PARASITISM IN THE FISHES OF THE MOAPA RIVER, CLARK COUNTY, NEVADA

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During a study of the fishes of the Moapa River a number of fish were found to be infected with the parasites *Lernea* and *Contracoecum*. In particular, *Lernea* was found to be common on *Crenichthys baileyi* which were placed in aquaria. As a result of these preliminary findings, our preserved fish collections from Moapa River, in addition to those borrowed from the University of Michigan Museum of Zoology, were examined for parasites.

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DESCRIPTION OF THE MOAPA RIVER

The Moapa River, a part of the Pluvial White River System of Southern Nevada, is tributary to the Colorado River (Hubbs and Miller, 1948). The general characteristics of the river and a brief account of its fishes are found in La Rivers (1962) and Bradley and Deacon (1965). Hubbs and Miller (1948), Kopec (1949), Deacon, et al. (1964), Hubbs and Deacon (1964) briefly discuss aspects of the ecology of the warm headwaters portion of the river. A more detailed discussion of the ecological distribution of the native and introduced fishes is in preparation by Deacon and Bradley (ms.).

Two species, *Moapa coriacea* and *Crenichthys baileyi*, occur in the warm springs and their outflowing streams in the headwaters of the Moapa River. *Gila robusta* is common to abundant throughout most of the river except in the extreme upper and lower reaches where it is rare. Two introduced species, Gambusia affinis and Poecilia mexicana, are abundant and distributed widely throughout the river. Lepomis cyanellus, Notropis lutrensis and Cyprinus carpio are introductions that are common in the lower portions of the stream.

METHODS AND MATERIALS

All fish collected from the Moapa River from 1960 through 1964 were examined for parasites and are on deposit in the Biology Museum, Nevada Southern University at Las Vegas. Additional specimens of Gila robusta and Crenichthys baileyi collected in 1938, 1940, 1941, 1942 and 1959 on loan from the University of Michigan were also examined.

Each specimen was examined under a dissecting microscope for external evidence of parasitism. Copepod (Lernea) infection is apparent by visible scar tissue on the surface of the body and often the copepod may be seen hanging from the site of infection. Nematode (Contracoecum) infection is marked by pronounced localized swellings on the surface of the body. When these swellings are dissected the nematodes can be clearly seen and removed for identification.

Table 1 presents data on frequency and density of infection by Lernea in all species in Moapa River. Density is derived by dividing the number of times a particular site is parasitized into the total number of parasites found at that site, and is essentially one parasite per site of infection for all species except Gila. In Gila, density is highest at the base of the pelvic fins (5.75), second at the base of the anal fin (3.3) and approximately equal on the branchiostegal rays and operculum and at the bases of the dorsal and the pectoral fins (1.8; 2.3; and 2.3, respectively).

The base of the dorsal fin in both Gila and Crenichthys is the most frequently parasitized site (36.0 and 62.7 per cent of the time respectively). The base of the pectoral fins is second in importance as a site of infection in both species (18.6 and 20.3 per cent of the time respectively). In Gila the branchiostegal rays and operculum and the bases of pelvic and anal fins appear about equally susceptible to attachment of parasites (12.8, 14.0, 11.6 per cent respectively). In Crenichthys the base of the anal fin is third in importance (13.6 per cent) as a site of attachment for Lernea. Differences in frequency of utilization of a particular site and the numbers of Lernea attached at that site are obvious in Gila. The base of the dorsal fin is most frequently utilized as a site of attachment, but density is highest at the base of the pelvic fins, etc.

Thirteen nematodes were found on the bodies of nine of the 146 Gila robusta examined. Of these, one was at the base of the pelvic fins, three at the base of the pectoral fins, one on the ventral half of the body, and eight (61.5 per cent) on the dorsal half of the body. One

Notropis lutrensis had a nematode on the ventral half of its body. External evidence of Contracoecum is lacking in all other species.

Eight of the thirteen specimens of Contracoecum found on Gila robusta were on four individuals taken from Anderson Dairy Farm, the only station we collected where raw sewage entered the stream. The other five specimens of Contracoecum were on five Gila taken elsewhere in the stream. Copepod parasitism was somewhat lower on the 62 Gila taken at this station (14.4 per cent) than in the rest of the middle stream (Table 5).

