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Helminth Fauna of Suckers (Catostomidae) of the Gila River System, Arizona. II. Five Parasites from Catostomus spp.[1]

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ABSTRACT: *Isoglaridacris hexacotyle* (Linton, 1897) Mackiewicz, 1968 (Cestoda: Caryophyllaeidae), metacercariae of *Clinostomum marginatum* Rudolphi, 1819 (Trematoda: Clinostomidae) and *Ornithodiplostomum ptychocheilus* Faust, 1917 (Trematoda: Strigeidae), *Neoechinorhynchus* sp. Hamann, 1892 (Acanthocephala: Neoechinorhynchidae), and *Illinobdella moorei* Meyer, 1940 (Hirudinea: Piscicolidae) were recovered from *Catostomus insignis* and *C. clarki* from one or more of the following localities: Upper and Lower Verde and Salt rivers, tributaries of the Gila River. All but the first parasite are new host and locality records. Methods of fish capture and processing of worms, notes on the ecology and food habits of hosts, sites of infection, host-parasite interrelationships of the five parasites, and a morphological growth study of the first two are included.

INTRODUCTION

Between July 1966 and January 1967, 200 *Catostomus clarki* were captured from the Upper and Lower Salt, Verde, and San Pedro rivers of the Gila River, Arizona, and 375 *C. insignis* from all but the Upper San Pedro River (Amin, 1968). All were systematically examined for helminth parasites, which were absent from the San Pedro River. This is the second and last paper of this series.

MATERIALS AND METHODS

Native suckers, genus *Catostomus,* were obtained from streams by seining, gill netting, or shocking using the current supplied by a 110-v 900-w generator. The fish, always examined within 24-38 hours after capture, were kept, prior to examination, covered with ice in coolers, in a cold room (about 5 C), after which they were handled individually. Additional specimens were placed in tightly sealed plastic bags, quick-frozen by placing in another cold room (about —15 C), and were thawed shortly before dissection.

Procedures used in dissection of the hosts and processing of *I. hexacotyle, C. marginatum, O. ptychocheilus,* and *I. moorei* were previously described (Amin, 1969).

Acanthocephalan worms recovered were not permanently mounted. Upon recovery, they were placed in 70% alcohol; an equal volume of glycerine was then added and the vials containing the worms were placed in a warm place after loosening the vial caps. A period of 2-4 weeks was necessary for the complete evaporation of alcohol and the

[1] Abstracted from a dissertation submitted in partial fulfillment of the requirements of the Doctor of Philosophy degree in zoology at Arizona State University, Tempe, Arizona 85281.

penetration of the glycerine. For microscopical examination, the worms were placed on a glass slide with a drop of glycerine and covered with a cover slip. After examination, the worms were returned to the glycerine vials.

RESULTS AND CONCLUSIONS

FISH HOSTS EXAMINED

One or more collections were made at the following localities between July 1966 and January 1967: the Upper Salt River (at Salt R. Canyon), 17 *C. insignis* and 4 *C. clarki;* the Lower Salt River (at Tempe), 261 and 39; the Upper Verde River (at Perkinsville), 59 and 37; the Lower Verde River (at Pinnacle Peak), 7 and 41; the Upper San Pedro River (at Sierra Vista), 0 and 27; the Lower San Pedro River (at Aravaipa Creek), 31 and 52. The total number of *C. insignis* and *C. clarki* examined was 375 and 200, respectively. Both species were recovered from all localities except that *C. insignis* was not recovered from the Upper San Pedro River.

Very young individuals of *C. insignis* and *C. clarki* "live in warm, quiet backwaters along the stream, moving into faster waters as juveniles, then into riffles or pool and pool-like areas as adults." (Barber and Minckley, 1966.) Adults of *C. clarki* are riffle and fastwater fish; smaller individuals are associated with quieter waters more than larger ones. Adults of *C. insignis* inhabit pool and backwater situations; the smaller individuals are more abundant in the shallower waters. *C. clarki* is herbivorous; the main food materials are algae, periphyton and other microscopic organic matter, and occasionally invertebrates (Smith, 1965). The food of *C. insignis* (a carnivore) was observed to include a high content of invertebrates and very little plant material.

