A Study of the Planarians (Dugesia) of an Oklahoma Stream

By MARIE M. JENKINS[1] and SUE E. MILLER[2]

Department of Zoology, University of Oklahoma

Planarians have long been an object of investigation, and studies are available concerning their ecology and distribution in the North Central and Eastern states. The most recent paper on this subject (Hyman, 1951) includes a resume of the known species of North America together with a taxonomic key. There are few reports of planarian distribution west of the Mississippi River (Hyman, 1929; Kenk, 1944). In view of this paucity of exact knowledge of species and distribution, a study is being undertaken of the planarian fauna of Oklahoma.

The site selected for the first investigation was Pennington Creek, a short but beautiful stream in Johnston County, southeastern Oklahoma. The headwaters of Pennington are in Murray County at the south end of the Turner ranch, approximately twenty miles northwest of the northernmost finger of Lake Texoma. The first few miles of the creek are dry except during a rainy period. Over the rest of its course Pennington is fed by springs, beginning with Pilot Springs, located about one-half mile north of the bridge over the creek, on the road between the small towns of Millcreek and Connerville. Much of the water in Pennington is received from Spring Creek, a tributary from the northeast which enters Pennington about a mile north of the Fish Hatchery (see map). The upper part of Pennington, above the Fish Hatchery, runs through Arbuckle dolomite, composed principally of calcium magnesium carbonate. Below this and over the greater part of its course, Pennington runs through Tishomingo granite, which is characterized by great, bare outcroppings and huge, eroded boulders. Because of this geologic formation, numerous rapids are to be encountered in the stream, as well as small islands composed of granite rocks, covered by soil and wild plants. Quieter backwashes of clear, cool water are to be found, often shaded by overhanging trees. In many places the stream bed is only a few inches deep; in other places, within a distance of a few feet, the depth may vary from less than a foot to well over one's head. Near Tishomingo the creek bed widens and the creek becomes quite sluggish and muddy. South of Tishomingo, Pennington Creek and the Washita River merge into an extension of Lake Texoma.

Spring Creek is very similar to Pennington. At a point approximately two miles north of the Fish Hatchery the creek runs through farmland, and is fed by a large spring known as *Big Spring,* which gushes forth from a pipe several inches in diameter. This spot is well known to biologists of the area for an abundance of planarians and amphipods.

METHODS

Two collecting trips to Pennington Creek were made, one in mid-summer and another in mid-autumn. A number of stations along the course of the creek were visited. These stations and their locations are shown on the accompanying map (Fig. 1). A short description of the type of habitat encounterd in each follows. Unless otherwise noted, conditions were the same in July and in October.

[1]Assisted by a grant from the University of Oklahoma Faculty Research Fund.

[2]Recipient of a National Science Foundation Undergraduate Research Participation grant, University of Oklahoma, 1961.

