Metazoan Ectoparasitic Fauna of American Eels from Brackish Water[1]

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Abstract: Approximately 48% of 211 American eel, *Anguilla rostrata,* collected from brackish portions of Cooper River, South Carolina, were infested with 1 or more ectoparasitic species representing 2 classes, Monogenea and Crustacea. Seasonal and host size- and age-related variations in the levels of parasitism of *Ergasilus cerastes* and *E. celestis* were observed. These variations in levels of parasitism are discussed with a proposed life history for *E. cerastes* in southern waters.

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The American eel is common in drainages of the western North Atlantic and Gulf of Mexico and serves as host for many parasite species throughout its range. Most previous studies of eel parasites have been surveys restricted to northeastern and northcentral United States and Canada. These surveys have been of 3 types: those focused on the eel as a host (Hanek and Threlfall 1970); on parasites of a geographic region (e.g. Mueller 1934, Linton 1940, Bangham 1955); and on particular species or groups of parasites (e.g. Van Cleave 1921, Komourdjian et al. 1977). Ecological aspects of the interactions of parasites with their eel hosts have not been reported; therefore, an investigation was undertaken to determine the parasite fauna of an American eel population vulnerable to commercial exploitation in a southern river system and to identify host-related and seasonal differences in parasite occurrence and intensity. This paper presents the data collected on crustacean and monogenean parasites. Data on helminth and protozoan parasites will be presented separately.

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Methods

Eels (N = 211) were caught with baited traps in the brackish portion (mean salinity = 5.3‰) of Cooper River, South Carolina, between Bushy Park boat landing (32°57′20″ N, 79°56′13″ W) and Wando River confluence (32°49′23″ N, 79°56′52″ W). Sampling began in July 1977 and was repeated at approximately 2-week intervals through June 1978. Ten eels were collected each sampling period when possible, placed on ice and transported to Clemson University for parasitological examination. Those not held live and examined fresh were frozen or preserved in 10% formalin and examined later.

Eels were weighed to the nearest 0.1 g. Total length (TL) was measured to the nearest mm. Age was determined from otoliths according to the method outlined by Hansen (1979). Three eels with unreadable otoliths were omitted from age comparisons.

Ectoparasites were sought by gross and microscopic (30X) examination was made of skin, fins, opercula, gills, and mucus scrapings. Parasites were collected separately by type, fixed, and preserved according to methods described by Rogers (undated) and Hoffman (1967).

Percentage of infested eels (% occurrence) and mean number of parasites per infested eel (intensity) were calculated for month of capture, age and 5-cm size group (e.g. 245–294 mm TL) of host. Small sample sizes limited statistical comparisons of seasonal and host-related differences in levels of parasitism. Differences in percent occurrence were tested using χ^2 (α = 0.05). Differences among mean intensities were tested with linear contrasts (α = 0.05), using the general linear model procedure of Barr et al. (1979).

Results

Five species of Crustacea and 1 of Monogenea were recovered from body surfaces and gills of 101 eels of 211 examined. The monogenean *Gyrodactylus anguillae* parasitized gill filaments. Eighty *G. anguillae* were recovered from 15 eels between February and June 1978. Occurrence (40%) and mean intensity (8.0) were highest in April. No significant differences ($P > 0.05$) in size or age were found between infested and noninfested eels.

A single specimen of *Argulus chesapeakensis* was found on the lateral surface of an eel in June 1978. Five eels caught during March and May 1978 were infested with *Lernaeenicus radiatus* and/or *L. polyceraus*. Three *L. radiatus* were recovered from mouth, gill arch, and pectoral fin insertion and 4 *L. polyceraus* from cheek and opercular flap.

Ergasilus cerastes and *E. celestis* were attached to gill filaments throughout the year. Seventy-seven eels were infested with 825 *E. cerastes,* while 17 eels were infested with only 24 *E. celestis.* The 2 species occurred together on 8 eels.

Seasonal variation in intensity, reproductive intensity (number of parasites with ovisacs per infested eel), percent occurrence, and percent ovisac occurrence (percent parasites with ovisacs) was demonstrated for *E. cerastes* (Fig. 1a, b). Occurrence of *E. cerastes* declined from 100% in July to 0% in October 1977, rose to 75% in January 1978 and fell again to 0% in April (Fig. 1b). Peaks in mean intensity of *E. cerastes* occurred in July and September 1977 (Fig. 1a). Mean intensity remained at a relatively low level (<4) from late fall through spring. Water temperature also declined in late fall and remained low (<15° C) until early spring (Fig. 1c).

Ovisacs were noted on 241 *E. cerastes* (29%), none of which was found during the period October 1977–February 1978 (Fig. 1b). When ovisacs were present, occurrence varied from 24% in August 1977 to 81% in June 1978. Peaks in mean reproductive intensity occurred in July and September 1977 (Fig. 1a).