PARASITES RECOVERED

Isoglaridacris hexacotyle (Linton, 1897) Mackiewicz, 1968

This cestode was previously reported from *Catostomus* sp. from the Gila and Salt rivers, Arizona (Linton, 1897; Hunter, 1930), and from the White River, Colorado (Mackiewicz, 1968); from *C. insignis* and *C. clarki* from the Gila River, Arizona, and from *C. clarki* from the Virgin River, Utah (Mackiewicz, 1968). *I. hexacotyle* is reported herein from *C. clarki* from the Upper Verde River at Perkinsville and from *C. insignis* from the same locality as well as from the Lower Verde River at Pinnacle Peak (new locality records) and from the Lower Salt River at Tempe.

Of 2152 *I. hexacotyle* recovered from both species of suckers, 2127 were obtained from *C. insignis* in the Lower Salt River at Tempe. Of these, 1031 worms (964 mature and 67 immature, a ratio of 14.4:1) were whole-mounted and measured. My mature specimens were considerably shorter than those reported by Linton (1897), length range = 8-14 mm (N = 8, no mean value given); and Hunter (1930), length range = 8-18 mm (no sample size or mean given), but somewhat wider. They were 1.53 to 12.04 mm long, mean = 5.746 (N = 964). The immature specimens were 1.22 to 4.54 mm long, mean

= 2.649 (N = 67). The length of the pre-vitelline region (the distance between the anterior end of the scolex and the anterior tip of the first vitelline gland or testis, whichever is anteriormost) of the mature specimens was 0.22 to 1.31 mm, mean = 0.682 (N = 881). That of the immatures was 0.20 to 0.86 mm, mean = 0.460 (N = 51). The length of the post-vitelline region (the distance between the first vitelline gland, or testis, and the hind end of the body) of the mature specimens was 1.31 to 10.73 mm, mean = 5.138 (N = 881). That of the immatures was 1.02 to 3.68 mm, mean = 2.093 (N = 51). The ratio of pre-/post-vitelline regions (taken from the above mean figures) is 1.00:7.53 and 1.00:4.55 in the matures and immatures, respectively, indicating that the region of the reproductive activity (post-v.r.) undergoes a considerably higher rate of growth than the pre-v.r. Scolex length was 0.16 to 0.73 mm, mean = 0.442 (N = 606) in the mature specimens and 0.20 to 0.45 mm, mean = 0.315 (N = 40) in the immatures. Scolex width (the widest place) was 0.24 to 1.31 mm, mean = 0.698 (N = 606) in the mature specimens and 0.24 to 0.77 mm, mean = 0.500 (N = 40) in the immatures. Width below scolex (neck, the narrowest place) was 0.18 to 1.26 mm, mean = 0.527 (N = 606) in the mature specimens and 0.16 to 0.57 mm, mean = 0.366 (N = 40) in the immatures. The ratio between these three latter measurements (taken from the above mean figures) in the same order is 1.00:1.58:1.19 and 1.00:1.59:1.16 in the matures and immatures, respectively, indicating that the pronouncement and dimensions of the scolex remain stable on the average throughout growth. A profile view of two scolices and a typical scolex are shown in figures 1B and C, respectively. The width at the common gonopore (the third widest place) was 0.14 to 1.10 mm, mean = 0.558 (N = 781) in the mature specimens and 0.24 to 0.65 mm, mean = 0.403 (N = 57) in the immatures. The width at the second widest place (often midway between the cirrus and the neck) was 0.20 to 1.51 mm, mean = 0.678 (N = 781) in the mature specimens and 0.29 to 0.73 mm, mean = 0.490 (N = 57) in the immatures. The ratio between these two measurements (taken from the above mean figures) in the same order was 1.00:1.22 in both mature and immature specimens, indicating that body width dimensions remain stable on the average throughout growth. The width of the cirrus sac was 0.06 to 0.31 mm, mean = 0.176 (N = 431) in the mature specimens and 0.05 to 0.14 mm, mean = 0.103 (N = 42) in the immatures

Mackiewicz (1968) has recently reviewed the systematic position of this cestode and removed it from the genus *Glaridacris* Cooper, 1920, to *Isoglaridacris* Mackiewicz, 1965. My observations of over 2000 worms are in complete agreement with this proposed change, which is based primarily on the number of gonopores (one) (Fig. 1C).

