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Taxonomy and Biology of North American Species of *Goezia* (Nematoda: Anisakidae) from Fishes, including Three New Species

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ABSTRACT: Three new species of *Goezia* from fishes in North America are described and supplemental data for *G. minuta* and several unidentified adults and larvae are presented. Males, especially their caudal papillae, are necessary to identify most species. For the new species, *G. pelagia* sp. n. from *Rachycentron canadum* and *Chaetodipterus faber* in the northern Gulf of Mexico possesses 12-19 preanal, two para-anal, and four postanal pairs of papillae; *G. kliksi* sp. n. from *Pogonias cromis* in Lake Borgne, Louisiana, has 10-16 preanal, two para-anal, and five postanal pairs of papillae, and *G. sinamora* sp. n. from *Tilapia aurea*, *Micropterus salmoides*, and *Morone saxatilis* in freshwater habitats in Florida possesses 13-16 preanal, two para-anal, and three postanal pairs of papillae. Records on several unidentified females without corresponding males and other assorted specimens are included to reveal a more complete understanding of hosts and localities for species of *Goezia*. Characteristics provided in a table distinguish the 18 nominal species parasitizing both fishes and aquatic reptiles throughout the world. We also provide observations on pathology, attachment, and life histories of selected species. Whereas most species of *Goezia* cause conspicuous lesions in fishes, few infected fishes are actually diseased. Also, those diseased fishes are often components of recently established host-parasite relationships.

In spite of reviews of the genus *Goezia* Zeder, 1800 by Railliet and Henry (1915), Dollfus (1935), Sprent (1978), and others, the species of this distinctive genus are incompletely known; all members have three characteristically overhung lips and plicated cuticular annulations, each possessing spines along its rear border. Herein, we describe and discuss the North American species from fishes. Previously, *G. lacerticola* Deardorff and Overstreet (1979) was reported from the American alligator in Florida which brought to three the number of species infecting crocodilians throughout the world. With the exception of *G. lacerticola*, fishes comprised the hosts for all North American reports. Two nominal species in the genus have been reported from the digestive tract of marine or estuarine fishes in North America: *G. minuta* Chandler, 1935 from a single specimen in *Bagre marinus* in Texas (Chandler, 1935) and more than one species misidentified as *G. annulata* (Molin, 1859b) from various fishes along the northeastern Atlantic seaboard (Linton, 1901, 1905; MacCallum, 1921). Rogers (1970), Ware (1971), and Gaines and Rogers (1972) reported extensive mortalities among stocked populations of the striped bass, *Morone saxatilis*, in freshwater lakes of central Florida and attributed the numerous deaths to *Goezia* sp. Other specimens also have been reported to cause extensive host-response (MacCallum, 1921).

Although *Goezia* spp. can detrimentally affect some sports and commercial fisheries, the complete life cycle of a species has not been established. Few biological data exist. Consequently, in addition to describing three new species from freshwater, estuarine, and marine hosts in North American waters and presenting supplemental data on others, we provide observations on loose and attached worms.

Materials and Methods

Most specimens we collected were removed from hosts, fixed in glacial acetic acid, stored in a solution of 5 parts glycerin and 95 parts 70% ethyl alcohol, and examined in glycerin after evaporation of the alcohol. A few others were obtained from hosts fixed in formalin and transferred to 40% isopropyl or 10% ethyl alcohol. Methods used with some loaned material are unknown; several had been permanently mounted on slides. Measurements locating the position of the nerve ring are from the anterior extremity of the worm to the center of the nerve ring. We calculated the spicule ratio as the length of the left spicule to that of the right one. Sections of attached and entire worms were stained with hematoxylin and eosin, Mason's trichome method, or other special methods (Luna, 1968) after the material had been fixed initially in buffered 10% formalin. Portions of three specimens were postfixed in osmium tetroxide, embedded in epoxy resin, sectioned with an ultramicrotome, and stained with toluidine blue. All measurements are in micrometers unless stated otherwise, and figures were drawn with the aid of a drawing tube.

Goezia Zeder

Goezia Zeder, 1800 (type-species *Culcullanus ascaroides* Goeze, 1782).

Cochlus Zeder, 1803 (type-species *Cochlus armatus* Zeder, 1803 = *G. ascaroides*).

Prionoderma Rudolphi, 1808 (type-species *P. ascaroides*).

