a little less than one-third the width of the head. The relative distance of the eyes from the frontal margin is variable. In young animals (Plate II, Figure 1) this distance is nearly twice the distance from the lateral margins, but in older animals these distances are nearly equal.

Internal features

Digestive system. The inner muscle zone of the pharynx consists of two separate layers, a circular and a longitudinal one; this arrangement is typical for the family Planariidae. The pharynx occupies about three-fifths of the posterior half. The three intestinal trunks each bear many side branches; the anterior trunk bears about 16 to 18 of these branches, and each lateral trunk bears about 40.

Reproductive system. Whole mounts and serial sections of several sexually mature specimens were made to determine the location of the various reproductive organs. There are many testes which extend from the most anterior side branches of the intestine near the brain nearly to the posterior end of the animal (Plate II, Figures 5 and 6). The testes are predominantly ventral. Cross sections show testes mostly above and lateral to the nerve cords, but many are also directly above or above and medial to the nerve cords (Plate II, Figure 7 and Plate III, Figure 2). The sperm ducts of the two sides twist several times in the region of the penis and never come in contact with each other before they enter the anterior end of the penis bulb separately but at the same level (Plate II, Figure 8 and Plate III, Figure 1).
The ovaries are slightly anterior to the most anterior testes, above and slightly medial to the nerve cords, and somewhat posterior to the most anterior areas of the intestine (Plate II, Figure 6 and Plate III, Figure 2). They are spherical and about the same size as the testes. Dorsal and anterior to the ovaries are masses of undifferentiated cells which may be paraovaria. The yolk glands are found throughout most of the length of the body dorsal, ventral, and lateral to branches of the intestine as well as between branches.

Copulatory complex. The genital pore leads into a fairly small genital atrium which is divided into a posterior chamber, the common atrium, and an interior chamber, the male atrium, which surrounds the penis (Plate II, Figure 3). The ovovitelline duct enters the roof of the male atrium on the left side very near the common atrium (Plate II, Figure 4). The penis bulb and papilla are both relatively short, and the lumen curves first dorsally then ventrally so that the distal end opens into the ventral portion of the male atrium (Plate III, Figures 3-5). No enlarged cavity or seminal vesicle is present. A finger-like lobe is at the tip of the penis papilla.

The bursa stalk (or canal) enlarges as it proceeds posteriorly and ventrally to form part of the common atrium. It enters the common atrium from the left side, and it enters the bursa to the dorsal and left of center. The canal is coated with the usual layers of circular and longitudinal muscle fibers. The bursa, when at its largest, is large enough to occupy most of the thickness of the body (Plate III, Figures 5 and 6). It is generally spherical in shape, but it has several diverticula.
**Diagnosis**

_P. crenophila_ can be distinguished from all other members of this genus by a prominent finger-like lobe at the tip of the penis papilla and by the ventral opening of the ejaculatory duct from the penis papilla (Plate III, Figures 3-5).

There are eight species of planarians in North America which resemble _P. crenophila_ in general form. From the two polypharyngeal subspecies, _Phagocata gracilis gracilis_ (Haldeman) and _Phagocata gracilis woodworthii_ Hyman, it can be readily distinguished by the presence of only a single pharynx. _Phagocata gracilis monopharyngea_ Hyman, 1945, has sperm ducts which are adjacent for a short distance before entering the penis bulb, while the sperm ducts of _P. crenophila_ never come in contact with each other. From _Planaria dactylicera_ Kenk, 1935, it can be distinguished by the absence of an adenodactyl. In _P. crenophila_ the testes are numerous, ventral, and extend from the area of the head nearly to the end of the tail; in _Phagocata velata_ (Stringer, 1909) the testes are dorsal, and in _Phagocata vernalis_ Kenk, 1944, they are few, prepharyngeal, and fused to form a compound testis on the medial side of each ventral nerve cord. _Phagocata morgani_ (Stevens and Boring, 1906), _Phagocata nivea_ Kenk, 1953, _Phagocata oregonensis_ Hyman, 1963, and _Phagocata cavernicola_ Hyman, 1954, all lack body pigment.

