

## NOTES ON THE CERCARIAE OF THE BITTER ROOT VALLEY, MONTANA \*

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Before the work of Cort (1915) only isolated accounts of North American Cercariae had been published. Most of these lacked the detail necessary to distinguish species of the same groups which bear a superficial resemblance to one another. The general idea which Charles Sedgwick Minot voiced is just as true for larval trematodes as for any other larvae, when he said "It is not true that embryos are alike; on the contrary, they show class, ordinal, and generic differences from one another." This has been the case with the trematode forms that have come under the observation and consideration of the writer. Some details of difference are visible from a study of the living animals. Other points of differentiation require a specific, altho not unusual technic.

During a two-years residence at Missoula, Montana, the writer became acquainted with the fauna of the Bitter Root Valley. One of the striking features of its fauna is the small number of species, altho the number of individuals of each species is large. In contrast with this fact is the large number of parasites found in the aquatic fauna of the region. Thru the courtesy of Mr. Bryant Walker of Detroit, Michigan, who has identified shells from some fifteen collections, the writer has ascertained that the gasteropod fauna of the vicinity consists of three species, *Lymnaea proxima* Lea, *Physa gyrina* Say, and *Planorbis trivolis* Say. Thirteen species of cercariae have been secured from these snails, species embracing three groups of Digenea. In addition, a fourteenth species, a *Diplostomulum*, has been found in the squawfish, *Ptychocheilus oregonensis* Richardson. Of these fourteen, two are Monostomata, two are Holostomata, and the remaining ten belong to the Distomata. The writer wishes to take this opportunity to thank Professor Henry B. Ward for many valuable suggestions, and to express his gratitude to Mr. Norbert Sager for faithful collection of material during the summer and fall of 1916.

Collections were made along the Bitter Root River for a stretch of some fifty miles from Hamilton to the confluence of the Bitter Root and Missoula Rivers. One collection came from Rattlesnake Creek, Missoula. From this latter collection, made in November, 1916, were

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secured one species common to several localities along the Bitter Root stream, and one new species not found in the Bitter Root Valley.

All of the species examined have proved to be new. Preliminary studies have been made on living specimens to note the general behavior of the organism and to work out the details of the excretory system. Other organs and tissues have come out more advantageously from preserved and stained mounts. Extremely satisfactory results have been obtained from material fixed in Gilson's fluid and stained with Delafield's and Ehrlich's acid hematoxylin.

#### MONOSTOMATA

Three monostome cercariae previously described for North America are: *Cercaria hyalocauda* Haldeman 1842; *C. (Glenocercaria) lucania* (Leidy) 1877; and *C. urbanensis* Cort 1914. Two new species are contributed from the Bitter Root Valley, *Cercaria pellucida* and *C. konadensis*.

#### CERCARIA PELLUCIDA nov. spec.

[Figure 1]

A light infection of *Cercaria pellucida* was found in the liver tissue of *Physa gyrina* Say, collected near Fort Missoula. A much heavier infection of the same species was secured from *Lymnaea proxima* Lea at Corvallis, Montana. The cercariae have an average length of 0.4 to 0.7 mm., and a width of 0.18 to 0.2 mm. The tail measures 0.5 mm. in length by 0.07 mm. at the base. The anterior end of the body tends to be bluntly fusiform, while the posterior part is elongate ovoid, with two symmetrically placed projections where the pair of locomotor pockets extend posteriad and ventrad. The pigmentation is prominent, centering around the two paired, lateral eye-spots, and a third which is single and median. The pigmentation proceeds posteriad along six lines, two lateral, two dorsal and two ventral. A single sucker at the anterior extremity is aided in locomotion by the paired lateral pockets, situated at the posterior extremity of the body somewhat lateral to the junction of trunk and tail.

The animal has a typical "measuring worm" movement, produced by the action of the oral sucker and the locomotor pockets, accompanied by alternate contraction of longitudinal and transverse muscles. The "turbine movement" of the tail also pushes the animal forward thru the medium. The body of the cercaria is smooth, covered with a heavy integument, and the inside of the pharynx has a spinose lining.

The cercaria is produced in a redia with a tough integument and well developed musculature. The redia measures 2.2 by 0.5 mm., and has a long single gut-pouch 2.0 by 0.3 mm. The gut is filled with reddish orange pigment caused by the digestive action of the organ on



the liver tissue of the host. The pharynx is strongly muscular and possesses a four-lobed evertible prepharynx with a spinose covering. The rhythmic driving of this organ against any object with which it comes in contact constitutes the most characteristic movement of the redia. The germinal epithelium is situated in the posterior part of the redia.

The cercaria usually remains in the redia until it is mature and ready to seek a new host. A slight pressure on the redia causes it to burst at the anterior end, and the rent allows the mature cercariae to escape. They do not remain long in the surrounding medium (water or liver tissue) before encystment. This process is extremely rapid. A mucoid is first poured out around the wriggling worm and within this a granular area which acts as a liquid cushion for the cercaria. During the process of encystment the cercaria has coiled upon itself so that the resulting cyst is spherical. Encystment is so rapid that the tail is not dropped until the completion of the cyst.

*Cercaria pellucida* is characterized superficially by no special feature that would differentiate it from any of the larger species of monostome cercariae with three pigment eye-spots. Internal characters, however, readily distinguish this form from previously described species. The locomotor pockets are smooth internally, differentiating the species from *C. imbricata* Looss (Looss, 1896) and *C. ephemera* Nitzsch (Ssinitzin, 1905). The tail has no central gland cells, so that the common median excretory tube is surrounded by the ordinary parenchyma cells. The excretory system of the trunk consists of a complete circuit with the anterior extremity just posterior to the median pigment eye, and the posterior limit of the system in the bladder. When contracted, the bladder is superficially triangular with the excretory pore caudad. The system is filled with many large granules of a high refractive index. They are probably of a derived protein nature and disappear on application of strong acids and alkalis. However, after treatment with a non-acid fixing agent (mercuric chlorid), they are acid-resistant.