Lecanocephalus Diesing, 1839 (type-species *L. spinulosus* Diesing, 1839).

Pseudogoezia Mozgovoi, 1951 (as subgenus of *Goezia*).

DIAGNOSIS: Body stout, reaching greatest width near midbody. Cuticle with conspicuous plicated rings; rings more compact near anterior and posterior ends of body, with maximal separation near midbody, possessing posteriorly directed spines attached to rear border; spines in rows commencing immediately posterior to cephalic constriction, close together in anterior region, longest and separated by greatest distance near midbody, present or absent in males dorsally at base of digitiform process. Lips approximately equal in size, broader than long, with prominent angulated overhang; dorsal lip with two double papillae; subventral lips each with one lateral amphid, papilla, and double papilla; pulp pedunculate, short, slightly narrower proximally, with anterior lobes bluntly rounded. Dentigerous ridges and interlabia lacking. Ventriculus nearly spherical; ventricular appendage like narrow cylinder or saclike, with septum dividing appendage into two equal longitudinal pouches; intestinal cecum shorter than ventricular appendage. Excretory system with duct extending within left lateral cord; excretory pore located near level of nerve ring. Spicules similar, alate, equal or unequal in length. Gubernaculum absent. Caudal papillae occasionally inconspicuous. Vulva usually anterior to midbody. Uteri didelphic, opisthodelphic. Ovaries and oviducts sinuous. Tail conical; tip of tail with digitiform process, terminating with or without spinous structures. Parasites of fishes and aquatic reptiles.

TYPE SPECIES: *Goezia ascaroides* (Goeze, 1782).

Remarks

Goezia was erected by Zeder (1800) for *G. ascaroides* Goeze, 1782. Railliet and Henry (1915) reviewed the genus and added *G. spinulosa* (Diesing, 1839), *G.*

kollari (Molin, 1859a) and *G. annulata* (Molin, 1859b); those latter species were transferred from the genus *Lecanocephalus* Diesing, 1839. Baylis (1920), unaware of a similar action by Travassos (1920), proposed Goeziinae as a subfamily of Ascaridae and recognized a close relationship of *Goezia* to *Contracaecum* Railliet and Henry, 1912 because members of both possessed a ventricular appendage and an intestinal cecum. Later, Yorke and Maplestone (1926) considered Goeziinae in the family Heterocheilidae. Dollfus (1935) critically reviewed the history of the genus and differentiated the six known species. Subsequently, Skrjabin and Karochin (1945) erected Goeziidae with *Goezia* as the only genus, a view supported by Hartwich (1954). Mozgovoi (1951) proposed the subgenus *Pseudogoezia* for *G. sigalasi* Stefanski, 1938 and *G. fluviatilis* Johnston and Mawson, 1940 because each possessed a double ventricular appendage. Both Hartwich (1957) and Rasheed (1965), however, doubted the validity of the subgenus *Pseudogoezia*, a view we support because all species of *Goezia* probably possess a bicylindrical ventricular appendage.

Mozgovoi (1951) considered *Neogoezia* Kreis, 1937 a junior synonym of *Goezia*. Hartwich (1957) and Yamaguti (1961) emphasized that *Neogoezia* should not be placed in Goeziidae since its members lacked characteristic features. We also agree with that action, even though Rai (1967, 1971) also considered *Neogoezia* a synonym of *Goezia*. Until the ascaridoid classification is critically reviewed, we follow Hartwich (1974 rather than 1975), and recognize *Goezia* in the family Anisakidae.

Rasheed (1965) listed 11 species in the genus and suggested that *G. onchorynchi* Fujita, 1940 be regarded a species *incertae sedis* until adult specimens are described. Table 1 updates that list and provides a means for comparisons with species we describe.

Goezia pelagia sp. n.

(Figs. 1–7, 37–38)

DESCRIPTION: Body reaching greatest width about $\frac{1}{3}$ body length from posterior end. Spines longest and separated by greatest distance toward end of anterior $\frac{1}{4}$ of body. Esophagus clavate, 10–17% of body length. Ventriculus narrower than widest level of esophagus, generally broader than long. Nerve ring located within anterior 22–32% of esophagus. Lateral cords salient, T-shaped anteriorly, taller than wide. Excretory system apparently similar to that in specimens from *Tilapia aurea* described later. Excretory pore slightly anterior to or at level of nerve ring. Tail conical, with digitiform process; process usually with circlet of spinous structures. Phasmids conspicuous near base of digitiform process.