The worms were most frequently found weakly attached or free in the upper part of the small intestine and occasionally, in heavily infected hosts, in the stomach. In one heavily parasitized *C. insignis*, 25 cm long, from the Lower Salt River at Tempe, one worm was found

live and active in the gall bladder. The recovery of even a single worm from the gall bladder suggests that *I. hexacotyle* has a potential tolerance to a wide range of chemical environments. Such a pattern may be more primitive than that exhibited by caryophyllaeids that are restricted to particular portions of the gut, *e.g., G. laruei* in the posterior portion of the intestine and *H. lintoni* in the stomach (Mackiewicz, 1960).

The frequency of infected *C. insignis* was high in the Lower Salt (37.9%, N= 261) and Lower Verde (57%, N = 7) but lower in the Upper Verde River (6.8%, N = 59). The number of parasites per host ranged between 0 and 250 (mean 8.15) 0 and 5 (mean 1.86), and 0 and 3 (mean 0.10) in the same localities, respectively. The over-

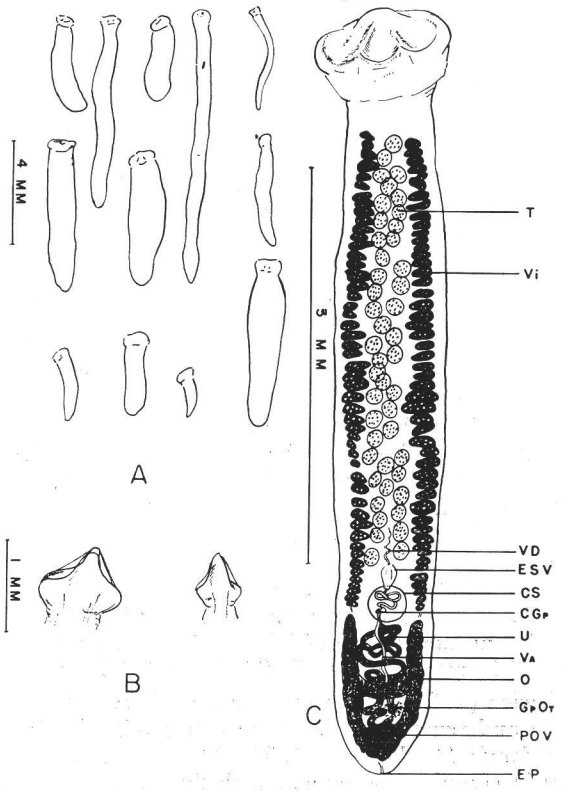

Fig. 1.—*Isoglaridacris hexacotyle* from *Catostomus insignis* and *C. clarki*. A, Variation in forms of adults. B, A profile of two scolices. C, A mature worm. Abbreviations: CGp: common gonopore; CS: cirrus sac; EP: excretory pore; ESV: external seminal vesicle; GpOt: glandular portion of ootype; O: ovary; POV: postovarian vitellaria; T: testis; U: uterus; Va: vagina; Vi: vitelline gland; VD: vas deferens.

all mean per host is 6.56. Only 3 of the 37 (8.1%) *C. clarki* examined in the Upper Verde River were found infected with 6 worms; a range of 0-3 and a mean of 0.16 per host. The total mean per host is 0.05. No *C. clarki* examined from other localities were found infected. These figures indicate clearly that *C. insignis* is more frequently and heavily infected with *I. hexacotyle* than *C. clarki*. The three infected fish of the latter species ranged between 15 and 20 cm in total length. The differences in infection rates are considered primarily due to habitat and diet. The intermediate host of this parasite (probably an annelid) presumably does not occur in riffles and swift water (inhabited by *C. clarki*) but should occur in pools and backwaters (inhabited by *C. insignis*). This does not exclude the three 15-20-cm *C. clarki* found infected with this parasite since it is the smaller *C. clarki* which have more frequent contact with pool conditions. *C. clarki* is also a herbivore and annelids and related invertebrates are seldom or accidentally used as food material; the opposite is true for *C. insignis*. Of these two ecological factors, the one pertaining to the feeding habits appears to be more important because: four species of helminth parasites (one leech species exclusive) were recovered from both suckers. With two parasitic species, the cestode *I. hexacotyle* and the acanthocephalan *Neoechinorhynchus* sp., the final host obtains the infection by ingesting the infective stage of the parasite. *C. insignis* was heavily parasitized by both parasites while *C. clarki* was found to suffer only very light infections. In contrast, the cercariae of the trematodes *C. marginatum* and *O. ptychocheilus* are not passively eaten but rather actively penetrate the integument of the host. The degrees of infection with metacercariae of these two parasites were rather similar in *C. insignis* and *C. clarki* despite their varied habitats.