The eye-spots consist of a terminal ganglion cell for each spot, surrounded by a pigment cup. The eyes open dorso-laterad. They have a direct connection with the brain.

Most specific of all the systems are the genital organs of *Cercaria pellucida*. The germaria (ovary and two testes) are situated in the posterior reaches of the trunk just anterior to the excretory vesicle. The ovary is median; the minute testes are lateral to the ovary. No Laurer's canal has been found. The vitellaria consist of five pairs of glands within the confines of the excretory circuit and three pairs situated more laterad. They cover a considerable area of the ventral surface. The glands are filled with fine granules closely associated.



The ducts from the glands traverse the region on each side intermediate between the inner and outer series, and meet one another in the region of the ovary, emptying thru a common duct into the ootype. From this region there proceeds forward along a median line the long slender uterus, which enlarges just behind the median eye to form the vagina. To the left of the uterus is the common vas deferens which has resulted from the junction of the vasa efferentia just anterior to the ovary. It runs parallel to the uterus, and at its anterior end expands into a cirrus pouch.

The body is crowded with cystogenous gland cells filled with rhabditiform granules. Crowded in between these cells are the parenchyma cells and connective tissue. The cystogenous cells with their contents give to the worm a milky translucent appearance.

The digestive ceca are given off from the esophagus just behind the plane of the paired eye-spots and extend to the posterior extremity of the body. Their lumina are filled with a jelly in which are granular inclusions.

*CERCARIA KONADENSIS nov. spec.*

[Figure 2]

From the same individuals of *Lymnaea proxima* Lea at Corvallis, Montana, from which *Cercaria pellucida* was obtained, there were found in lesser numbers specimens of another new species of monostome cercariae for which I propose the name *Cercaria konadensis*, the specific designation of which is derived from the Indian term for Bitter Root.

This species is very unlike *Cercaria pellucida*. It is considerably smaller, having a length of 0.4 to 0.46, and a width of 0.1 to 0.16 mm. The tail is equally long and has a transverse diameter of 0.03 to 0.04 mm. at the base. The anterior end is lanceolate, as is also the extremity of the tail. Superficially, the most striking feature of this cercaria is the lack of the median pigment eye, accompanied by a lesser amount of pigmentation in the posterior half of the body. This stands in contrast with the trioculate monostome cercariae where the pigmentation is more extensive. In this respect *Cercaria konadensis* bears similarity to *C. urbanesis* Cort (Cort, 1915), which has only two true eyes and a median condensation of pigment, and contrasts with *C. ephemera* Nitzsch (Ssinitzin, 1905; Lebour, 1905), and *C. imbricata* Looss (Looss, 1896).

The germinal epithelium of the redia in which the cercaria develops is modified into a central rachis which is proliferated from the posterior part of the body. This redia is much smaller than that of the trioculate cercariae, with a length measurement of 1.7 mm., and a diameter in cross section of 0.35 mm. The pharynx is comparably



smaller and the gut extends only about three-fifths the way to the posterior extremity. It is about 1.0 mm. long and about 0.1 mm. in diameter. There is no oral armature. The walls of the redia are muscular and fairly well covered with integument.

Superficially, *Cercaria konadensis* cannot be distinguished from *C. urbanensis* Cort, altho the writer believes it is on the average more attenuate than that species. On the other hand, there are internal characters that readily allow a differentiation.

The posterior locomotor pockets are lined on their inner faces with a group of ten to twelve gland cells which probably pour out a secretion for attachment of these organs to the surface of the contact objects. There exist six paired groups of glands in the tail, lying just laterad to the caudal excretory tube. Each group constitutes a rachis, with the broadened end of mature cells directed toward the trunk, and the acute end of proliferating cells directed distad. This paired series of twelve groups of glands in the tail constitutes the readiest mark of distinction for the species. It separates it from *C. pellucida*, on the one hand, and on the other from *C. urbanensis* Cort, in which the writer has found six pairs of glands in the tail, each gland composed of a single polygonal cell. The exact number of these cells is not stated by Cort (1915), altho he mentions their presence.

The excretory system is not dissimilar on the whole to that of other monostome species. The bladder is small, 14 to 15 $\mu$  thru the longitudinal axis of the larva and 16 to 17 $\mu$  in breadth. The excretory tubes empty into the bladder from the extreme antero-lateral angles. The general aspect of the vesicle is a strongly compressed spheroid. The excretory pore is dorsal.

The genital fundaments are hardly as clearly outlined in *Cercaria konadensis* as they are in *C. pellucida*. The ovary is just anterior to the excretory bladder, is pyriform in shape and lies dorsad to the ootype. It has a distinct Laurer's canal. The testes are slightly postero-lateral to the ovary. The cells of these glands are poorly defined, altho the efferent duct of each is indicated by a double row of cells. These ducts lead into a common efferent duct anterior to the ovary, and this runs forward to the right of the uterus, ending in a bulbous cirrus pouch a slight distance behind the vagina. As is usual for monostome cercariae, the yolk glands consist of a paired inner series of five glands and a paired outer series of three glands. They are very diffuse, dendritic, and are readily traced to the common lateral ducts which proceed posteriad, and, finally, turning mesad in the plane of the ovary, empty thru a common vitelline duct into the ootype. The uterus reaches from the region of the ootype to the plane of the anterior vitelline glands, where it enlarges into the vagina. This loca-



tion of the genital atrium is considerably behind the two eye-spots, so that this feature distinguishes it from that of *C. pellucida*.

The eye-spots are two in number situated superficially to the right and left of the roots of the posterior dorsal nerve trunks from which they receive innervation. Pigmentation is centered around the brain and its immediate nerve trunks.

Cystogenous glands fill the greater portion of the connective tissue complex. Encystment is rapid. This species is precocious in that it encysts frequently within the tissues of the snail.