MALE (based on 4 mature specimens for postcloacal papillae and 17 for most other described characters): Body 3.4–12.0 mm long by 0.4–1.0 mm at greatest

→

Figures 1–7. *Goezia pelagia*. 1. Anterior end of female including intestinal cecum and ventricular appendage, lateral view. 2. Posterior end of male showing postanal papillae and conspicuous phasmids, ventral view. 3. Atypical digitiform process of female tail, lateral view. 4. Digitiform process of female tail, lateral view. 5. *En face*. 6. Posterior end of male, ventral view. 7. Female tail, lateral view.

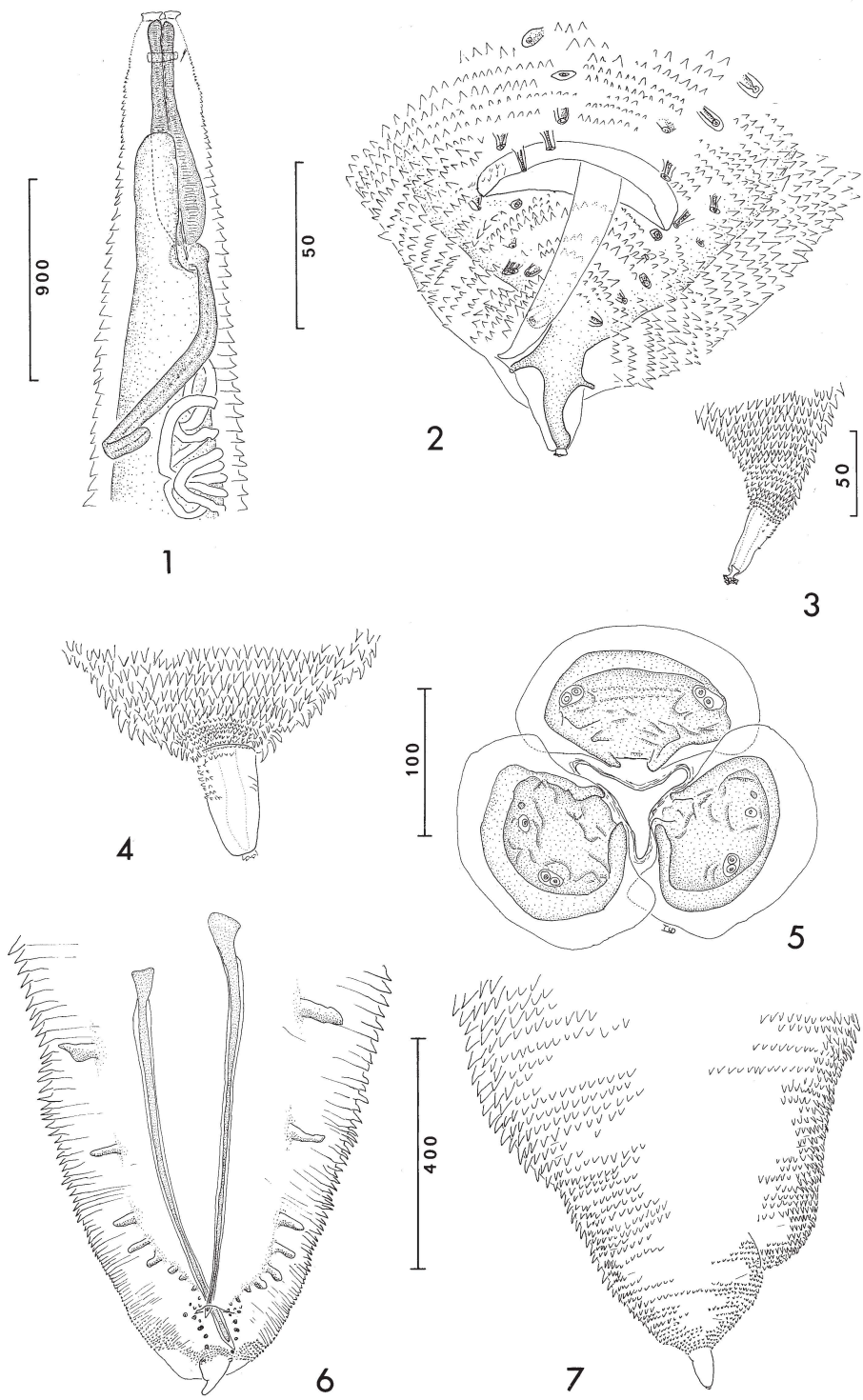


Table 1. Nominal species of *Goezia* parasitizing fishes and aquatic reptiles of the world.