TABLE 1.—The effect of the size of *Catostomus insignis* from the Lower Salt River at Tempe on a population of *Isoglaridacris hexacotyle*

	Host size classes (Total length)					
	I 10-15 cm	II 15-20 cm	III 20-25 cm	IV 25-30 cm	V 30-35 cm	Total
Fish examined	54	112	20	7	5	261
No. infected	15	61	12	6	5	99
Per cent infected	27.8	54.5	60.0	85.7	100	37.9
Parasites recovered	174	827	158	373	595	2127
Percentage composing immature parasites recovered	34.5	14.6	4.4	3.2	2.3	1.0
Range of parasites per host	0-64	0-93	0-35	0-166	12-250	0-250
Mean/host	3.22	7.38	7.90	53.29	119.00	8.15

No ill effects were apparent and hosts with the heaviest infections appeared as healthy as the uninfected ones.

The 261 *C. insignis* examined from the Lower Salt River at Tempe were divided into five size classes as indicated in Table 1. The larger the hosts, the more frequently and heavily they were infected (Table 1), presumably as a direct effect of the proportional increase in food volume (containing the intermediate host) consumed by the larger fish, and also as a result of the cumulative effect of parasitic infections in older (larger) fish. In contrast, the index of immature worms decreased with increase in host size. The largest cestodes (15 mm long) were obtained from the longest *C. insignis* examined (about 50 cm in total length) from the Lower Verde River at Pinnacle Peak. The fact that fewer immature cestodes were recovered from larger fish hosts might be due to the availability of more time for growth of worms in the older and longer fish.

Morphological growth study.—The 1031 whole-mounted *I. hexacotyle* (mature and immature) from *C. insignis* from the Lower Salt River at Tempe were divided into 10 size classes according to total body length. The specimens of the first class measured between 1.22 and 1.99 mm. Each of the subsequent classes between the second and ninth covered one mm; specimens of the tenth class measured between 10.00 and 12.04 mm. Each class was represented by 20 nonrandomly selected worms, two for each 0.1 mm length except when unavailable in the first or the latter three classes (N = 0-16).

Figure 2A shows that while the length of the pre-vitelline region increases slowly from a mean of 0.290 mm (N = 16) in the first class to 1.120 mm (N = 6) in the last, the length of the post-vitelline region rapidly increases from a mean of 1.405 mm (N = 16) in the first class to 9.793 mm (N = 6) in the last. These results are further supported by the length of the post-/pre-vitelline region (Fig. 2B). This ratio is 5.008 (N = 16) in the first class, reaching a peak of 9.635 (N = 20) in the eighth class, but shows a slight drop afterwards, partially because of small sample size (six) in the tenth class. These results are in agreement with those of Hunter (1930) on the caryophyllaeid cestode *Glaridacris confusus* and suggest that the maximum growth in length of *I. hexacotyle* is localized in the post-vitelline region where reproductive activity occurs. This pattern is analogous to that of trematodes, *e.g.*, as shown for *C. marginatum* (following).

Growth of other characters has been discussed (see Amin, 1968, for more details and illustrations), a brief summary of which follows. The scolex length gradually increases from a mean of 0.228 mm (N = 15) in the first class to a peak of 0.520 mm (N = 4) in the ninth, N = 0 in the tenth class. The increase in length of scolex, being somewhat greater than that of the pre-vitelline region, suggests that the scolex increases faster than the neck region in length.

The width of the cirrus sac slowly increases from a mean of 0.075 mm (N = 6) in the first class to a peak of 0.215 mm (N = 16) in the eighth class, but declines to 0.190 (N = 4) and 0.127 mm (N =

3) in the ninth and tenth classes; this apparent decline is probably due to the small sample sizes.

The four width measurements of scolex, below scolex (neck), at common gonopore, and at the second widest place consistently increase from low in the first class to a peak of maximum width at the seventh class, paralleling a corresponding increase in body length. Worms longer than 7-8 mm (8th-10th classes) were relatively slimmer. Further increase in length of worms above 7-8 mm might somehow involve a cessation or retardation of growth in width. The emptying of the uterus of eggs might account for a more "slender" configuration.