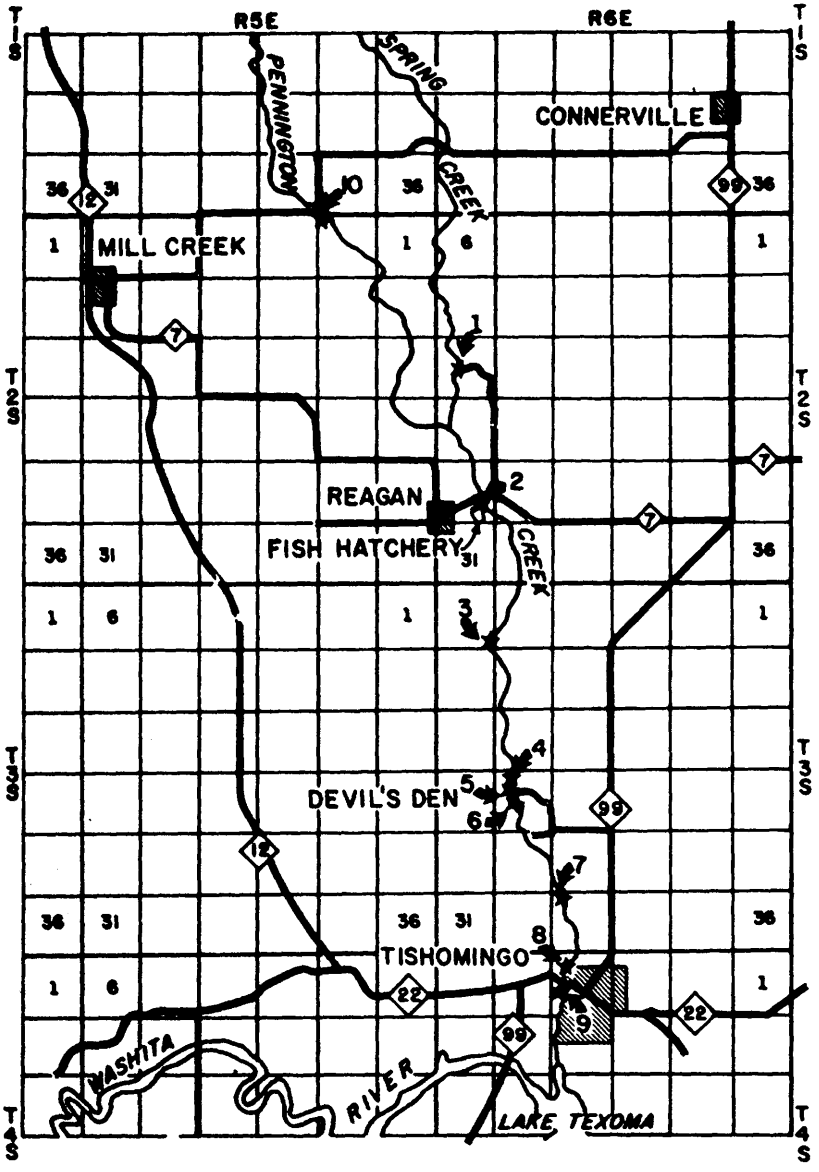

Fig. 1. Collecting stations on Pennington Creek, Johnston County, Oklahoma.

Station One is the location on Spring Creek noted above. The creek immediately below the spring is shallow, with a strong current, and the stream bed is covered with rocks varying from an inch to a foot in diameter. The water is quite cold, even in mid-summer. In July, much of the creek at this point was covered with watercress *(Nasturtium officinale)*, but most of these plants had disappeared before the autumn visit was made.

Station Two is on Pennington Creek near the Fish Hatchery. The collecting spot, 50-75 yards below the bridge on State Highway 7, was at the side of the stream, where it is extremely shallow and well shaded. The bottom is partly covered with silt, but is rocky near the edge. The current is not at all swift compared with the main bed of the stream.

Stations Three, Four, and *Five* are similar, with a swiftly flowing current, and large granite outcroppings. The stream is shallow, with algae in fair abundance. Station Three is at a ford about halfway between the Fish Hatchery and Devil's Den. The latter is a recreation area at the end of the road which leaves Highway 99 two miles north of Tishomingo. Station Four is in Devil's Den, about 100 yards above the ford near the entrance to the park. Station Five, also in Devil's Den, is directly above this ford.