Species	Type host	Type locality	Number of anal papillae pairs			Length ratio IC:VA
			pre	post	para	
<i>G. annulata</i> (Molin, 1859)	<i>Morone labrax</i> ^a	Trieste, Italy ^b	—	—	—	—
^d <i>G. ascaroides</i> (Goeze, 1782)	<i>Silurus glanis</i> ^a	Europe ^c	—	—	—	—
<i>G. fluviatilis</i> Johnston and Mawson, 1940	^{f,g}	Tailem Bend, South Australia	5	3 ^h	3	1:3.9
<i>G. gavialidis</i> Maplestone, 1930	<i>Gavialis gargeticus</i>	Calcutta, India		Male unknown		1:1–7.5
<i>G. holmesi</i> Sprent, 1978	<i>Crocodylus porosus</i> ^a	Liverpool River, Northern Australia	5	3	5	1:2.8–8.6
<i>G. intermedia</i> Rasheed, 1965	<i>Cichla ocellaris</i>	Georgetown, British Guiana	22–23	4	0	1:4–7
ⁱ <i>G. kiksi</i> sp. n.	<i>Pogonias cromis</i>	Lake Borgne, Louisiana	10–16	5	2	1:1.9–3.3
<i>G. kollari</i> (Molin, 1859)	<i>Chrysophrys aurata</i>	Europe	—	—	—	—
ⁱ <i>G. lacerticola</i> Deardorff and Overstreet, 1979	<i>Alligator missis- sippiensis</i>	Lake Apopka, Florida	22–26	4 ^j	2	1:2.1–4.6
^{d,i} <i>G. minuta</i> Chandler, 1935	<i>Bagre marinus</i> ^a	Galveston Bay, Texas	16	4 ^b	2 ^j	1:4.4
<i>G. nankingensis</i> Hsü, 1933	^{f,k}	Nankin, Peoples Republic of China	6–7	3–4	3	—
ⁱ <i>G. oncorhynchi</i> Fujita, 1940	<i>Oncorhynchus keta</i>	Mashike, Japan				Adults unknown
ⁱ <i>G. pelagia</i> sp. n.	<i>Rachycentron can- adum</i>	Off Alabama Point in Gulf of Mexico	12–19	4 ^j	2	1:2.0–4.4
<i>G. pseudoascaroides</i> Rehana and Bilqees, 1972	<i>Mustacembelus pancalus</i>	Kalri Lake, W. Pakistan	29	2	0	—
<i>G. sigalasi</i> Stefanski, 1938	<i>Trachinus draco</i>	Aquarium in Brazil	9 ^m	2	0	1:3.3–3.7
ⁱ <i>G. sinamora</i> sp. n.	<i>Tilapia aurea</i>	Lake Parker, Florida	13–16	3 ^j	2	1:1.6–5.0
^d <i>G. spinulosa</i> (Diesing, 1839)	<i>Arapaima gigas</i> ^a	Brazil	13 ⁿ	6	2	1:1.5–5.3
<i>G. tricirrata</i> Osmanov, 1940	<i>Onos tricirrata</i> ^a	Black Sea	—	—	—	1:2.1–2.5

^a Other hosts listed in same or subsequent reports.^b See our text for data on other material.^c See discussion in text.^d Based entirely on holotype.^e Additional localities listed in subsequent reports.^f No type host designated.^g Hosts: *Nannoperca australis*, *Tandanus tandanus*, *Morgunda adspersa*, *Mc-
Cullochella macquariensis*, *Percalates colonorum*, and *Plectroplites ambiguus*.^h Four postanal papillae illustrated.ⁱ Indicates confirmation by authors.^j Double papillae present.^k Hosts: *Psephurus gladium*, *Leiocassis longirostris*, and *Parasilurus asotus*.^l Based on larval specimen.^m Ten preanal papillae illustrated.ⁿ Numerical values from Santos et al. (1979). We estimated proportional data by com-
paring largest and smallest values in their ranges.

Table 1. Continued.