INCIDENCE OF PARASITISM

The incidence of copepod parasitism in the fish fauna of Moapa River is indicated in Table 2. Copepods were found on all species with the exception of carp (Cyprinus carpio). Of the abundant species, Gila robusta has the highest incidence of copepod parasitism. This, together with the unusually high density of parasitism in Gila previously discussed, indicates that the population is somewhat unhealthy.

The low incidence and density of copepod parasitism in C. baileyi is surprising, since it was that species in which heavy infestation was first noted in the fall and winter of 1963 when we introduced several specimens into a 100-gallon aquarium. Heavy morality, which we had not previously experienced with other aquarium populations of this species, was attributed to a heavy Lernea infestation on nearly every specimen. Unfortunately, preserved specimens from this data are not available.

Table 3 indicates that Lernea either did not occur or was quite rare in the Crenichthys population until after 1942, but has been present in the population since 1959.

Table 4 presents data on incidence of parasitism of Gila robusta in Moapa River since 1938. Here we note the absence of copepods in 1938 and their abundance in 1942. This abundance is maintained up to the present. The nematode, Contracoecum, did not appear until 1963 and incidence was much lower than for Lernea.

DISTRIBUTION OF PARASITISM IN THE STREAM SYSTEM

The incidence of Lernea on the more abundant species at different locations in the river is given in Table 5. Incidence is higher in the lower portions of the stream, decreases upstream and is lowest in the springs at the headwaters.

Lernea was found only on Moapa coriacea and Crenichthys baileyi where associated introduced species were without parasites in the springs. Gila robusta, not abundant in upper or lower portions of the river, was heavily infected throughout all portions of the stream. In both areas of lowered abundance, the incidence of parasitism in Gila is higher than in the area of highest abundance in the middle portion of the stream.

The river water, except in the extreme upper extent, is heavily utilized for irrigation. This activity probably increases both turbidity and dissolved substances. The Indian name, Moapa, means "muddy", indicating that the river probably always carried a relatively heavy silt load. Our upper station in the middle portion of Moapa River was located at Anderson Dairy Farm where a pipe discharges raw sewage into the stream. These modifications of the habitat may contribute to conditions that result in increased susceptibility of native species to parasitism.

Lepomis cyanellus and Notropis lutrensis, the most heavily infected exotic species (Table 2), are most abundant in the lower portion of the stream.

DISCUSSION

Table 2 indicates that largemouth bass (Micropterus salmoides) and green sunfish (Lepomis cyanellus) are both susceptible to Lernea. Largemouth bass and "sunfish" (probably including L. cyanellus) were first introduced into Lake Mead in 1935 and 1937, respectively, and these lake populations were parasitized by Lernea and Contracoecum in 1950-54 (Jonez and Sumner, 1954). We suggest that these species are the most probable sources of infection. The lake first filled in 1941, thereby providing the first good opportunity for invasion of the lower end of Moapa River by Lepomis and Micropterus. Gila occupies the lower reaches of Moapa River, although not as abundantly as it occupies the middle section of the river (Table 5 and Deacon and Bradley, ms.). Direct interaction between bass, sunfish and Gila from Moapa River may not have occurred until about 1941. Dogiel et al. (1961) indicate that spread of parasites throughout a new reservoir can occur quite rapidly. This is also true of small tributary streams such as Moapa River.

Lernea is transmitted from one host to another through a free-living planktonic stage. Since planktonic organisms cannot travel upstream, sympatry between the native stream population and the exotic population must have been established in order to effect transfer of the parasite. That this sympatry was established in the stream is suggested by the fact that the stream and lake (Colorado River) populations of Gila robusta show some taxonomic distinction and maintain ecologically isolated populations. Therefore, transfer of Lernea from the lake population of Gila robusta elegans to the stream population of Gila robusta: elegans x robusta is unlikely. Lepomis and Micropterus occupy both Lake Mead and the lower extent of Moapa River where they come in contact with the stream population of G. robusta and provide a more plausible mechanism for the dispersal of the parasite. Once Lernea became established in the Gila population, its dispersal upstream was assured since distribution of Gila is continuous throughout Moapa River.