**Relationships**

As with any taxonomic group, it is difficult to determine the relationships of planarian species. However, since there are only ten
species of *Phagocata* in North America, zoogeographical as well as morphological characteristics can be utilized to show certain possible relationships. Kenk (1953) states that the Alaskan planarians are more closely related to Eurasian species than to other North American species. However, *P. nivea* from Alaska closely resembles *P. morgani* from the Appalachian region, both being without pigment, having a truncate head with eyes far back on the head, and having a short, rounded penis with a ventral opening and slight indications of a lobe at the tip of the penis.

Externally these two species are indistinguishable, and both are externally similar to *P. crenophila* except that the latter is pigmented. The major internal differences of these three species are the location of testes (they extend only to the level of the mouth in *P. morgani*) and the degree to which the lobe at the tip of the penis is developed (highly developed in *P. crenophila*, less in *P. nivea*, and even less in *P. morgani*). It therefore appears that these three species may be closely related.

Of course, there are many possible evolutionary schemes, and in order to determine the most probable ones, more information must be obtained on the morphological variations of these species and on their geographic distributions. Further investigations may lead to the discovery of intermediate species or subspecies which would show the true relationships of these planarians.

**Key to Species and Subspecies of North American Phagocata**

This key is composed in part from Hyman, 1951, with additions and modifications from Kenk (1953), Darlington (1959), and Hyman (1954 and 1963) to include *P. nivea*, *P. bursaperforata*, *P. cavernicola*, and *P. oregonensis*. Only specimens of *P. crenophila* and *P. oregonensis* were personally examined.
1.a. White (without pigment) ........................................... 2
   b. Colored (with pigment) ................................. 8

2.a. Polypharyngeal ........................................... subterranea Hyman
   b. Monopharyngeal ...................................... bursaperforata Darlington

3.a. Eyes absent ........................................... bursaperforata Darlington
   b. Eyes present ........................................ 4

4.a. Two short longitudinal bands of eyes in place of two normal eyes morgani polycelis Kenk
   b. Two normal eyes ........................................ 5

5.a. Testes extend to mouth ........................................ morgani morgani (Stevens and Boring)
   b. Testes extend posterior to mouth ........................................ 6

6.a. Penis papilla with oval cavity ...................................... oregonensis Hyman
   b. Penis papilla without oval cavity ........................................ 7

7.a. Testes extend to posterior end ...................................... nivea Kenk
   b. Testes extend to region of genital pore ................................ cavernicola Hyman

8.a. Polypharyngeal ........................................... 9
   b. Monopharyngeal .......................................... 10

9.a. Penis long and pointed ...................................... gracilis gracilis (Haldeman)
   b. Penis short and truncate ...................................... gracilis woodworthi Hyman

10.a. Ejaculatory duct with ventral blind sac ................................ velata (Stringer)
   b. Ejaculatory duct without ventral blind sac ................................ 11

11.a. Sperm ducts adjacent before entering penis bulb, penis lumen sac-like gracilis monopharyngea Hyman
   b. Sperm ducts not adjacent before entering penis bulb, penis lumen tube-like 12

12.a. Testes fused, extending to mouth ........................................ vernalis Kenk
   b. Testes not fused, extending to posterior end ................................ crenophila Carpenter

**Distribution and Natural History**

Dr. Kenk (1968) has found P. crenophila "in several localities in Utah and also in neighboring states," but the details of these localities are not readily available. Hyman (1931) mentions a new record of P. velata from Boulder, Colorado, but does not mention details of the collection of the specimens; it is the opinion of this writer that the planarians were probably P. crenophila because of the type of habitat
in that area (many mountain streams) and because all other records for
*P. velata* come from "Mississippi Valley, Michigan and Ontario westward
to Nebraska and southward into Missouri" (Hyman, 1951a, p. 161). Furthermore at the time of the Colorado collection in 1931, *P. vernalis* (externally identical to *P. velata*) had not yet been described. Therefore, further collections will have to be made to determine what species is in that area.