Species	Spicules		Body length in mm	Esophagus as % of body length	Important reference
	% of body length	Length ratio left:right			
<i>G. annulata</i> (Molin, 1859)	—	—	3–4 ^b	—	Molin (1859b) ^c
^a <i>G. ascaroides</i> (Goeze, 1782)	—	—	18.4	8.1	Dollfus (1935), Khan and Yaseen (1964), Rasheed (1965)
<i>G. fluviatilis</i> Johnston and Mawson, 1940	10–22	1:1.0	2–6	13.6–17.0	Johnston and Mawson (1940)
<i>G. gavialidis</i> Maplestone, 1930	—	—	6.6	11.3	Maplestone (1930)
<i>G. holmesi</i> Sprent, 1978	7–12	1:1.0	2.6–6.7	10.4–14.2	Sprent (1978)
<i>G. intermedia</i> Radheed, 1965	3–4	1:1.1	9–15.5	9.6–10.9	Rasheed (1965)
¹ <i>G. kliksi</i> sp. n.	8–14	1:1.0–1.2	6–14	8–10	This paper
<i>G. kollari</i> (Molin, 1859)	—	—	8–11	—	Dollfus (1935), Molin (1859a)
¹ <i>G. lacerticola</i> Deardorff and Overstreet (1979)	8–16	1:0.8–1.0	3.9–8.2	7–15	Deardorff and Overstreet (1979)
^{d,1} <i>G. minuta</i> Chandler, 1935	11	—	3.1 ^b	10	Chandler (1935), this paper
<i>G. nankingensis</i> Hsü, 1933	—	1:1.0	5.5–9.3	7.6–8.2	Hsü (1933)
¹ <i>G. oncorhynchi</i> Fujita, 1940	—	—	—	—	Fujita (1940)
¹ <i>G. pelagia</i> sp. n.	6–10	1:0.9–1.1	3.4–14.5	10–17	This paper
<i>G. pseudoascaroides</i> Rehana and Bilqees, 1972	—	—	3.6–7.8	11–15	Bilqees et al. (1972)
<i>G. sigalasi</i> Stefanski, 1938	10–20	1:0.83	2.8–6.1	13.7–20.8	Stefanski (1938)
¹ <i>G. sinamora</i> sp. n.	4–20	1:0.7–1.3	1.4–16.0	8–18	This paper
^a <i>G. spinulosa</i> (Diesing, 1839)	3	1:1.0	16.3–24.8	3.1–8.7	Baylis (1927), Freitas and Lent (1946), Rasheed (1965), Santos et al. (1979)
<i>G. tricirrata</i> Osmasnov, 1940	11	1:1.0	6–7	12.5–21.0	Osmasnov (1940), Pogorel'tseva (1952), Dolgikh and Naidenova (1968)

width; ratio of greatest width to length 1:8–13. Cuticular spines absent dorsally from base of digitiform process to immediately anterior to spicules and ventrally near mucron. Lips 31–48 long by 74–125 wide. Nerve ring 192–309 from anterior extremity, 14–36 in breadth. Esophagus 0.4–1.0 mm long by 116–271 wide. Ventriculus 41–105 long by 67–210 wide; ventricular appendage 0.8–2.2 mm long by 49–117 wide. Intestinal cecum 327–961 long by 92–203 wide; ratio of cecal to appendage lengths 1:1.4–3.8; ratio of cecal to esophageal lengths 1:1.0–2.0. Spicules 6–10% of body length, equal in length in 7 of 16 specimens; right spicule 800–980 long averaging 877, 9–24 wide; left spicule 800–980 long averaging 861, 12–24 wide, longer than right one in 2 specimens; spicule ratio 1:0.9–1.1. Caudal papillae 18–25 pairs, preanal pairs 12–19 in J-shaped pattern, becoming closer together and more medial when approaching anus except for posterior 3 extending laterally; postanal pairs 4, with 3rd pair from posterior end double and slightly lateral to others (one apparent atypical specimen with 4 single papillae); para-anal pairs 2. Posterior end of worm flexed ventrad; tail 84–120 long including digitiform process 21–48 long, usually terminating with 4–6 minute spinous structures; structures occasionally absent.