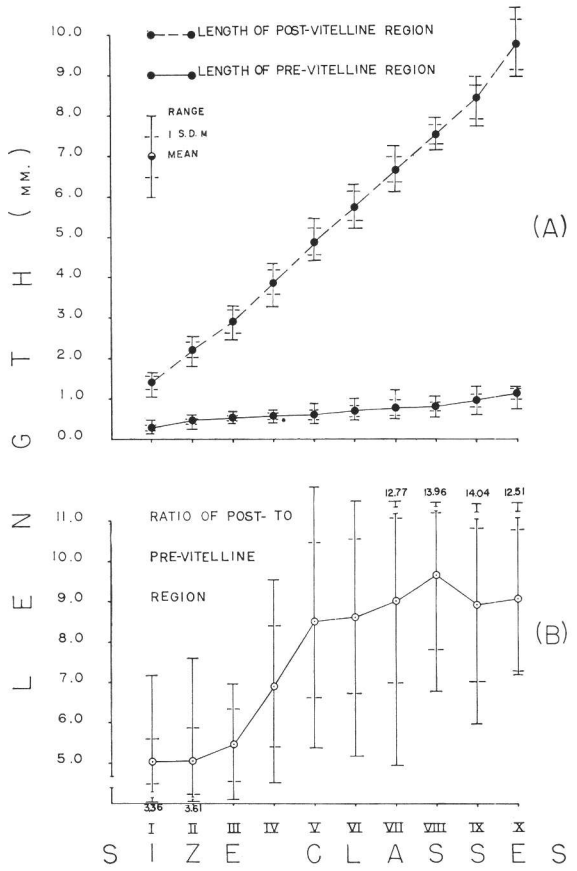

Fig. 2.—Absolute and relative growth in length of post- and pre-vitelline regions of *I. hexacotyle*. Size-class measurements of total body length as follows: I: 1.22-1.99 mm; II: 2.00-2.99 mm; III: 3.00-3.99 mm; IV: 4.00-4.99 mm; V: 5.00-5.99 mm; VI: 6.00-6.99 mm; VII: 7.00-7.99 mm; VIII: 8.00-8.99 mm; IX: 9:00-9.99 mm; X: 10-12.04 mm.

Data of other observers are in agreement with this pattern. The larger specimens examined by Linton (1897) (8-14 mm long) and Hunter (1930) (8-18 mm long) are considerably narrower than my shorter specimens. In their and my specimens, the maximum width measurements of the scolex are 0.72, 0.608, and 1.31 mm; below scolex (neck), 0.68, 0.758, and 1.26 mm; and at the second widest place, 1.0-1.50, 1.23, and 1.51 mm, respectively. A close relationship was observed in the pattern and rate of growth, between the scolex width and the second widest place and also between the width below scolex and at the common gonopore although this was slightly less pronounced than in the first case.

The relative growth of the scolex width/scolex length and that of the scolex width/width below scolex closely follows the above pattern of variation, which further demonstrates the consistency in maintaining the relative scolex dimensions and its expression throughout growth.

In summary, this study suggests that the maximum rate of growth is localized in the region of reproductive activity. Also that general body form is relatively consistent in the various size classes, but with a tendency towards slimmer configuration in larger worms.

Clinostomum marginatum Rudolphi, 1819

C. marginatum was originally found in Brazil (Cort, 1913) but was first reported in North America by Leidy (1856) and is known now to be widely distributed. *C. marginatum* metacercariae are herein reported from *Catostomus insignis* and *C. clarki* from the Upper Salt River at the Salt River Canyon, Arizona, during July 1966—new host and locality records. For a complete account of intermediate and final hosts see Amin (1968: 121-138). Of 24 known definitive bird hosts, eight were reported from Arizona by Lowe (1964) — *Ardea herodias, Botaurus lentiginosus, Chlidonias nigra surinamensis, Larus argentatus, Nyctanassa violacea, Nycticorax nycticorax, Phalacrocoras a. auritus,* and *Sterna hirundo.*

The metacercarial cysts of *C. marginatum* are creamy white spherical balls from 1.5 to 3.0 mm in diameter. See Osborn (1911) and Hunter and Dalton (1939) for cyst wall origin and anatomy. Unprocessed excysted worms kept in saline solution at 5 C remained alive for a week. During this period, the worms were observed to exhibit active movements of expansion and contraction.