#### HOLOSTOMATA

Few Holostomes, either in larval or adult condition, have been described for North America. *Diplostomum cuticula*, *D. grande*, *D. volvens*, and *Tetracotyle typica*, all Old World forms, have been reported for North America, and Stafford (1904) has described a new species, *Diplostomum parvulum*. The descriptions of these forms are not detailed, and it is doubtful if they are sufficient for exact determination of the species. An undescribed hemistome larva occurring in the vicinity of Urbana, Illinois, has features common to all of these, and especially characteristic for *Diplostomum cuticula*; yet it is undoubtedly a new species, as determined by internal structure. An isolated case of a holostome larva yet unnamed has been recorded by Rettger (1897).

The writer has found two holostomate larvae in the Bitter Root fauna, one a representative of the Hemistomes, and one a representative of the Holostomes.

#### CERCARIA PTYCHOCEILUS *nov. spec.*

[Figure 3]

This species was found in very large numbers (several thousand) in the agamic stage in the mesentery of *Ptychocheilus oregonensis* Richardson, caught at Stevensville and Carlton, Montana, in April, 1915. As a hemistome larva encysted in a vertebrate, it is technically a *Diplostomulum*. The stage in the mollusc has not been secured. The larvae were included in large vesicular cysts of a translucent consistency. The cyst was attached to the mesentery by a disc. Upon transfer to normal saline or Ringer's solution the end of the cyst was split and the larva emerged.

*Cercaria ptychocheilus* is conspicuous because of its abbreviated posterior portion and its elongate patelliform anterior region. The body averages from 0.48 to 0.63 mm. in length by 0.17 to 0.37 mm. in width. There is a medium-sized pharynx. The ceca extend to the



acetabular region. The oral sucker is small and the acetabulum somewhat larger.

The excretory system consists of a bellows-shaped bladder into which leads a single median excretory trunk. In the mid-acetabular region it divides into three trunks, one branch proceeding forward and one each directed laterad. The lateral trunks form anastomoses both anteriorly and posteriorly. The median trunk continues its course unbranched until it approaches the region of the forking of the digestive tract, where it branches. The branches bend laterad right and left, and join the anterior anastomoses of the lateral trunks. Thus the system is bisymmetrical and constitutes a double circuit for the conduction of the excretory products. All of the tubules are filled with granules.

The genital system is typically holostomate, with the genital pore posterior. A muscular organ anterior to the acetabulum represents the original genital pore, which has lost its connection with the genitalia. The ovary is a club-shaped organ lying transversely posterior to the acetabulum and continuous mesad with the oviduct on the left side. The vitellaria are diffuse, ventro-lateral. No uterus is present in the larva. Two testes are situated on the right side, ventral and posterior to the ovary. No vasa efferentia or vas deferens is present. The genital pouch lies ventral to the excretory bladder. It is muscular and has paired groups of glands emptying into it.

CERCARIA FLABELLIFORMIS *nov. spec.*

[Figure 4]

This holostome larva possesses a right and left sucking disc in addition to the oral and ventral suckers; in consequence it belongs to the group designated as tetracotyle larvae. The species was found in the livers of a large percentage of *Physa gyrina* Say from three collections in the vicinity of Corvallis, Montana, in October, 1916. Some of the parasites were encysted, others were free in the liver tissue, and still others were in the redia. No mature cercariae were found in the rediae. The animal is broadly spatulate from ventral aspect. The length of the mature cercaria is 0.48 to 0.56 mm., and the width, 0.44 mm. The redia measures about 0.5 mm. in length and 0.16 mm. in width. The rhabdocoel gut is short. A pharynx is present. The birth-pore is situated on the ventral side, slightly lateral. Within the redia the germ balls are developed from the germinal epithelium localized at the posterior end. These balls develop into other rediae or tetracotyle larvae, both within the same redia.

Characteristic of the younger *Cercaria flabelliformis* is the tetracotyle suctorial apparatus, consisting of the oral and ventral suckers



and two lateral sucking disks. Behind the acetabulum are two transversely plicated lappets. The lateral sucking disks are modified as the larva matures so that they become lappets and come to lie within a cup-shaped hollow. Even at an early stage the larva is encysted.

The excretory system consists of a very truncate common vesicle and two long vesicular tubes. In the region of the transverse lappets these trunks give off a transverse tube which joins the two lateral systems. On its anterior side are given off tubules in fan-shaped arrangement. Lateral to the transverse trunk, and extending posteriad, are numerous anastomoses.

The genital cell-masses bespeak a typical holostome system. The yolk glands consist of paired tubular chords extending from the forking of the gut to the testes. They have large vesicular cells. Thick ducts lead into the ootype which is ventral to the ovary. The uterus leads obliquely from the right side of the ovary posteriad into the genital pouch. The testes are large pyriform glands, lying at the sides of the genital pouch. They open into the cone near the genital pore.

#### DISTOMATA

Distome cercariae may be grouped according to certain larval characters, which, altho not holding over to the adult trematode, are coexistent with other characters that are more deep seated. The Bitter Root species of the distome larvae consist of six xiphidiocercariae, two echinostome cercariae, and two furcocercariae. Among the xiphidiocercariae were found six species.

#### *CERCARIA CRENATA nov. spec.*

[Figures 5 and 10]

A heavy infection of this species was found in 13.6 per cent. of *Lymnaea proxima* Lea collected at the springs at Fort Missoula, Montana, in October, 1916. It is a minute larva, oblong-ovate in contour. The length of the trunk is 0.25 mm. and the width 0.13 mm. A weak tail, 0.15 to 0.16 mm. in length by 0.02 to 0.03 mm. in cross section at the base, is inserted into an aspinose caudal pocket, just posterior to the excretory vesicle. The larva possesses a very acute stylet fastened into the dorsal roof of the oral sucker, about 30 $\mu$  long and 5 $\mu$  broad at the base (Fig. 10).