Upstream dispersal would, of course, require time. The 1938 collections reported in Table 4 were taken near our upper station in the middle portion of the stream. The 1942 collections were taken further downstream at what is our middle station in the middle portion of the river (immediately below U.S. 91 bridge). Thus, the parasite had not reached the upper middle portion of the river in 1938, but was well established in the middle portion by 1942.

The *Crenichthys* population was not parasitized in 1938 but was in 1959. We suggest that *Gila* was the source of infection since that species was the only one to span the distance from the lower to the upper part of the stream during the intervening 21 years.

Gambusia affinis and *Notropis lutrensis* are other possible sources of infection. We discount these possibilities because *Gambusia* was present in the headwaters springs in 1938 and neither *Crenichthys* nor *Gila* were infested with *Lernea* at that time. Jonez and Sumner (1954) and La Rivers (1962) do not record *Notropis* from the Nevada portion of the Colorado River system. Hubbs (1954) first recorded this species from the lower Colorado River in 1953 but it probably did not become established in this part of the Colorado River system until after that date and, therefore, cannot be considered as a possible source of *Lernea* infection.

Jonez and Sumner (1954) recorded *Contracoecum* from bass and sunfish in 1950-54. The parasite, however, did not encyst in the muscle and cause the raised lumps on the body noted by us in *Gila*. It is quite possible that this parasite may be much more frequent in *Gila* (where it is most pronounced) and other native species than is externally evident.

Figure 1 shows catch per trap hour of *C. baileyi* in Moapa Valley Water District Spring (MVWD) since March 1963. Also shown is the time of introduction of *Poecilia* into the stream and subsequent invasion of that species into MVWD Spring. *Poecilia* was introduced into the stream in the winter or spring of 1963 and had radiated throughout the stream except in the headwaters springs by the spring of 1964 (Hubbs and Deacon, 1964). It reached the headwaters springs in February 1965. The heavy *Lernea* infestation in our aquarium population of *C. baileyi* followed the introduction of *P. mexicana* into the stream. A decline in relative abundance of *C. Baileyi* following invasion of MVWD Spring by *P. mexicana* is indicated in Figure 1. Decline in relative abundance also preceded the *Poecilia* invasion into the spring. The first decline might be related to parasitism and the second might be due to competition following the *Poecilia* invasion, or these declines may only reflect annual cycles in population size. Data identifying MVWD Spring as the location from which our *Lernea*-infected aquarium population of *C. baileyi* came, are not available. We can, therefore, only suggest a relationship between *Poecilia* introduction, *Lernea* infestation, and population decline.

An examination of Table 2 further suggests that parasitism is more prevalent in native than in introduced fishes. Approximately 12.8 per cent of the native fish examined had copepod infections in comparison to 3.8 per cent of the introduced fishes. Approximately 1.6 per cent of the native fish examined were infected by nematodes in comparison to less than 0.1 per cent of the introduced populations.

We suggest that the high incidence of parasitism in the native population is due to the deterioration of the habitat that has occurred increasingly in recent years. The headwaters springs are least altered by man; physical, chemical and biotic changes increase downstream where irrigation increases turbidity and dissolved substances, raw sewage is deposited, and increased numbers of exotic species are established. Incidence of parasitism is lowest in the headwaters springs and increases downstream.

Evidence for reduced population size in native fishes has been presented by Deacon et al. (1964), Hubbs and Deacon (1964) and in Figure 1. Evidence for increased incidence of parasitism is presented in Tables 3 and 4. The problem appears to be serious for *Gila* at the present time. A population decline in *Gila* is strongly suggested from the fact that a party from the University of Michigan Museum of Zoology was able to collect 193 specimens with a seine in 1938 in a location from which we were able to collect only 32 and 14 specimens with a shocker in 1964 and 1965 respectively. Michigan collected 72 specimens in 1942 in an area from which we collected only 6 and 16 specimens in 1964 and 1965.

Native species probably have an adaptive peak which corresponds to the natural conditions of the stream and as these conditions change the habitat becomes less suitable, possibly resulting in reduced population size and/or increased incidence of parasitism. Exotic species, if successful, usually are more generalized and, therefore, more tolerant of habitat changes.

We believe that the alterations of the physical, chemical and biotic habitat by man have resulted in a general deterioration of Moapa River as a fish habitat. This deterioration is in part reflected by an increased incidence of parasitism in the native species.