The anatomy of the worm was described in considerable detail by MacCallum (1899) and Osborn (1912). Of 165 larvae recovered, 136 were whole mounted. The body length was 2.49 to 6.04 mm, mean = 3.727 (N = 136). The forebody length was 0.65 to 1.43 mm, mean = 0.937 (N = 136). The hindbody length was 1.80 to 4.61 mm, mean = 2.787 (N = 136). The maximum body width (invariably between the two testes) was 0.86 to 1.67 mm, mean = 1.234 (N = 133). The width at the acetabular constriction was 0.45 to 1.14 mm, mean = 0.801 (N = 133). The width of the oral sucker was 0.16 to 0.29 mm, mean = 0.230 (N = 123). The width of the ventral

sucker (acetabulum) was 0.37 to 0.65 mm, mean = 0.493 (N = 135).

Most of the earlier records of metacercariae of this species were from the body musculature and under the body wall. However, of the 165 worms recovered, 122 (73.94%) were recovered from the gill filaments, rakers and branchial chamber, 18 (10.91%) from the body musculature at various depths, 15 (9.09%) from under the skin, 7 (4.24%) from the fin rays, 2 (1.21%) from the eye socket, and 1 (0.61%) from the heart.

Of 17 *C. insignis* and four *C. clarki* examined from the Upper Salt River, 16 (94.12%) of the first and three (75.00%) of the second species were found infected. This relatively similar frequency of infection is partially because penetration of the cercariae into the host body wall is a function of exposure and is independent of the fish feeding behavior. However, the higher infection rate in *C. insignis* (0-40

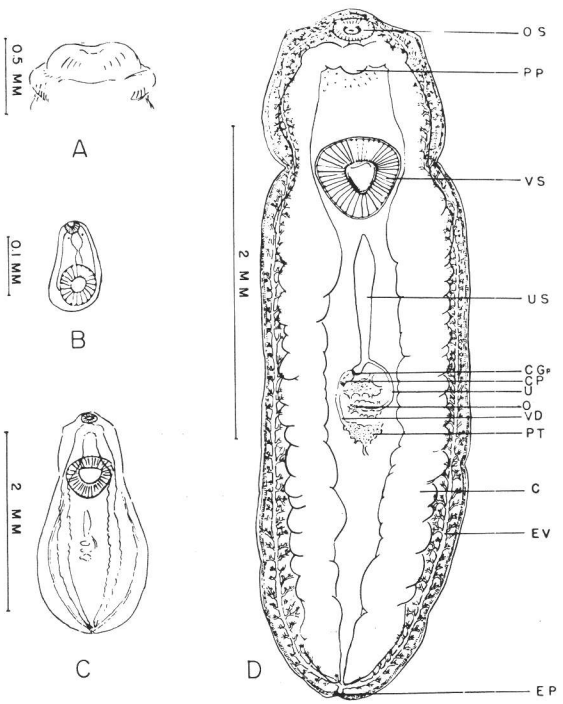

Fig. 3.—Metacercariae of *Clinostomum marginatum* from *Catostomus insignis* and *C. clarki*. A, The oral field in a sucking position. B, smallest metacercaria (0.15, 0.22 mm when alive). C, A 2.5 mm metacercaria. D, a fully grown metacercaria. Abbreviations: C: caecum; CGp: common gonopore; CP: cirrus pouch; EP: excretory pore; EV: excretory vesicle; O: ovary; OS: oral sucker; PP: pharyngeal pouch; PT: posterior testis; U: uterus; US: uterus sac; VD: vas deferens; VS: ventral sucker.

worms per host, mean = 8.71) than in *C. clarki* (0-13 worms per host, mean = 4.25) may be due to the speed of current. In the swifter waters(inhabited by *C. clarki*) the cercariae may have fewer chances of successfully finding and penetrating the fish-host, as has been previously suggested by Nigrelli (1936).

No ill effects were apparent and hosts with the heaviest infection (40 cysts) appeared as healthy as the uninfected ones.

Morphological growth study. — The 136 whole-mounted metacercariae were divided into six size classes according to their total length. The specimens of the first class measured between 2.49 and 3.00 mm. Each of the subsequent classes from the second through the fifth covered 0.50 mm. Specimens of the sixth class measured between 5.00 and 6.04 mm. Sample size was 10, 44, 45, 19, 11, and 5 in the classes 1 to 6, respectively.