Specimens of *Ergasilus celestis* were found in July, October, and December 1977 and March, April, and June 1978. Occurrence was highest in December (28%), but monthly mean intensity never exceeded 2.0 (individual range 1–4). Nine *E. celestis* (38%) had ovisacs, all in April and June.

Eels infested with *E. cerastes* were, on average, 0.5 years older and 28 mm

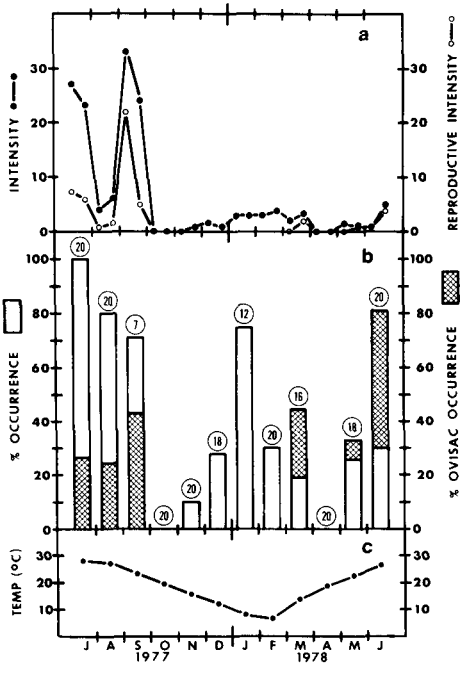

Fig. 1

a Biweekly mean intensity and reproductive intensity (see text for definitions) of *Ergasilus cerastes* on American eel.

b Monthly percent occurrence and percent ovisac occurrence of *E. cerastes* on American eel (total number of eels examined encircled).

c Mean water temperatures in vicinity of eel collecting locations in lower Cooper River near Charleston, S.C.

Table 1. Frequency,[a] occurrence, and intensity of *Ergasilus cerastes* (*E. cer*) and *E. celestis* (*E. cel*) in American eel, *Anguilla rostrata*, collected from Cooper River, S.C.

Size group (TL-mm)	*N* eels examined	Frequency %		% Occurrence		Mean Intensity	
		E. cer	*E. cel*	*E. cer*	*E. cel*	*E. cer*	*E. cel*
245–294	1	0	0	0	0	0	0
295–344	14	1.3	11.7	7.1	14.3	4.0	1.0
345–394	23	2.6	17.6	8.7	13.0	1.5	1.0
395–444	36	22.1	23.5	47.2	11.1	6.3	1.5
445–494	57	31.2	23.5	42.1	7.0	17.1	1.2
495–544	43	23.4	23.5	41.9	9.3	13.2	2.0
545–594	20	11.7	0	45.0	0	4.1	0
595–644	14	6.5	0	35.7	0	4.8	0
645–694	3	1.3	0	33.3	0	1.0	0

[a]Number of infested eels per size group expressed as percentage of total eels infested with *E. cerastes* (N = 77) and *E. celestis* (N = 17).

Table 2. Frequency,[a] occurrence, and intensity of *Ergasilus cerastes* (*E. cer*) and *E. celestis* (*E. cel*) in American eel, *Anguilla rostrata*, collected from Cooper River, S.C.

Age (Yr)	*N* eels examined	Frequency %		% Occurrence		Mean Intensity	
		E. cer	*E. cel*	*E. cer*	*E. cel*	*E. cer*	*E. cel*
1	2	0	0	0	0	0	0
2	14	4.0	12.5	21.4	14.3	2.3	1.0
3	38	16.0	25.0	31.6	10.5	5.4	1.5
4	49	20.0	18.8	30.6	6.4	9.1	1.0
5	57	25.3	25.0	33.3	8.5	15.6	1.5
6	37	28.0	12.5	56.8	5.4	13.7	1.5
7	8	5.3	0	50.0	0	6.0	0
8	2	1.3	6.2	50.0	50.0	1.0	1.0
9	1	0	0	0	0	0	0

[a]Number of infested eels per size group expressed as percentage of total eels infested with *E. cerastes* (N = 77) and *E. celestis* (N = 16).

longer than non-infested eels. Percent occurrence of *E. cerastes* was significantly greater ($P < 0.05$) in longer (≥395 mm TL) and older (≥6 years) eels than in shorter and younger ones (Tables 1, 2). Mean intensity was significantly higher ($P < 0.05$) in eels of intermediate size (445-544 mm TL) and age (5–6 years) groups than in other groups.

Eels infested with *E. celestis* were 0.3 years younger and 47 mm shorter than non-infested eels. Occurrence of *E. celestis* decreased from a high of 14% in eels 295–344 mm TL to 9% in eels 495–544 mm TL (Table 1). Eels longer than 544 mm TL were not parasitized by *E. celestis*.

Discussion

A single specimen of *Gyrodactylus anguillae* has been reported from American eel (Crane and Eversole 1980); otherwise, the species is known only from Euro-

pean eel, *Anguilla anguilla* (Ergens 1960, Malmberg 1970, Ogawa and Egusa 1978). Reported hosts of *G. anguillae* were elvers collected from fresh water.