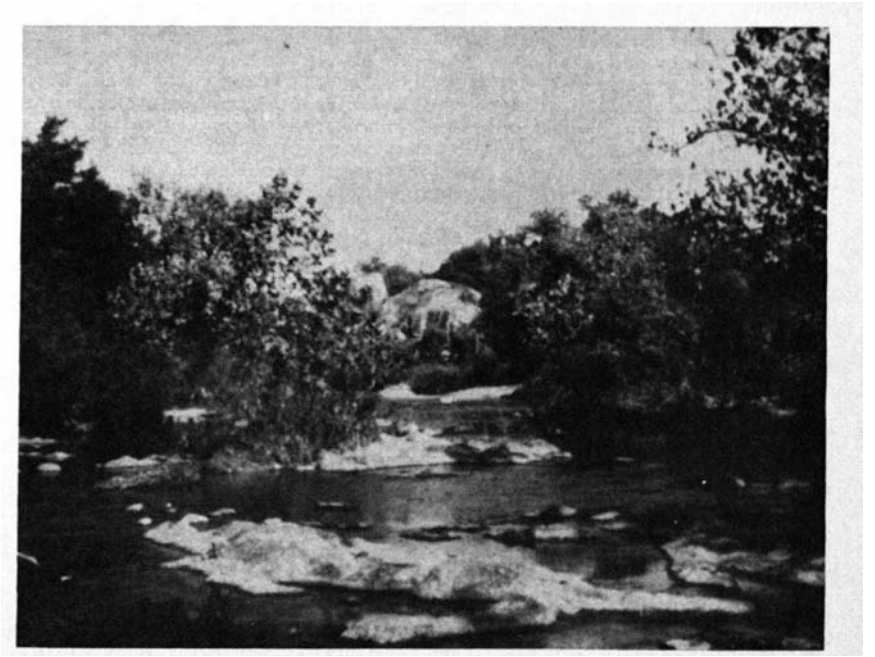

Fig. 2. Pennington Creek, looking upstream from Station Four in Devil's Den.

Station Six, the last station in Devil's Den, is 50-75 yards below the ford, and just south of the formation known as "Washington's Profile." There are few small rocks here, but some large boulders stand in the stream.

Station Seven is about 50 yards below the bridge on a section line road which runs west from Highway 99, one mile north of Tishomingo. At this station there is an island in the middle of the stream. On the east side of the island the water is deep and the current swift, but on the west side, where the collection was made, the stream is rocky and shallow, and well shaded by trees.

Station Eight is west of Tishomingo, about 150 yards below a dam. Here the stream is broad, with a sluggish current, and the bottom slopes quickly away from the bank. Granite outcroppings occur on the bank, but do not extend appreciably into the water . The bed of the stream is extremely mucky, with very few rocks.

Station Nine is located a few yards below the bridge on Highway 22 at Tishomingo. It is similar to Station Eight, but has no rock outcroppings on the banks.

Station Ten is below the bridge on the road between Millcreek and Connerville. The stream is shallow with a fairly swift current. Under the bridge there is silt in the stream bed, and few rocks, but downstream about twenty-five feet from the bridge the bottom is rocky and rapids can be found. Much watercress and coontail *(Ceratophyllum demersum)* is present.

Collections. Rocks in the stream, and occasionally leaves and logs, were picked up and examined, and any planarians found were carefully brushed into a snap-cap vial containing creek water. The vials were numbered, and kept in an insulated ice-chest for transportation to the laboratory. If no planarians were found, water and vegetation were placed in a glass jar for later examination (Zebrowski, 1926). On the second trip a number of other invertebrates were collected at each station and taken to the laboratory for identification. The temperature and pH of the water at each station was obtained, and a sample of the water taken for chemical analysis. Notes were taken of the habitat, and of the abundance and size of the planarians found.

After returning to the laboratory, the planarians were examined with a dissecting binocular microscope. A few of the mature specimens were then set aside for the preparation of cross and sagittal sections. The remaining planarians were placed in the planarian culture room, and maintained in aerated lake water at a temperature of approximately 18° C.

RESULTS

Planarians were found at most of the stations, but an abundance of specimens was found only at Station One on Spring Creek. Both in July and in October, sexually mature individuals were found here, as well as smaller ones in varying stages of maturity, but no cocoons were observed at either time. The temperature of the spring was approximately 15° C. at both visits. The planarians at this station have been identified as *Dugesia dorotocephala* (Woodworth) 1897.

No sexually mature specimens were found at any of the other stations except at Station Ten, where one sexual planarian was obtained. A very few planarians were found in the summer at Station Eight, where the creek is beginning to be quite mucky and muddy, but none were observed here in the fall. At Station Nine, where the creek becomes broad and sluggish as it approaches the river, no worms were seen on either trip. In both July and October, a large bottle of water and vegetation from this station was brought back to the laboratory for later inspection, but no planarians were found in the debris.

A summary of the number of planarians found, and the prevailing environmental conditions in October, is given below in Table I. Results given here apply equally well to observations taken in July, with the exception of temperature. In the summer, the temperature at all the stations on Pennington where planarians were collected was in the range of 26-27° C.