These specimens assumed a variety of shapes which could be assigned to two major body forms characterized by the medium and the large sizes (Figs. 3C and D, respectively). The 0.15 mm long metacercaria in Fig. 3B is after Hopkins (1933). The smallest specimens are almost oval in shape with a terminal oral sucker, a large posterior ventral sucker, and posteriorly extending intestinal caeca. The next stages indicate a rapid increase in length of the hindbody coupled with a slower increase in length of forebody. The increase in the tissue volume of the hindbody contains developing reproductive system and intestinal caeca. The acetabular constriction becomes more pronounced in older worms.

While the forebody length increases slowly from a mean of 0.776 mm in the first class to a maximum of 1.290 mm in the last (a net increase of 65.38%), the hindbody length increases at a faster rate from a mean of 2.034 mm in the first class to a peak of 4.056 mm in the last (a net increase of 97.54%) (Fig. 4A). Figure 4B shows an increase in ratio of the hindbody to forebody from a mean of 2.636 in the first class to a maximum of 3.260 in the fifth. The mean of 3.149 in the sixth class might be due to a small sample size (N = 5). These results clearly demonstrate that the maximum growth in length of *Clinostomum marginatum* metacercariae is localized in the post-acetabular region where the reproductive activity occurs (see *I. hexacotyle* above).

Growth of the other characters has been discussed (see Amin, 1968, for more details and illustrations), a brief summary of which follows. The oral sucker appears to continue growing in width between the middle-sized and large-sized specimens. It increases from a mean of 0.213 mm in the first class to a maximum of 0.249 mm in the fifth (a net increase of 19.05%). A mean of 0.234 mm in the sixth class is probably due to small sample size of five. The ventral sucker appears to have attained its maximum width in the medium-sized specimens.

The ratio of acetabular width to body length decreases at a slightly lower rate than does that of maximum width/body length.

Ornithodiplostomum ptychocheilus Faust, 1917

Intermediate and final hosts of this parasite have been reported only from North America. For a complete account on these hosts see Amin (1968:166-168). Metacercariae of this strigeid trematode, also known as *Neascus ptychocheilus* Faust, were recovered in this study from both *Catostomus insignis* and *C. clarki* from the Upper Verde River at Perkinsville and less frequently from *C. insignis* from the Upper and Lower Salt River, Arizona, at the Salt River Canyon and at Tempe, respectively. These are new host and locality records. Of the four definitive bird hosts known to harbor this parasite, two were reported from Arizona by Lowe (1964). They are *Mergus serrator* and *Lophodytes cucullatus*.

The metacercariae recovered from both suckers were identical. The spherical cysts measured between 0.53 and 0.73, with a mean of 0.647 mm in diameter (N = 24). The metacercariae measured between 0.24 and 0.41 with a mean of 0.331 mm in maximum length and between 0.12 and 0.29 with a mean of 0.202 mm in maximum width (N = 24).

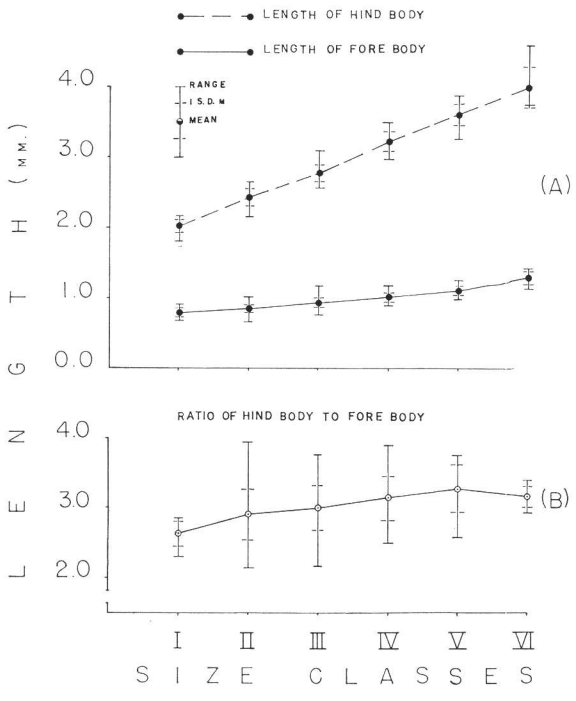

Fig. 4.—Absolute and relative growth in length of fore- and hindbody of *C. marginatum* metacercariae. Size-class measurements of total body length are as follows: I: 2.49-2.99 mm; II: 2.99-3.49 mm; III: 3.50-3.99 mm; IV: 4.00-4.49 mm; V: 4.50-4.99 mm; VI: 5.00-6.04 mm.