The cercaria develops from the germ balls proliferated from the localized germinal epithelium within the very simple oval sporocyst. The mature sporocyst measures about 0.5 by 0.25 mm. It is non-muscular and has no organs of attachment. It depends for movement on the movement of the cercariae developing within it.

The prominent muscular parts of the larva are the large oral sucker, 60 $\mu$  in diameter, the small acetabulum, 30 $\mu$  in diameter, the small but



powerful pharynx with a median transverse constriction, and the crenate muscular excretory bladder.

Above the vesicle the excretory trunks diverge as a U from a single stem, each arm giving off a posterior and two anterior tubules.

The digestive system consists of a filiform esophagus and two ceca in the form of a typical furculum. The oral pocket anterior to the esophagus is large and deep. The pharynx sphincter surrounds the posterior half of the esophagus. When at rest the ceca end at the posterior margin of the acetabulum. Salivary glands consist of two series, an outer group of eight small cells and an inner group of five large cells. These groups empty into the oral cavity thru separate ducts.

The genitalia are represented by cell masses in the acetabular and postacetabular regions of the body. Antero-sinistral is Laurer's canal and proceeding forward is the coiled uterus-vagina fundament, ending in the genital pore mesad and just anterior to the acetabulum. The testes are elongate pyriform bodies, extending postero-laterad at a 40° angle. The vitellaria are poorly developed, altho a few follicles and three main ducts are visible as they proceed mesad toward the ootype. The vitellaria are probably limited in the adult to the third quarter of the body.

*CERCARIA GLANDULOSA nov. spec.*

[Figures 11 and 16]

This species was obtained from a heavy infection of liver tissue of *Physa gyrina* Say from the vicinity of Hamilton, Montana, in October, 1916. The cercaria is moderately small, with a length of 0.45 mm. and a width of 0.2 mm. The tail has a length of 0.35 mm. and is 0.05 to 0.06 mm. in trans-section at the base. It is set into a caudal pocket, with locomotor spines in the lateral pockets. The stylet is placed in the roof of the oral sucker. It has a blunt point and measures 39 $\mu$  in length by about 5 $\mu$  in width (Fig. 11).

The sporocyst is extraordinarily simple in structure with a delicate epidermal wall. It is obovoid and measures 0.34 mm. in long diameter by 0.17 mm. in short diameter. The cercaria is proliferated from a localized germinal epithelium.

The cercaria is characterized by an unusual supply of glands. Cystogenous glands fairly crowd the other body structures. A paired series of nine glands of salivary nature empties into the oral cavity. In addition, the entire digestive tract is covered with gland cells, especially in the region of the muscular pharynx, so that the alimentary tract simulates superficially a cluster of grapes. The esophagus and the crura are short, just clasping the anterior margin of the acetabulum.



The oral sucker is somewhat larger than the acetabulum; the former measures  $86\mu$  in diameter and the latter  $66\mu$ .

The excretory system consists of a compressed vesicle and two cornua, each of which receives a single posterior tube and a single anterior tube. The anterior tube has three tributaries in the region of the acetabulum. Posterior to this region it receives several transverse tributaries (Fig. 16).

The genitalia are typically Plagiorchid. The ovary is situated dorsal to the acetabulum and merges into a large uterus-vagina fundament. Laurer's canal is prominent, arising from the vicinity of the ovary and turning dorso-sinistrad. The testes are not distinguishable at this time. The vitelline follicles extend from the extreme oral region to the extreme posterior region. Vitelline ducts run mesad toward the region of the ovary.

CERCARIA DIAPHANA nov. spec.

[Figures 12 and 17]

The species *Cercaria diaphana* is a delicate larva of such a beautiful gray as to remind one of a mere shadow. It is extremely transparent. It occurred as a heavy infection in the liver tissues of *Lymnaea proxima* Lea obtained from the Bitter Root River, Corvallis, Montana, in October, 1916. When contracted the larva is compressed ovoid, and measures 0.2 to 0.26 mm. in length and 0.1 to 0.12 mm. in width, but it is capable of extraordinary expansion. The tail is lanceolate, 0.15 mm. in length by 0.04 mm. in trans-section at the base, where it is included within the spinose caudal pocket.

The sporocyst in which the cercaria develops, is oblong, measuring 0.35 by 0.15 mm. One end may be drawn out as a sort of club-shaped process. An extremely simple germinal epithelium produces the cercariae. It is non-localized and lines the whole body cavity. No external organs of attachment or movement are present.

The oral sucker of *Cercaria diaphana* measures  $44\mu$  in cross section, and the acetabulum only  $32\mu$ . The tail is deeply sunken at the base into the posterior caudal pocket. There are a few (eight to ten) long spines at the dorsal edges of the pocket. A unique stylet is located in the dorsal roof of the oral cavity. It measures  $39\mu$  in length by  $5\mu$  in breadth at the base. Its anterior reinforcement is confined to two dorso-lateral plates at the anterior end. Between these lies a minute spine  $5\mu$  in length by  $0.5\mu$  in diameter (Fig. 12).

The excretory system consists of a highly muscular, compressed vesicle, from which there extends anteriad a long median protuberance. This trunk forks to form two trunks slightly posteriad to the acetabulum. Just postacetabular each trunk becomes constricted and connects



with a common lateral tubule. The tubule receives three main branches, two from the cephalic region and one from the caudal portion (Fig. 17).

The digestive system consists of a long slender esophagus and crura of equal length. The latter are broadly furcate. A small muscular pharynx is provided with an immense mass of gland cells. The pharynx itself measures about  $15\mu$  in cross section, while the gland complex includes a sphere of  $65\mu$  diameter. In addition, there are the paired salivary glands, eight in each paired group, small and poorly developed, emptying into the oral pocket.