TABLE I. SUMMARY OF PLANARIANS FOUND, AND PREVAILING ENVIRONMENTAL CONDITIONS, PENNINGTON CREEK, OCTOBER 21, 1961

Station	pH	Temp. °C.	Time of day	Current*	Water depth*	Abundance	Sexual maturity
1	8.3	15.5	4:30 PM	Swift	4-12"	+++++	+
2	8.35	16	5:15 PM	Very slow	1-2"	+	—
3	8.3	16	4:00 PM	Swift	10-12"	++	—
4	8.3	14	9:00 AM	Moderate	6-12"	+	—
5	8.5	14.5	10:00 AM	Swift	6-8"	++	—
6	8.45	15	11:00 AM	Moderate	1-3"	+	—
7	8.55	15	12:00 M	Moderate	3-4"	+	—
8	8.55	15.5	1:30 PM	Sluggish	4-6"#	—	
9	8.6	19	2:30 PM	Sluggish	-	—	
10	7.8	15.5	6:30 PM	Swift	12-14"	+	+

*In region of stream, usually near banks, where planarians were found.

#Depth at which planarians were found in July, 1961.

A number of the worms obtained at the stations below the entrance of Spring Creek became sexually mature in the laboratory and began producing cocoons. The animals appeared to be identical in every way with the planarians found at Spring Creek, with the exception of two quite immature specimens which showed some of the external characteristics of *Dugesia tigrina*. Because of their immaturity, no conclusions can be drawn as to their identity, but it is assumed, in view of the habitat, that they are also *D. dorotocephala*.

The invertebrates found at the various stations were identified as far as family or genus, when possible. These results are summarized in Table II below. It will be noticed these invertebrates are quite characteristic of the types of habitat: swift current near springs; clear, cool, rocky-bottomed shallows; and sluggish, silty deeper water.

An analysis of the sodium, calcium, and potassium content of the water at the various stations was made, and the results are listed in Table III.

DISCUSSION

Although planarians are widely distributed in Oklahoma, as evidenced by their collection over the years for classroom and research purposes, reports of their classification and distribution in the state are meagre in the extreme. Interestingly enough, the earliest report (Hyman, 1939a) deals with the first finding in America of the Asiatic genus, *Sorocelis*, in Bat Cave, Adair County. Shortly thereafter Levengood (1940) published a comparative study of the reactions and behavior of *Sorocelis americana* and *Dugesia (=Euplanaria) dorotocephala*, but did not state where the latter was obtained. An abundance of *Dugesia dorotocephala* has been reported to occur in Buckhorn Springs, Murray County (Jenkins, 1960), but no study of distribution is available.

TABLE II. OCCURRENCE OF INVERTEBRATES AT STATIONS ON PENNINGTON CREEK, OCTOBER, 1961*

Invertebrates	Stations									
	1	2	3	4	5	6	7	8	9	10
Fresh water sponge: *Spongilla*			x				x			
Annelids: oligochaetes								x		
leeches	x		x		x					x
leech cocoons	x		x							x
Ostracods					x		x			
Amphipods: *Hyalella*	x							x		x
Decapods: crayfish								x	x	x
Hydracarina: water mites								x	x	
Collembola: springtails, *Podura*				x						
Ephemeroptera: mayfly naiads, *Ephemerella*			x	x	x	x	x			x
mayfly naiads, *Stenonema*		x	x		x	x	x	x		x
mayfly naiads, *Baetis*					x	x	x			
Odonata: damsel fly naiads. *Hetaerina*				x				x		
damsel fly naiads, *Argia*			x				x	x	x	
dragon fly naiads, *Progomphus*				x	x	x		x	x	x
dragon fly naiad, Aeschnidae									x	
Hemiptera: water striders, *Gerris*										x
water striders, Veliidae				x	x		x			
electric light bug nymph, *Belostoma*								x		
Megaloptera: hellgrammites, *Corydalus*		x		x		x	x	x		

TABLE II (CONT.)

	1	2	3	4	5	6	7	8	9	10
Trichoptera: caddis fly adults and egg masses										x
caddis worms and cases, *Polycentropus*		x	x	x	x	x	x			x
caddis worms and cases, *Hydropsyche*			x	x	x	x	x			
caddis worms and cases, *Helicopsyche*			x	x	x	x				
caddis worms and cases, *Parapsyche*			x							
caddis worms and cases, Leptoceridae				x						
Coleoptera: diving beetles, Dytiscidae							x			
water scavenger bettle larva, Hydrophilidae					x		x			
riffle beetle larvae and adults, *Hexacylloepus*		x	x	x	x	x	x			
riffle beetle larvae and adults, *Microcylloepus*		x	x	x	x	x	x	x		
riffle beetles, *Stenelmis*							x	x		
riffle beetles, *Helichus*								x		
Diptera: black fly larvae, *Simulium*				x						
bloodworms, *Chironomus*							x	x		
snipe fly larvae, *Atherix*				x						
Gastropods: snail, *Physa*			x	x			x	x		
limpets, *Ferrissia*							x	x	x	
Pelycypods: fingernail clams, Sphaeriidae	x			x	x		x			

*We wish to thank Dr. Harley P. Brown for his assistance in making the collections, and both Dr. Brown and Lothar Hornuff for their help in identifying the invertebrates.