Of the 2 species of *Ergasilus* recovered, only *E. celestis* has been reported previously from American eel. *E. celestis* was found on eels in New York (Mueller 1936, cited in Roberts 1969*a*), Massachusetts (Roberts 1969*a*), Mississippi and Alabama (Johnson 1971), and North Carolina (Burris and Miller 1972). Johnson (1971) considered *E. celestis* the species of *Ergasilus* expected to parasitize American eel. *E. cerastes* was described by Roberts (1969*b*) from specimens found on an ictalurid in a Washington, D.C., fish market and synonymized with an ergasilid from ictalurids captured in Florida. *E. cerastes* has also been reported from white catfish, *Ictalurus catus,* in Ashley River, South Carolina, and from other ictalurids in Gulf of Mexico drainages (Johnson 1971). The Ashley, Cooper, and Wando rivers join at Charleston Harbor near the lower end of the sampling area. White catfish, often part of the incidental catch in eel traps, were not examined for parasites.

Little is known about specific habitat requirements of ergasilids in North America. Some species appear to tolerate a wide range of habitat types (cf. Roberts 1970). However, most published data are insufficient to permit distinction between tolerance of and preference for particular environmental conditions. Clines certainly exist and species distributions are probably circumscribed by physical or physiological requirements of the parasites.

Large differences in intensity and occurrence between *E. celestis* and *E. cerastes* suggest that the Cooper River habitat may be more suitable for *E. cerastes* than *E. celestis.* According to Johnson (1971), *E. celestis* has a "general inland" distribution. Since this is the first record of *E. celestis* from brackish water, salinity may be a factor limiting its abundance in Cooper River.

The difference in abundance between species may also result from sampling bias. The eel size most susceptible to trapping coincided with what appeared to be the optimum host size for *E. cerastes* while the optimum host size for *E. celestis* may not have been sampled. The data indicate a negative relationship between eel size and occurrence of *E. celestis,* but few small eels were collected.

Susceptibility to parasitism by *Ergasilus* spp. may be a function of gill filament size. *Ergasilus* spp. attach to fish gills by means of prehensile second antennae which either surround or impale a filament. Wilson (1916) noted that ergasilids tended to occur more frequently on small rather than large fish, and gave 7.6–12.7 cm TL as the size range for nearly 100% infestation of crappie, *Pomoxis* spp., by *E. caeruleus.* Van Duijn (1973) stated that *Ergasilus* spp. did not parasitize fish less than 5.1 cm TL because gill filaments were too small to grasp. If filaments can be too small for ergasilids to grasp, presumably they can also be too large. Large gill filament sizes may be the reason that, according to Amlacher (1970), tench, *Tinca tinca* >20 cm TL are not parasitized by *E. minor.*

Modified second antennae of *E. celestis* and *E. cerastes* differ greatly in size and shape. Antennae of *E. celestis* are much shorter and appear to have a more limited range of motion than those of *E. cerastes. E. celestis* may be restricted to smaller gill filaments and, therefore, to smaller eels than *E. cerastes.* Peak intensity

of *E. cerastes* among intermediate size eels indicates there may be a definable range of gill filament sizes which provide satisfactory anchorage for ergasilids.

The migratory nature of anguillid eels and the lack of information on the host-parasite relationships of ergasilids make explanation of seasonal variation in occurrence and intensity of *E. cerastes* difficult. However, the following hypothesis concerning the life history of *E. cerastes* appears reasonable. *E. cerastes* completes 3 generations annually. Ovisacs first appear in March (water temperature ≈13° C) on overwintering third generation adults. First generation *E. cerastes* appear as adults in the summer peak (May–July) following a 12- to 16-week developmental period from egg through free-living naupliar and copepodite stages. Development time decreases with increasing water temperature. Eggs produced by the first generation hatch and reach adult stage, second generation, in late August and September, after 8–12 weeks. Eggs produced by the second generation in August and September mature to form third generation adults which overwinter and produce eggs in March. The life span of the third generation, from egg to adult, is approximately 26 weeks. Population crashes, as evidenced by the sharp decline in intensity in August and the disappearance of the parasite in April and October, indicate that *E. cerastes* die or drop off following release of nauplii. Such behavior has not been reported for species of *Ergasilus* for which there are life histories (Bauer 1959, Tedla and Fernando 1969*b*).

The gradual rise to a mid-winter peak in occurrence and subsequent decline may result from a combination of factors: 1) a slow accumulation of third generation adults developing from eggs hatched in September and October; 2) migration into and out of the sampling area of more or less heavily parasitized eels; 3) drop off or death of third generation adults after release of nauplii in March; and/or 4) sampling error. Tedla and Fernando (1969*a*) reported without explanation a similar rise in occurrence of *E. confusus* on yellow perch, *Perca flavescens*, during late winter in Lake Ontario. Investigations which may further elucidate the nature of the relationship between ergasilids and American eel are continuing.

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