The genital cell masses are typically Plagiorchid. Vagina, Laurer's canal and ovary are situated dorsad to the acetabulum. Testes are not yet visible. Vitelline follicles extend from the posterior margin of the oral hood to the base of the caudal pocket. Ducts arise from the ovary posterior and lateral, and are directed antero-mesad.

*CERCARIA DENDRITICA nov. spec.*

[Figures 13 and 18]

The species *Cercaria dendritica* was obtained from the liver tissues of highly infected *Lymnaea proxima* Lea, collected from the sloughs of the Bitter Root River at Fort Missoula, Montana, in October, 1916. The larva is an extremely muscular individual, altho the tail is weak and of questionable value in movement. The cercaria performs a characteristic "measuring worm" movement as it travels forward. It is about 0.38 mm. long by 0.15 mm. wide, and has a tail 0.16 by 0.04 mm. at the base, inserted into a spinose caudal pocket.

The oral and ventral suckers are large and well developed. They measure  $62\mu$  and  $60\mu$ , respectively, in diameter. The tail is included at its base within a caudal pocket provided with stout spines thruout the entire lining. The stylet in the roof of the oral cavity measures  $44\mu$  in length by  $14\mu$  in breadth thru its basal knob. The quill is triangular, scutate, and is joined to the shaft by a median and a pair of lateral reinforcements (Fig. 13).

The sporocyst is well developed. It consists of an elongate ovoid body provided with an oral sucker  $80\mu$  in diameter and is well supplied with muscular elements. The sporocyst itself measures 0.38 by 0.11 mm. The germ cells are situated at the posterior end. The cercaria is obovate, possibly due in part to the extreme muscular development of the oral sucker.

The excretory system deserves special emphasis. The sub-spherical crenate vesicle is remarkably muscular and the two cornua which are anterior are equally muscular. At the extreme anterior reaches of each cornu three tubules flow into it, two from the anterior portion and one from the posterior extremity. The tubules are dendritic (Fig. 18).



The digestive tract consists of a large pharynx  $30\mu$  in transection and  $36\mu$  long, a short esophagus of about two-thirds the length of the pharynx, and extremely rudimentary crura, hardly as long as the non-muscular portion of the esophagus. Salivary glands, eight in number on each side, arise from the region just anterior to the oral cavity.

The genital organs are well-defined. Ovary and uterus lie on the right side over the acetabulum. On the left side is the definitely outlined Laurer's canal, and just caudad to the acetabulum are the testes. Yolk glands consist of a pair of rather slender racemes arranged in zigzag fashion all along the lateral reaches of the cercaria, from the extreme ends of the trunk. The vitelline ducts lead into the ootype from a posterior angle.

Cystogenous cells fill all of the mesenchyme spaces of the body. They are large, white, oval bodies. All of the cercariae reach maturity almost synchronously. They are mature when they break thru the wall of the sporocyst and swim out into the surrounding medium. The tail is soon cast off. In fact, the animal travels much more rapidly without the tail than with it, for it can then use the spines of the caudal pocket. Encystment is slow; the cyst is a thin oval membrane within which the larva is coiled.

CERCARIA MICROPHARYNX *nov. spec.*

[Figures 14 and 19]

This species was secured from the liver tissues of *Lymnaea proxima* Lea obtained from the Rattlesnake Creek, Missoula, Montana, in November, 1916. The cercaria is oval, minute, measuring 0.18 mm. in length by 0.09 mm. in width. The tail is 0.14 mm. long by 0.03 mm. in width at the base. It is fairly active.

Anteriad is the stylet organ, superficially set in the oral roof, so that its leverage is poor. The organ is rounded at the point, and reinforced all around the margin. Across the top is a thin translucent mucoid velum. The stylet is  $34\mu$  long and  $5\mu$  in breadth along the shaft (Fig. 14). The tail is inserted proximally into the caudal introvert provided with spinose projections. The entire body is covered with minute spines arranged in diamond pattern and decreasing in size from the anterior to the posterior margin.

The excretory system is entirely non-muscular. The vesicle is sub-spheroid and laterally compressed, and the two cornua which arise antero-laterad are likewise sub-spherical. Each receives three tubules, a small posterior, a large outer, and a small inner anterior tubule (Fig. 19).

The digestive tract is diminutive. It consists of a minute pharynx around the middle portion of the esophagus, and small vesicular crura.



Paired groups of salivary glands, each with eight cells in the group, are found in the acetabular region. The pre-pharynx is provided with a large spheroidal group of small gland cells.

The genital cell masses consist of a non-differentiated band of tissue just dorsal and posterior to the acetabulum, in the neighborhood of the future ootype, a uterus-vagina cell mass running cephalad over the acetabulum, and in addition broad bands of yolk follicles extending along the margins from the pharynx region to the caudal pocket. The beginning of the tests are not yet distinguishable. Laurer's canal is definitely set off to the right of the uterus.

The sporocyst is ovoid, measuring 0.24 by 0.18 mm. It is remarkably simple, with a single layer of epidermal cells constituting the body wall. The germinal epithelium is non-localized. There is an intercellular complex of excretory channels in which are found many excretory calculi. When the germinal epithelium has been exhausted, the cercariae maturing last drop off their tails and encyst within the sporocyst. The cercaria is provided with many minute subspherical cystogenous cells thruout the parenchyma.

*CERCARIA RACEMOSA nov spec.*

[Figures 15 and 20]

This ornate cercaria was found in the liver tissues of *Lymnaea proxima* Lea obtained from the sloughs at Fort Missoula, Montana, in October, 1916. It is oblong-spatulate, with a delicate quill stylet and a fluted tail. The body measures 0.29 mm. in length by 0.11 mm. in width, while the tail is 0.22 mm. in length by 0.04 mm. in width at the base.

*Cercaria racemosa* is found developing in rhomboidal sporocysts about 0.93 mm. long and 0.56 mm. in trans-section, with a poorly defined attachment pocket at one end. At the antipodal end is the localized germinal epithelium from which the cercariae develop. The cercariae grow to maturity within the sporocyst.