In the area of Logan, Utah, *P. crenophila* has been found only in the vicinity of cold mountain springs and their associated streams, and only in five general localities despite searches of other springs and streams in the area. The map of Logan River and associated springs (Figure 3) shows the locations where *P. crenophila* has been found. Highway U. S. 89 follows the course of the river through Logan Canyon.

The results of several collecting surveys are shown in Table 1. Unusually high or low percentages in some collections were due to small samples. Other changes throughout the year may be due to actual structural changes in the populations resulting from different birth and death rates. The totals give a reasonably accurate picture of the populations.

1. The type locality (Plate I, Figure 1) is the spring which feeds Spring Hollow Stream in Logan Canyon, Cache County, Utah. This spring comes out of the side of a cliff in the spring of the year when snow melt is great; the remainder of the year the water springs from between rocks which form the floor of the stream. The water then travels about one-half mile before it enters the third dam reservoir of Logan River. This reservoir is located 4.0 miles from the mouth of the canyon.

*P. crenophila* can be found in this area of the stream throughout the year. *P. coronata* also occurs in the same place as *P. crenophila*
and in larger proportions. While the population of *P. coronata* remains the same or increases in size downstream from the spring, *P. crenophila* becomes progressively more difficult to find in most localities downstream. A small spring about midway between the main spring and the reservoir contains individuals of both species at least some of the time. It is strange that another small spring about 100 feet above this one contains only *P. coronata*.

The reasons for this unusual distribution are not definitely known, but some hypotheses can be suggested. Changes in water chemistry may occur in that short distance, but pH readings indicate only slight changes from near the source (about 7.75) to near the reservoir (about 8.2), dissolved oxygen is high throughout the stream, and the temperature remains close to 6° or 7°C. during all seasons. Laboratory experiments show that both species of planarians can survive temperatures of 16°C. for several weeks. Experiments concerning rheotactic responses (see methods and materials) indicate that *P. crenophila* has a stronger tendency to move into a current (and therefore to move upstream) than does *P. coronata*. How or why it has acquired this tendency is not known, but it may be survival behavior to avoid competition from *P. coronata* in the lower areas of the stream.

2. Ricks Spring (Plate I, Figure 3) is located in Logan Canyon 15.8 miles from the mouth of the Canyon. The water from this large spring comes out of a hole in a mass of rocks; the water collects in a pool about 50 feet in diameter, then flows over a short rocky stream bed about 100 feet before it enters the Logan River. As is seen in Table 1, this short stream is the only location where *P. crenophila* outnumbers *P. coronata* throughout most of the year. The unusually high proportions of
**P. crenophila** may be due to a greater ability to withstand the very strong current. They may also be associated with the fact that the spring dries up during a few months of most winters. This may result in less food of some kinds or in a higher mortality of **P. coronata**; some planarians and several kinds of insect larvae have been found under rocks in the dry stream bed.

3. Logan Cave Stream (Plate I, Figure 4) is located 12.1 miles from the mouth of Logan Canyon. This stream begins several yards below the mouth of Logan Cave and travels down a steep hill about 50 feet before it goes through culverts under the highway and enters Logan River. During the heavy snow melt of early spring, water pours out the mouth of the cave and greatly increases the volume of the stream. **P. coronata** outweighs **P. crenophila** about 8 to 1 in this stream.

4. A few specimens of **P. crenophila** have been found in China Row Stream (Plate I, Figures 5 and 6), which is located in Logan Canyon 10.0 miles from the mouth. This relatively slow moving stream starts from seepage, as well as from pipes providing drinking water for campers. The stream travels about 200 feet before going through a culvert under the highway; then it travels another 150 feet before joining Logan River. The stream bed has fewer rocks than do the other localities, most of the soil is very dark, and many of the planarians (both species) are very darkly pigmented.