Table 1. Incidence of parasitism at sites of infection and number of *Lernea* (in parenthesis) occurring at these sites on fishes of the Moapa River, Clark County, Nevada, for the period 1938-1964.

Native species	No. of Fish Examined	Branchiostegal and Operculum	pelvic	pectoral	dorsal	anal	caudal
Gila robusta	411	11(20)	12(69)	16(37)	31(71)	10(33)	6(10)
Moapa coriacea	87			2(2)	2(2)		
Rhinichthys osculus	23		1(1)		1(1)		
Plagopterus argentissimus	1			1(1)			
Crenichthys baileyi	1482	1(1)		12(12)	37(37)	8(9)	1(1)
Introduced species							
Cyprinus carpio	8						
Notropis lutrensis	112	1(1)	3(3)	3(3)	3(3)	2(2)	1(1)
Pimephales promelas	8			1(1)			
Gambusia affinis	475			2(2)		1(1)	
Poecilia mexicana	325		1(1)	1(1)		2(2)	
Lepomis cyanellus	102	2(2)	8(8)	8(9)	4(4)		2(2)
Micropterus salmoides	2			1(1)	2(2)		

Table 2. Incidence of *Lernea* on fishes of the Moapa River, Clark County, Nevada. (1960-64)

Native Species	Number Examined	Number with *Lernea*	Per cent Parasitized
Gila robusta	146	53	36.3
Moapa coriocea	87	4	4.6
Rhinichthys osculus	23	2	8.7
Plagopterus argentissimus	1	1	100.0
Crenichthys baileyi	290	10	3.4
Total	547	70	12.8
Introduced species			
Cyprimus Carpio	8	0	0
Notropis lutrensis	112	10	8.9
Pimephales promelas	8	1	12.5
Gambusia affinis	475	3	0.6
Poecilia mexicana	325	4	1.2
Lepomis cyanellus	102	19	18.6
Micropterus salmoides	2	2	100.0
Total	1032	39	3.8

Table 3. Incidence of parasitism by _Lernea_ on _Crenichthys baileyi_ from 1938-1964 in the headwaters of Moapa River.

Year	No. Examined	No. with _Lernea_	Per cent Parasitized
1938	250	0	0
1940	7	0	0
1941	9	0	0
1942	6	0	0
1959	920	47	5.1
1961	11	1	9.1
1962	68	0	0
1963	201	9	4.5
1964	10	0	0
Total	1482	57	

Table 4. The incidence of parasitism in _Gila robusta_ collected from the Moapa River, Clark County, Nevada, for the period 1938 to 1964.

		Parasitized by _Lernea_		Parasitized by _Contracoecum_	
Year Collected	Number Examined	No.	Per cent	No.	Per cent
1938	193	0	0	0	0
1942	72	37	51.4	0	0
1960	2	1	50.0	0	0
1963	48	26	54.2	4	8.3
1964	96	26	27.1	5	5.2
Total	411	90		9	

Table 5. The Incidence of Copepod Parasitism in the Abundant Fish Species Collected at Different Stations on the Moapa River, Clark County, Nevada. (Collected 1960-64.)

Species	Springs			Upper Stream			Middle Stream			Lower Stream		
	No. Examined	No. With Copepods	Per Cent With Copepods	No. Examined	No. With Copepods	Per Cent With Copepods	No. Examined	No. With Copepods	Per. Cent With Copepods	No. Examined	No. With Copepods	Per Cent With Copepods
Native species												
<u>Gila robusta</u>				11	6	54.4	121	38	32.0	14	8	57.1
<u>Moapa coriacea</u>	51	3	5.9	15	1	6.7						
<u>Rhinichthys osculus</u>				5	0	0	18	2	11.2			
<u>Chrenicthys baileyi</u>	92	1	1.0	6	1	16.7						
Total	143	4	2.8	37	8	21.6	139	40	28.8	14	8	57.1
Introduced species												
<u>Notropis lutrensis</u>							4	0	0	108	10	9.2
<u>Pimeophales promelus</u>							8	1	12.5			
<u>Gambusia affinus</u>	208	0	0	74	1	3.5	161	1	0.3	32	2	6.2
<u>Poecilia mexicana</u>	19	0	0	111	1	0.9	187	3	1.2	8	0	0
<u>Lepomis cyanellus</u>										102	19	18.6
Total	227	0	0	185	2	1.1	360	4	1.1	250	31	12.4
Grand Total	370	4	1.1	222	10	4.5	499	45	9.0	264	39	14.8