FEMALE (based on 29 mature specimens): Body 3.6–14.5 mm long by 0.3–1.3 mm at greatest width; ratio of greatest width to length 1:7.0–16.0. Lips 26–78 long by 81–142 wide. Nerve ring 108–364 from anterior extremity, 21–49 in breadth. Esophagus 0.5–1.3 mm long by 79–346 wide. Ventriculus 50–129 long by 67–216 wide; ventricular appendage 0.6–2.3 mm long by 41–135 wide. Intestinal cecum 247–788 long by 101–409 wide; ratio of cecal to appendage lengths 1:2.2–4.4; ratio of cecal to esophageal lengths 1:1.4–3.0. Vulva without salient lips, opening 1.2–7.0 mm or 29–55% of body length from anterior extremity. Ovaries and oviducts directed posteriad, nearly reaching tail, usually occupying posterior $\frac{1}{3}$ of body. Eggs with smooth thin shell, spherical, 25–35 in diameter. Tail 108–284 long including stout digitiform process 14–111 long, usually terminating with 3–6 minute spinous structures; structures occasionally with 3 clove-like projections or absent.

TYPE HOST: *Rachycentron canadum* (Linnaeus), cobia (Rachycentridae).

OTHER HOSTS: *Chaetodipterus faber* (Broussonet), Atlantic spadefish (Ephippidae); nonparatypes from *Ophichthus* sp. being described by Böhlke and Caruso (Academy of Natural Sciences of Philadelphia No. 143071).

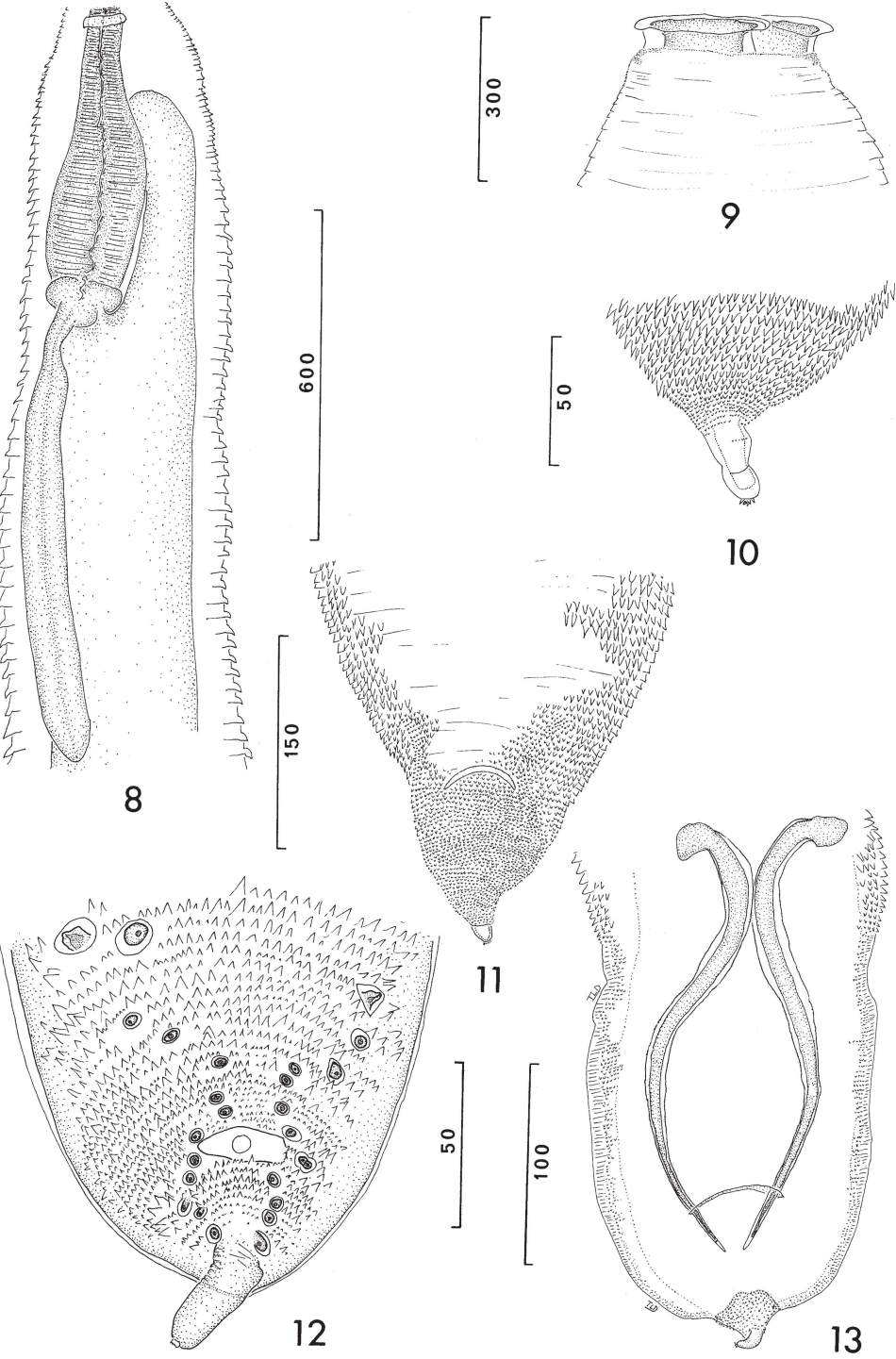
SITES OF INFECTION: Embedded in wall and free in lumen of stomach.