5. Two small springs (Plate I, Figure 2) about 100 yards south of the Temple Fork turnoff (15 miles from the mouth of the canyon) contain a few **P. crenophila** and many **P. coronata**. The low proportions of **P. crenophila** at Temple Fork Streams and at China Row Stream may be explained
by conditions during the summer months. The water often runs very slowly, becomes warmer, and supports large amounts of water cress and snails. Since these planarians prefer cold, running water, they may die or move to the river under these unfavorable conditions. If the populations die every year or every few years, *P. coronata* would probably re-populate these streams faster because of its ability to survive in the river.

The species was not found at any other locality despite many searches of nearby springs and streams. A list of other streams of the Logan River drainage system which were examined includes the following: Twin Creek, Tony Grove Stream, Bunch Grass Creek, Right Hand Fork of Logan River, and the main branch of Logan River. (*P. crenophila* has been found in Logan River occasionally, but only in places where springs or spring-fed streams enter.) Streams examined in other drainages include High Creek, Smithfield Creek, Left Hand Fork of Blacksmith Fork River, Gray Cliff Spring, Lime Spring, Spring Campground Spring, Right Hand fork of Blacksmith Fork River, Rock Creek, and Curtis Creek. All these areas contained *P. coronata* but not *P. crenophila*.

It is interesting to speculate on the causes of this limited distribution. Of course, it can partially be explained by unfavorable ecological factors in some areas during part or all of the year. For instance, *P. crenophila* may avoid the waters of Logan River because of the more extreme temperatures, the high turbidity during the spring run-off, the lack of a suitable substrate, or the lack of food. However, other hypotheses must be employed to explain its absence in other areas. Since Beck (1954) mentions that he found *P. coronata* in Ricks Spring but does not mention any other planarians, it is conceivable that *P. crenophila*
may be a relatively recent introduction into this stream. Many tourists stop at Ricks Spring, and it is possible that P. *crenophila* could have been introduced from other areas via egg capsule. This could explain its absence in apparently suitable springs in other nearby drainage systems. On the other hand, it is possible that this species was merely overlooked by Beck or that the populations were low at that time. It is also possible that the species may have been present in the headwaters of Spring Hollow Stream or one of the other streams for many years and that only recently has it traveled to Ricks Spring.
SUMMARY

Comparison of the anatomy of *P. crenophila* to other similar species prove that this is a new species. Its distinctive characteristics include the following: testes ventral and extending from near the brain to near the posterior end, ejaculatory duct opening ventrally from penis, penis short and rounded with a prominent finger-like lobe at the tip, two eyes situated far back on the truncated head, and color usually dark gray. A new key to the species and subspecies of the genus *Phagocata* is proposed.

Experiments performed in the laboratory indicate a tolerance of temperatures around 16°C for more than a month; thus temperature alone does not restrict the distribution of the new species. Experiments using an artificial current indicate a stronger positive rheotactic response for *P. crenophila* than for *P. coronata*. This strong response in laboratory experiments and observations in the natural habitats throughout the year show that *P. crenophila* prefers cold, fast flowing head waters of streams with substrates composed of moss and rocks. Reasons for this preference are not definitely known, but a possible factor influencing their choice of habitat is reduced competition from *P. coronata*, which cannot withstand the strong current as well and which may prefer downstream areas where food is more abundant. *P. crenophila* probably avoids the waters of Logan River because of the more extreme temperatures, the high turbidity during the spring run-off, or the lack of a good substrate. The extremely large proportion of *P. crenophila* at Ricks Spring may be explained by its greater ability to survive dessication during the winter dry period and to withstand the strong current during spring.
LITERATURE CITED


Braithwaite, Lee F. 1967. Professor of zoology at Brigham Young University. Personal interview. May 20.