The body of the cercaria is aspinose. The slender stylet measures  $12\mu$  in length by  $2\mu$  in width at the base (Fig. 15). This is reinforced only at the pointed tip. It is advantageously set in the roof of the oral cavity so as to give a good leverage.

A pair of non-pigmented eye-spots are present superficially in the region of the brain ganglia.

The excretory organs consist of a truncate vesicle, a median tube anterior to the vesicle, and two fusiform cornua which receive racemose tubules at their anterior extremities. The vesicle contains two groups of three cells each, probably glandular, attached to the anterior margin of its inner wall (Fig. 20).



The digestive tract consists of a small muscular pharynx, a long slender esophagus, and short crura clasping the anterior margin of the acetabulum. Paired salivary glands, eight in each group, are situated in the acetabular region. Their long ducts open into the oral cavity. The genital cell masses are restricted to the acetabular and post-acetabular portion of the cercaria. A vagina and a Laurer's canal are discernible. Vitelline glands are confined to the region just posterolateral to the ootype. No testes can be made out.

The tail is of considerable power in swimming and is not readily detached. No encystment occurs for some time after the cercaria is placed in a watch glass of normal saline solution.

#### ECHINOSTOME CERCARIAE

Echinostome cercariae possess a circum-oral collar with spines and usually contain three large flame cells in the anterior portion of the excretory system. The further criteria added by Cort (1915:37), namely, an excretory system opening on each side of the anterior part of the tail, and "tail powerful, longer than body," may or may not be typical of individual species: they are not family characters. Of the two species of this family that have come under the writer's observation, only one has a tail longer than the trunk, while neither one has the excretory system opening on each side of the anterior part of the tail.

The two species described by Cort (1915) as echinostome cercariae, *C. trivolvis* and *C. rubra*, with the probable echinostome larva, *C. reflexae*, constitute the only species of this group previously described from North America. Two new species are contributed from the Bitter Root collection.

#### CERCARIA TRISOLENATA nov. spec.

[Figure 6]

This species is an echinostome larva of unusual features. It is considerably more slender than the usual species in this group. The tail is short and lanceolate. The acetabulum is studded with spines. The body is 0.45 mm. long and 0.1 mm. wide when the animal is at rest. The tail measures about 0.2 mm. in length and 0.016 mm. in section at the base. The acetabulum is a third larger in diameter than the oral sucker which measures 30 $\mu$ . Around the dorsal margin of the collar and extending a short distance ventrad is a ring of spines, 36 in number, in a single, altho somewhat irregular line. These spines are aciculate, yet blunt at the base and at the extreme tip.

The cercaria is developed in rediae found in the liver tissues of two snails, *Physa gyrina* Say and *Planorbis trivolvis* Say, collected along the entire course of the Bitter Root River. It is one of the two dis-



tinctly cosmopolitan species of the valley. While the infection of the *Physa* was heavy (22 to 100 per cent of all *Physas* examined) and the *Planorbis* infection was 50 per cent, the infection of the individual *Planorbis* was much heavier than that of the individual *Physa*.

The redia when mature measures 1.0 mm. in length by 0.25 mm. in cross-section. It is provided with a small pharynx,  $55\mu$  in trans-section, and a large rhabdocoel gut extending the entire length of the body cavity. The locomotor "feet" occupy a position about one-third the body distance from the oral opening. Proliferation of germ balls occurs from the posterior end. The rhythmic movement of the redia is due to its own muscular action and that of the daughter cercariae.

The excretory system of the cercaria consists of a small obtruncate bladder and the lateral canals which remain unbranched until they reach the cephalic region. Here each forms a single deltoid anastomosis and end in three flame cells. The tubules are filled with excretory granules. The caudal tube is single, median, and unbranched thruout the entire course.

The digestive tract consists of a long esophagus with a small pharynx mid-way along its length, and a pair of long crura extending posteriad to the subterminal region. Soon after the crura arise from the esophagus they cross under the excretory trunks and run parallel to them externally all the way posteriad.

The genitalia are not well developed in the larva. They consist of an ovarian mass some distance behind the acetabulum, a vagina to the right and just anterior to the acetabulum, and two testes, one behind the other in the posterior extremity of the trunk.

Encystment starts with the rejection of the tail and later the slow formation of a semi-membranous cyst capsule from the abundance of glandular material with which the cercaria is filled. The cyst is very transparent, but extremely resistant to mechanical and chemical disturbances. The trisolenate arrangement of the excretory tubules cephalad is clearly seen thru the cyst membrane.

*CERCARIA BIFLEXA nov. spec.*

[Figure 7]

This form is broadly wedge-shaped at the cephalic margin and rounded posteriad, with long powerful tail, large groups of salivary glands and marked bodily activity; the cercaria is extraordinarily destructive to the host which harbors it. It was found in a small percentage of *Physa gyrina* Say from the vicinity of the Buckhouse Bridge near Fort Missoula in November, 1916.

The collar spines are elongate-ovoid,  $10\mu$  in length, 42 in number. The acetabulum is situated in the posterior third of the trunk. It is  $60\mu$  and the oral sucker  $50\mu$  in diameter. The body measures 0.45 to



## EXPLANATION OF PLATE

Fig. 1.—Dorsal view of *Cercaria pellucida*; specimen partially contracted, showing eye-spots, excretory and genital systems.  $\times 80$ .

Fig. 2.—Dorsal view of *Cercaria konadensis*; specimen relaxed, showing eye-spots and anterior pigmentation, excretory and genital systems, and gland cells of tail.  $\times 105$ .

Fig. 3.—Ventral view of *Cercaria ptychocheilus*; specimen freed from cyst, showing digestive, excretory and genital systems.  $\times 80$ .

Fig. 4.—Ventral view of *Cercaria flabelliformis*; young specimen within cyst, showing digestive ceca, excretory system and lateral suckorial cups.  $\times 50$ .