TABLE III. IONS FOUND IN PENNINGTON CREEK WATER, 21 OCTOBER 1961*

Stations	Na ppm	K ppm	Ca ppm
1	6	2	47
2	2	1.5	57
3	3	2	50
4	6	2	43
5	7	2	43
6	5	2	40
7	8	1.5	40
8	4	2	38
9	5	2	38
10	4	2	40

*We wish to thank Carl W. Prophet for performing the analysis.

Habitat. An early study of the characters *D. dorotocephala* indicated that this species was apparently restricted to a spring-fed marsh, such as occurs in the morainic country about Chicago (Hyman, 1925). Later reports show that it is also to be found in cool, unpolluted springs and creeks, and spring-fed lakes (Kenk, 1944; Hyman, 1951). The present study confirms this finding. Planarians of this species were found only where the water was clear, cool, and not sluggish. The very few specimens observed on one occasion in the lower, silty parts of Pennington could well have been washed downstream, for the observations at that time were made shortly after a series of heavy rains.

Pattern and coloration. With the exception of color, the external characteristics of most of the specimens appeared to conform to published accounts of *D. dorotocephala*. The small, immature individuals from Stations Two to Seven inclusive were gray to grayish white in color, with an almost white ventral surface. No pigment pattern was notiieable to the naked eye. The planarians obtained at Station Ten, above the entrance of Spring Creek into Pennington, were much larger than those downstream. The pigment in these appeared to be dark gray, and evenly distributed and patternless (granular).

Planarians obtained at Big Spring in July were a dark brownish-gray color. After these worms had been kept in the laboratory for three months at approximately 18° C., the pigment had assumed a yellow-red cast, and a spotted or stellate pattern was clearly visible. In the immature worms which were originally gray, and remained immature, the yellowish-red color did not appear. No light mid-dorsal stripes were noted on any of these specimens.

A number of planarians taken at Stations Four, Five, and Seven, in July, were quite green in color. Although planarians of this species are known to be carnivorous, it was assumed the green color was due to the animals' having ingested some of the algae, which was abundant. However, in October, at Station Seven, two planarians were found on a green fresh-water sponge, and were quite possibly feeding upon it. An attempt was made to collect them for possible preservation and sectioning, but when dislodged, they were claimed by the current before they could be safely placed in a vial.

Sexuality. With the exception of a recent report from Oklahoma (Jenkins, 1960), all earlier papers indicate that *Dugesia dorotocephala* is rarely or never found sexually mature in nature (Hyman, 1925; Kenk, 1944). A few sexual specimens have been reported from California (Hyman, 1929) and Pennsylvania (Hyman, 1939b). The present study shows that, in some localities, an abundance of sexually mature individuals of this species may be found.

Since sexual maturity was evident at only two stations, the question arises as to what constitutes the difference in environmental conditions between these two localities and the other stations farther downstream where only immature planarians were observed. That there is no inherent difference in the two groups, as has been proposed for *Dugesia tigrina* (Kenk, 1937) is attested by the fact that many of the asexual specimens became sexually mature under laboratory conditions.

The pH of the water can be discounted as an important factor, for a glance at Table I will show there was no great difference in the pH at any station. Temperature appears likewise to have little influence, although in sexual strains of *D. tigrina* sexuality can be induced at any season by raising the temperature to 25° C. after previously exposing the worms to 15° C. for a short time (Hyman, 1941). In this study the abundance of mature individuals was found where the water temperature did not change appreciably during the year. At the stations farther downstream, where the water was warmer in the summer, sexuality was not evident.