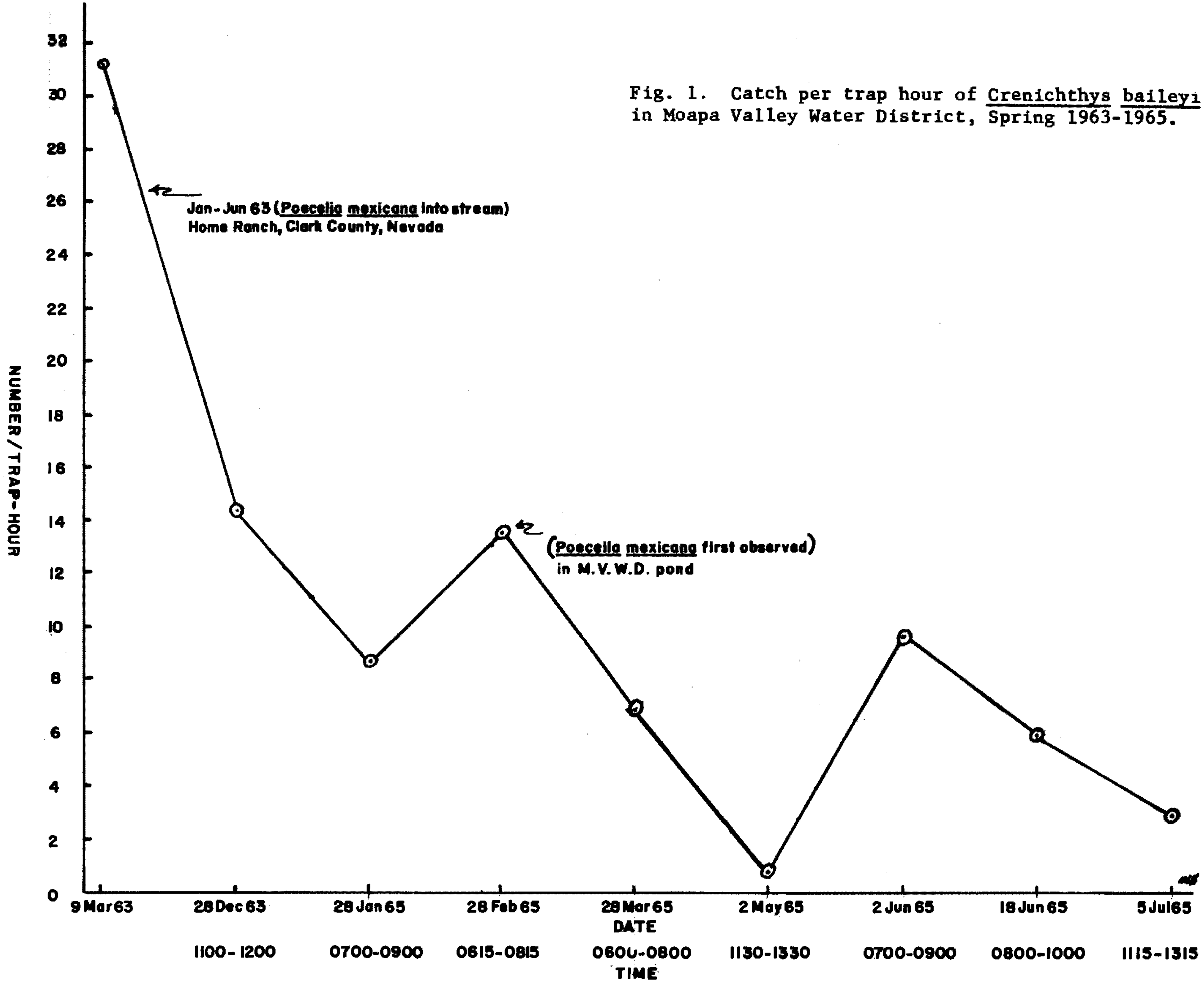

Fig. 1. Catch per trap hour of _Crenichthys baileyi_ in Moapa Valley Water District, Spring 1963-1965.

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