APPENDIX
Figure 1. Miniature press.
Figure 2. Artificial current apparatus.
Figure 3. Map of Logan River and associated springs.
Figure 4. Populations in upper Spring Hollow Stream from collection on January 21, 1968.
Table 1. Numbers and percentages of *P. crenophila* to *P. coronata*

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<th>Location</th>
<th>May 7</th>
<th>Sept. 12</th>
<th>Sept. 23</th>
<th>Oct. 7</th>
<th>Nov. 4</th>
<th>Nov. 12</th>
<th>Jan. 6</th>
<th>Jan. 25</th>
<th>Feb. 17</th>
<th>Mar. 20</th>
<th>Mar. 21</th>
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<td>Spring Hollow</td>
<td>100/400</td>
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<td></td>
<td>75/130</td>
<td>58%</td>
<td>300/930</td>
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<td>Spring</td>
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<td>7/11</td>
<td>30/50</td>
<td>140/170</td>
<td>94/100</td>
<td>237/250</td>
<td>540/620</td>
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<tr>
<td>Ricks Spring</td>
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<td>64%</td>
<td>60%</td>
<td>82%</td>
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<td>8/2315</td>
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<td>.3%</td>
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<tr>
<td>China Row</td>
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<td>15/75</td>
<td>8/300</td>
<td>35/1080</td>
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<td>107/1934</td>
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Key to Figures

b  bursa
bc bursal canal
c ca  common atrium
cg cement glands
de dorsal epidermis
ed ejaculatory duct
gp genital pore
i intestine
ma male atrium
mc nerve cord
o ovary
p penis
pc pharyngeal cavity
ph pharynx
pl penis lobe
sp spermatophore
t testis
vd vas deferens
ve ventral epidermis
xs cross section
ls longitudinal section (longitudinal sections with anterior end to the right)
Figure 1. Type locality. Head of Spring Hollow Stream looking downstream. Author in foreground.

Figure 2. Smaller of two small springs near Temple Fork turnoff.

Figure 3. Ricks Spring during winter dry season.

Figure 4. Logan Cave Stream.

Figure 5. China Row Spring on east side of highway. Slow current unfavorable for *P. crenophila*.

Figure 6. China Row Spring on west side of highway. Faster current favorable for *P. crenophila*. 
PLATE II

All figures refer to *Phagocata crenophila* except Figure 2.

Figure 1. Anterior end of *Phagocata crenophila*. Photograph from live, X30.

Figure 2. Anterior end of *Polycelis coronata*. Photograph from life, X30.

Figure 3. Is through copulatory organs showing relative shapes and positions of organs, X40.

Figure 4. Is through copulatory organs showing entrance of ovovitelline duct into male atrium, X40.

Figure 5. Is through posterior end showing testes in ventral position, X23.

Figure 6. Is through anterior end showing relative positions and sizes of ovary and most anterior testis, X30.

Figure 7. xs anterior to pharynx showing relative positions of testes and nerve cords, X40.

Figure 8. xs through penis showing several sections of vas deferens before entering ejaculatory duct, X90.
Sections of *P. crenophila*

Figure 1. xs through anterior portion of penis showing vas deferens as they enter ejaculatory ducts, X90.

Figure 2. xs through anterior end showing relative positions of ovaries, testes, and nerve cords, X75.

Figure 3. Is through penis showing ventral opening and enlarged lobe of penis, X75.

Figure 4. xs through penis showing ventral opening and enlarged lobe of penis, X90.

Figure 5. Is through copulatory organs showing penis lobe, course of ejaculatory duct, and spermatophore exiting penis, X75.

Figure 6. xs through bursa showing diverticula of bursa and a spermatophore, X90.
VITA

Jerry H. Carpenter

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Master of Science

Thesis: A Description of the Planarian Phagocata Crenophilus, New Species, From Utah

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