Fig. 5.—Dorsal view of *Cercaria crenata*; digestive, excretory and genital systems shown; salivary glands in two series, inner and outer, empty into oral cavity thru long ducts; cystogenous cells not shown.  $\times 170$ .

Fig. 6.—Ventral view of *Cercaria trisolinata*; digestive and excretory systems shown.  $\times 150$ .

Fig. 7.—Ventral view of *Cercaria biflexa*; excretory and genital systems shown.  $\times 105$ .

Fig. 8.—Posterior two-thirds of *Cercaria gracillima*; specimen shows genital cell masses; testicular follicles proliferated from the posterior end.  $\times 270$ .

Fig. 9.—Dorsal view of *Cercaria tuberistoma*; excretory system and salivary glands shown.  $\times 170$ .

Fig. 10.—Stylet organ of *C. crenata*.  $\times 540$ .

Fig. 11.—Stylet organ of *C. glandulosa*.  $\times 370$ .

Fig. 12.—Stylet organ of *C. diaphana*.  $\times 540$ .

Fig. 13.—Stylet organ of *C. dendritica*.  $\times 250$ .

Fig. 14.—Stylet organ of *C. micropharynx*.  $\times 540$ .

Fig. 15.—Stylet organ of *C. racemosa*.  $\times 333$ .

Fig. 16.—Excretory vesicle of *C. glandulosa*.  $\times 75$ .

Fig. 17.—Excretory vesicle of *C. diaphana*.  $\times 170$ .

Fig. 18.—Excretory vesicle of *C. dendritica*.  $\times 113$ .

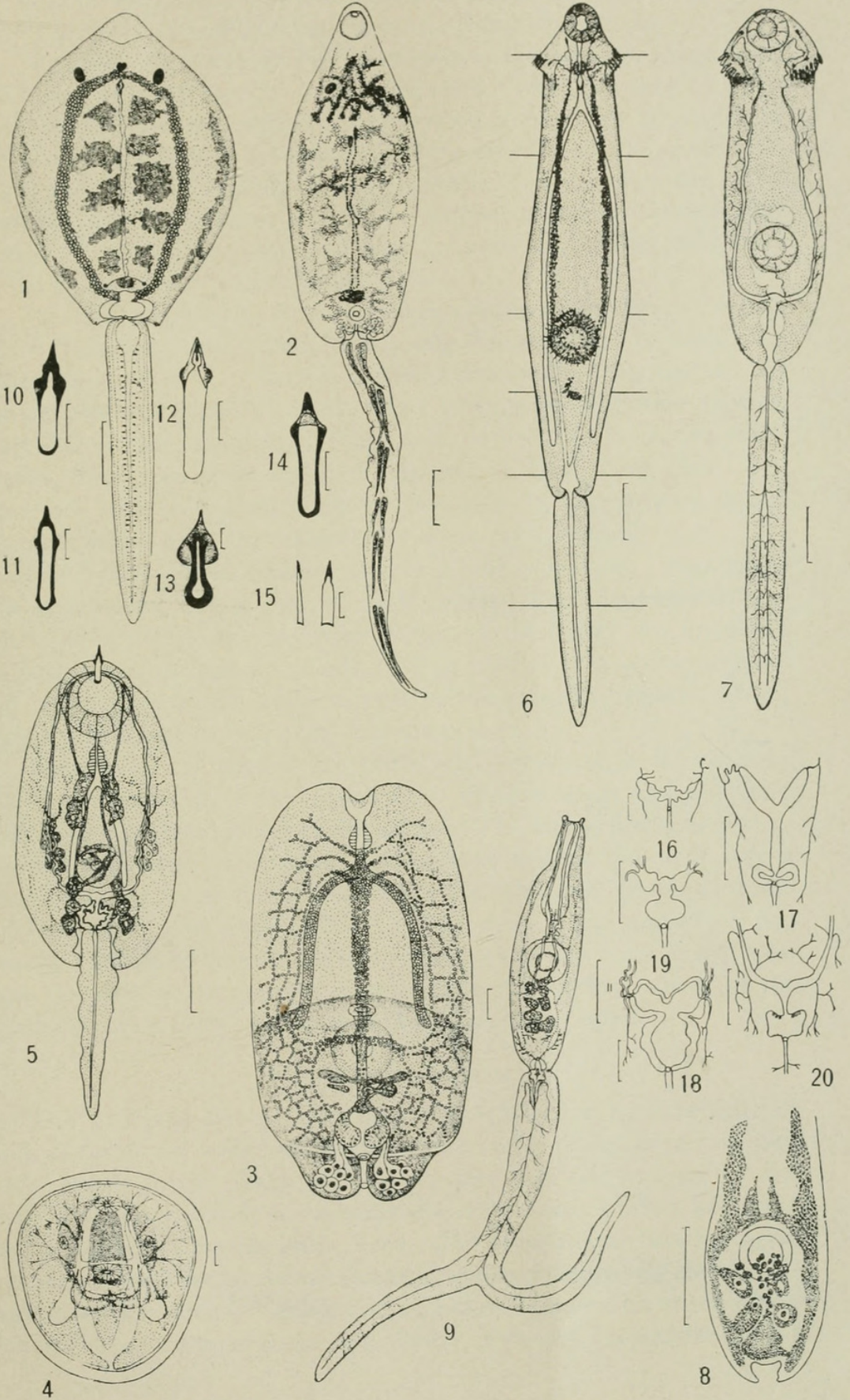
Fig. 19.—Excretory vesicle of *C. micropharynx*.  $\times 270$ .

Fig. 20.—Excretory vesicle of *C. racemosa*.  $\times 150$ .

Reference line in Figs. 1-9 and 16-20,  $50\mu$  long; in Figs. 10-15,  $10\mu$  long. Lines in Fig. 6 indicate important regions not discussed in this paper.