All specimens were recovered from the intestinal mesenteries (body cavity) of the fish-hosts. The maximum number of cysts recovered per host was less than 200. Hoffman (1958) showed that in heavily infected fish, the parasite tends to occupy additional sites (the orbit, and less frequently brain and musculature), probably as a result of crowding.

Host specificity, as in *C. marginatum,* is highest in snails, lowest in fish, and somewhat intermediate in birds.

Of 59 *C. insignis* and 37 *C. clarki* examined in the Upper Verde River at Perkinsville, 13 (22.03%) of the first and 12 (32.43%) of the second species were infected. These 25 fish were almost equally infected, averaging 50-100 metacercariae per fish with a probable maximum of less than 200. The role of the speed of water current in preventing cercarial host contact is probably responsible for the fact that two *C. insignis* from the Upper and Lower Salt River were infected with 2-3 metacercariae each, while none of the 43 *C. clarki* examined from both areas was infected.

In reporting *O. ptychocheilus* metacercariae, Hoffman (1958) reported marked hyperemia at the base of fins. In heavy infections hyperemia was extended to the body surface. This was not observed in my study.

Neoechinorhynchus sp.

Adults of this acanthocephalan were recovered from the intestine of both *C. insignis* and *C. clarki* in the Upper Salt River and only from *C. insignis* in the Upper Verde River, Arizona.

Professor W. L. Bullock of the Department of Zoology, University of New Hampshire at Durham, examined some of my specimens and expressed his belief that they belong to an undescribed species. Twenty-five adults (14 females, 11 males) were recovered.

Of 76 *C. insignis* and 41 *C. clarki* examined from the Upper Salt and Verde rivers, 13 (17.1%) *C. insignis* and 1 (2.4%) *C. clarki* were infected with 24 (range = 0-6, mean per host = 0.315) and 1 (range = 0-1, mean per host = 0.024) worms, respectively.

Slight tissue damage was observed in the intestinal mucosa of suckers infected with this acanthocephalan only at the site of attachment. Venard and Warfel (1953) showed that infection of largemouth bass by *N. cylindratus* results in an increased number of leucocytes and in damage to the mucosa only in the immediate area of attachment.

Illinobdella moorei Meyer, 1940

Meyer (1946) indicated that freshwater piscicolid leeches may use any fish as a temporary host, with *I. moorei* showing the widest parasite-host distribution. He listed 16 fish-host species from North America. In the present study, *I. moorei* was recovered from both *C. insignis* and *C. clarki* in the Upper Verde River at Paulden and Perkinsville and from the latter fish in the Upper Salt River at Cibecue Creek and the Lower Salt River at Tempe; these are new host and locality records. *C. insignis* was heavily infested in the Upper Verde

River at Paulden (44.83% of 29 hosts examined) but free of infestation in the other localities. *C. clarki* was less frequently infested (2.70% of 37 hosts, 10.00% of 10 hosts, and 2.56% of 39 hosts) in the three other localities in the same order.

The specimens recovered varied between 2.1 and 12.0 mm in length after fixation. Both suckers appear anatomically weak although the specimens were firmly attached to the fish-hosts and after removal (with difficulty) deep ulceration spots were noted at the sites of attachment.

Pennak (1953) and Barnes (1963) reported that it is not uncommon for members of Piscicolidae to remain permanently on the fish-host, except when breeding. Such an intimate type of relationship appears to be the case in *I. moorei.*

The leeches exclusively parasitized the fins with a preference for the anterior ones. Eleven pectoral, 4 pelvic, 3 caudal, and 2 anal fins were infested. The nature of these sites, together with the difficulty with which those leeches were removed from the host, suggests that the suckers of *I. moorei* are not as weak as previously suggested by Meyer (1946). The fins are considered a unique site of infestation, as attachment to such highly mobile organs would increase the likelihood of being disengaged as opposed to other common sites reported by Meyer (1946), *e.g.,* "inside the operculum, in the mouth, or if truly external, usually on the body surface protected by the pectoral and pelvic fins and about the anus of the host."

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