Another possibility considered was the effect of water speed and violence. Hyman (1939b) has presented the theory that *D. tigrina* becomes sexual in sites exposed to violent wave action, while in nearby spots, where the water is quiet, sexuality does not develop. In this study, the swiftness of the stream, or the presence of rapids, or both, appeared to have no effect on the sexual maturity of the worms. At stations where sexuality was observed, the water was swift and more or less turbulent. However, at Stations Three to Six, where there were small rapids and somewhat turbulent water, all specimens taken were immature.

The possibility that one or more of the various ions in the water might act a a determining factor was investigated to some degree. The analysis of the sodium, calcium, and potassium content of the water at the various stations (see Table III) gives no indication of any marked difference. There are known to be localized iron deposits in the Arbuckle dolomite, where the mature specimens were found. Further and more comprehensive analyses and experimentation might shed some light upon the matter, but such could not be included within the scope of this study.

Cocoon production. Although sexual planarians have been collected in June and July at Spring Creek for a number of years, there is no report of any cocoons having been found. The sexual worms taken from Big Spring in July began producing cocoons during the latter part of August, and have deposited cocoons regularly since that time. It appears possible that a period of adjustment is necessary before the animals begin to reproduce sexually.

As noted above, many of the worms taken in July from stations on Pennington below Spring Creek, became sexually mature in the laboratory. In these worms, cocoon production began in the middle of October, and cocoons have been deposited every week since. Many of these planarians, however, have not become mature, but continue to reproduce asexually. Fission products are seen regularly in the pan.

SUMMARY AND CONCLUSIONS

1. A study was made of the species, habitat, sexual maturity, and distribution of planarians at nine stations on Pennington Creek and one station on its major tributary, Spring Creek.

2. *Dugesia dorotocephala* was the only species found to be present.

3. Planarians were found both in the summer and the fall where

the water was clear, cool, and fairly shallow. Other invertebrates observed at these locations were typical of the habitat.

4. It is suggested that fresh-water sponges may at times be used as food by planarians.

5. Contrary to usual accounts for this species, an abundance of sexually mature specimens was found in both seasons at the station on Spring Creek, although no cocoons were observed at either time.

6. No sexual individuals were found at any distance greater than a few yards from a major spring. The majority of sexual planarians were within a few feet of Big Spring on Spring Creek.

7. Many of the asexual worms became sexual under laboratory conditions and have continued producing cocoons for several weeks.

8. The relationship between sexuality in planarians and environmental conditions is discussed.

LITERATURE CITED

Hyman, L. H. 1925. The reproductive system and other characters of *Planaria dorotocephala* Woodworth. Trans. Am. Microsc. Soc., 44: 51-89.

..... 1929. Studies on the morphology, taxonomy, and distribution of North American triclad Turbellaria. II. On the distinctions between *Planaria agilis* and *Planaria dorotocephala* with notes on the distribution of *agilis* in the western United State. Trans. Am. Microsc. Soc., 48: 406-415.

..... 1939a. New species of flatworms from North, Central, and South America. Proc. U. S. Nat. Mus., 86: 419-439.

..... 1939b. North American triclad Turbellaria. IX. The priority of *Dugesia* Girard 1850 over *Euplanaria* Hesse 1897 with notes on American species of *Dugesia*. Trans. Am. Microsc. Soc., 58: 264-275.

..... 1941. Environmental control of sexual reproduction in a planarian. Anat. Rec., 81 (Suppl.): 108.

..... 1951. North American triclad Turbellaria. XII. Synopsis of the known species of fresh-water planarians of North America. Trans. Am. Microsc. Soc., 70: 154-167.

Jenkins, M. M. 1960. Respiration rates in planarians. I. The use of the Warburg respirometer in determining oxygen consumption. Proc. Okla. Acad. Sci., 40 (1959): 35-40.

Kenk, R. 1937. Sexual and asexual reproduction in *Euplanaria tigrina* (Girard). Biol. Bull., 73: 280-294.

..... 1944. The fresh-water triclads of Michigan. Misc. Pub. Mus. Zool., Univ. of Mich., No. 60.

Levengood, C. A. 1940. Some notes on the cave flatworm, *Sorocelis americana*. Proc. Okla. Acad. Sci., 20: 33-34.

Zebrowski, G. 1926. Technique for planaria. Trans. Am. Microsc. Soc., 65: 258.