PLATE









0.5 mm. in length by 0.13 to 0.15 mm. in width. The tail is of equal length to the body and 0.06 mm. in cross-section at the base.

The redia of *Cercaria biflexa* measures 0.4 mm. in length and 0.09 mm. in cross section. The locomotor "feet" are found in the posterior third of the body. The pharynx is moderately large,  $40\mu$  in cross section, and well developed. On the other hand, the rhabdocoel gut is short, extending only thru the cephalic fourth of the body. The posterior margin is characterized by a number of small integumentary spines. Cercariae are produced from a localized germinal epithelium in the posterior part of the body.

The excretory system of the cercaria consists of an elongate vesicle and a U-shaped trunk system leading into it anteriorly. Lateral tributaries are received by these two branches thruout the body tissues. At the anterior end cephalad to the collar prominence, the main tube on each side becomes attenuated, loops back on itself as far as the collar region, then turns again antierad and ends in three flame cells. The excretory tube in the tail is single, two-fifths of the distance distad. There it forks, altho the bifurcations never open laterad.

The digestive tract consists of a very long esophagus, extending to the acetabulum, and a pair of ceca arising just preacetabulad and extending nearly to the posterior margin of the body. An inner and an outer series of salivary glands, fifty to sixty in each series, occupies the larger part of the body ventral to the excretory trunks. They empty thru united lateral ducts into the oral cavity.

The genital cell masses are fairly well developed in the cercaria. An ovary posterior to the acetabulum, vitelline ducts and a uterine duct have a common center at the ootype. The uterus proceeds antero-dextrad around the acetabulum and ends in a large muscular vagina anterior to the acetabulum. Two testes are observable posteriad to the vitelline ducts, one almost on top of the other. The animal encysts readily. While no encystment was noticed within the redia, it may take place as soon as the cercaria escapes from the mother. Most of the specimens were found encysted in the tissue of the host.

#### THE FURCOCERCARIAE

This group of larval trematodes is characterized by a forked tail and, as far as the writer knows, the absence of a true pharynx. However, glands in the pharyngeal region may lead one to consider the mass a pharynx, which is evidently the error Looss (1896) has made in his study of *Cercaria vivax* Sons. The apharyngeal furcocercariae are undoubtedly larval Schistosomidae, as demonstrated by the experimental work of Leiper (1916) and by a close comparative study which the writer has made on larvae and adults. Two new furocercous larvae



have been obtained from the Bitter Root Valley. These, in addition to *Cercaria douthitti* (Cort, 1915), constitute the only described forms of North American Schistosome larvae.

*CERCARIA GRACILLIMA nov. spec.*

[Figure 8]

This is an extremely slender tho wiry individual. It has a body length of 0.13 to 0.16 mm. and a width of 0.02 to 0.03 mm. The tail is approximately twice as long as the body and is equally divided between the simple and bifurcate portions. This cercaria is of common occurrence in the Bitter Root Valley, altho it is most abundant in the lower part of the valley. It was found abundantly in liver tissues of *Physa gyrina* Say, and in *Lymnaea proxima* Lea, along with a large infection of *Cercaria micropharynx*.

The body is provided with an oral sucker covered with spines; the ventral sucker measures about 12 $\mu$ . The oral sucker can be drawn into the esophagus. Vestiges of non-pigment eye-spots are found dorsally in close proximity to the brain.

The cercariae develop in sporocysts from a localized germinal epithelium. The proximal end is provided with an attachment disk. The sporocyst is about 0.5 mm. long at maturity and 0.025 mm. wide. It has no musculature and depends on the cercariae within for its motility. The cercariae escape thru a rent in the wall of the sporocyst.

The excretory system includes a common non-muscular vesicle at the posterior margin of the trunk, and two lateral canals which anastomose frequently and characteristically in the anterior two-thirds of the body. Flame cilia are present in a restricted region of the main tubes in the posterior third of the body. The junction of body and tail is accompanied by an "eyelet anastomosis," commonly found in furcocercous larvae. The common tube of the anterior unbranched region of the tail, branches into the rami of the tail.

The digestive system consists of a long esophagus which branches to form the ceca just anterior to the acetabulum. The ceca end at the posterior margin of the acetabulum. Paired salivary glands, four to each series, lying in the posterior third of the body, open by long ducts into the oral cavity.

Anterior to the acetabulum are the ovary-uterus cell mass on the right and that of the cirrus on the left. Posterior is the male germinal epithelium from which is proliferated a large number of testicular follicles. Ventro-lateral are lines of vitelline glands which empty their products thru ducts into the ootype anterior to the acetabulum.

Encystment has not been noted in the species.



CERCARIA TUBERISTOMA *nov. spec.*

[Figure 9]

Two prominent tubercles are present at the anterior end of the spineless body of this species. The chamber for the oral sucker occupies the core of the anterior third of the worm. The body is about 0.2 mm. long by 0.05 to 0.06 mm. wide. The tail is about 0.32 mm. long, of which the unbranched portion constitutes approximately one-half. It measures  $35\mu$  at the base. The ventral sucker measures  $30\mu$ . The larva was found in *Physa gyrina* Say at Corvallis, Montana, in October, 1916. The infection was light.

The cercaria develops in sporocysts, which are about 0.5 mm. long and 0.05 mm. in trans-section. At one end is a sucking disk, and at the other end is the broad attachment organ. The germinal epithelium is localized at this latter end.

The excretory system consists of a small muscular maliform bladder situated posteriad, and slender lateral trunks which receive occasional branches more anteriad. No flame cell areas have been made out. The "eyelet anastomosis" at the junction of the body and tail is muscular. A slender median caudal canal divaricates just anterior to the bifurcation of the tail. At the proximal end of the tail are given off a pair of lateral tubules which are recoiled on themselves.

The digestive system is of the usual type for the furcocercariae. The genital anlagen have not been worked. Encystment has not been observed in the species.

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