LOCALITIES: Offshore from Alabama Point, Alabama (type locality); Mississippi Sound, Mississippi; and Louisiana in Gulf of Mexico.

SPECIMENS DEPOSITED: Holotype, male, USNM Helm. Coll. No. 75680; allotype, female, No. 75681; paratypes, No. 75682 (pair), British Museum (Natural History) Reg. No. 1980.81–82.

ETYMOLOGY: The Latin *pelagia* refers to the habitat of the host.

COMPARISONS: Of the North American species, *Goezia pelagia* has an arrangement of preanal papillae with the most prominent recurvature posteriorly. By possessing four postanal papillae, it closely resembles *G. minuta*, *G. intermedia*, *G. nankingensis*, and *G. lacerticola*. It differs from the first three in having the third pair of postanal papillae from the posterior end doubled. In addition, *G. pelagia* differs from *G. minuta* by having more conspicuous phasmids and lacking a double para-anal papilla and differs from *G. intermedia* and *G. nankingensis* in the number of pre- and para-anal papillae (for actual values of characters,



Figures 8–13. *Goezia minuta* from catfish. 8. Anterior end including intestinal cecum and ventricular appendage. 9. Lateral view of ventral lips. 10. Digitiform process of female tail, lateral view. 11. Female tail, ventral view. 12. Posterior end of male showing postanal papillae, holotype, ventral view. 13. Posterior end of male, ventral view.

consult Table 1). *Goezia lacerticola* has a doubled third pair of postanal papillae, but *G. pelagia* differs from it most conspicuously by having a more extensive projection of the somatic musculature and lateral cords into the pseudocoel (Figs. 37–38 and Deardorff and Overstreet, 1979). *Goezia lacerticola* has been reported from an alligator in a freshwater lake only.

***Goezia minuta* Chandler**
(Figs. 8–19)

Goezia minuta Chandler, 1935.

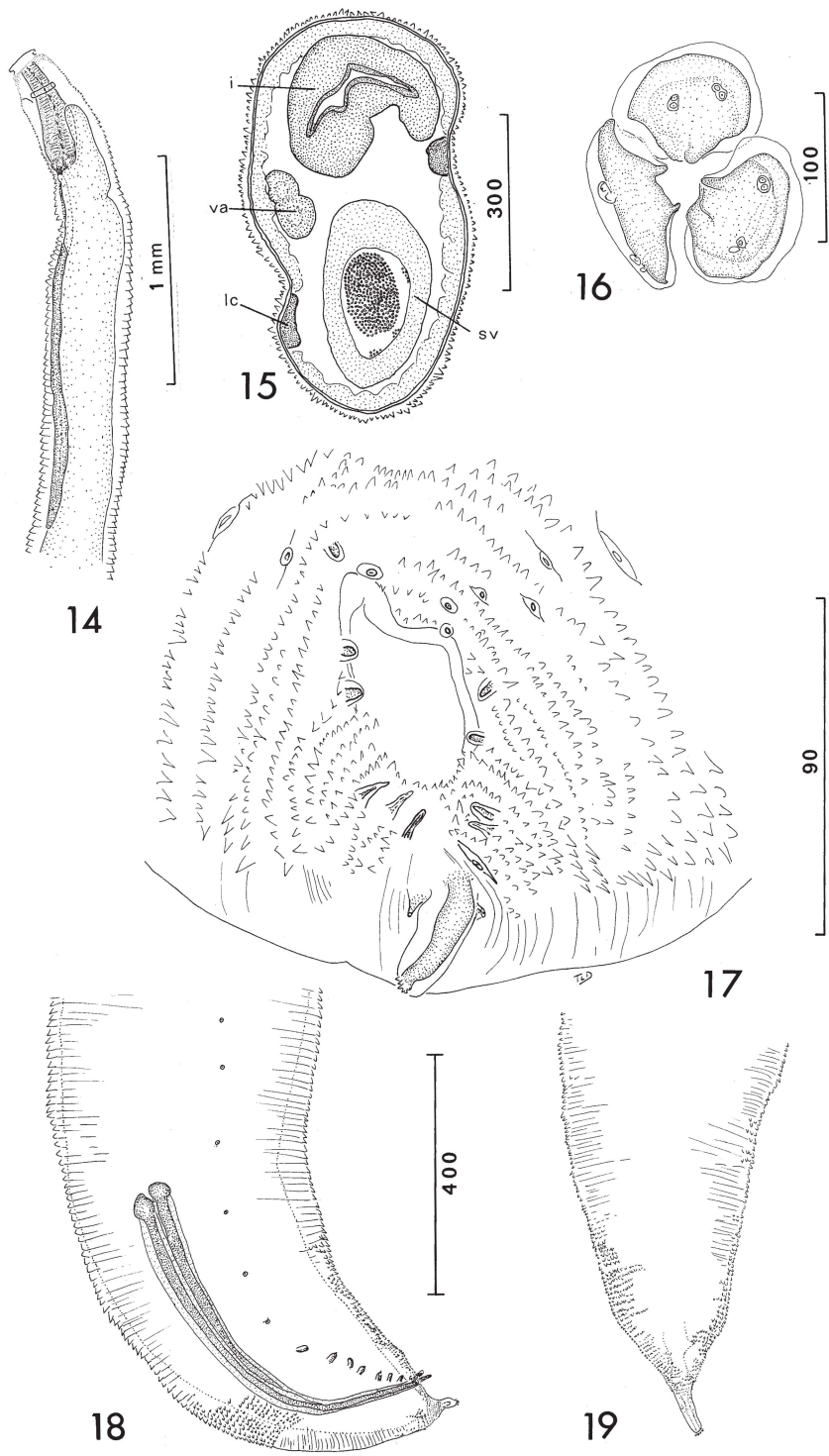
REDESCRIPTION (based on specimens from *Bagre marinus* and *Arius felis*; measurements of holotype in parentheses): Body reaching greatest width about $\frac{1}{3}$ body length from posterior end. Spines longest and separated by greatest distance toward end of anterior $\frac{1}{4}$ of body. Esophagus clavate, 15–17% (10%) of body length. Ventriculus narrower than widest level of esophagus, generally broader than long. Nerve ring located within anterior 30–35% of esophagus. Excretory pore not visible. Tail conical, with digitiform process; process with circlet of spinous structures. Phasmids usually inconspicuous.

MALE (based on 3 specimens for most characters): Body 2.9–3.6 (3.1) mm long by 379–457 (300) at greatest width; ratio of greatest width to length 1:7.8–7.9 (10.1). Cuticular spines absent dorsally from base of digitiform process to just anterior of cloacal papillae. Lips 24–36 (36) long by 77–90 (79) wide. Nerve ring 156–195 (132) from anterior extremity, 36 (92) in breadth. Esophagus 463–550 (321) long by 166–185 (92) wide. Ventriculus 60–74 (43) long by 86–120 (24) wide; ventricular appendage 321–346 (850) long by 80–111 wide. Intestinal cecum 290–364 (192) long by 55–117 (154) wide; ratio of cecal to ventricular appendage lengths 1:0.9–1.1 (4.4); ratio of cecal to esophageal lengths 1:1.5–1.6 (1.6). Spicules equal, 6–17% (11.1) of body length, right spicule 220–494 (346), left spicule 220–494 (broken); spicule ratio 1:1.0. Caudal papillae difficult to discern (preanal pairs 16; para-anal pairs 2, lower papilla on left side double; postanal pairs 4). Posterior end of body flexed ventrad; tail 155–160 (69) long including digitiform process 43 (26) long, terminating with 6 minute spinous structures.

FEMALE (based on 3 mature specimens): Body 2.0–3.6 mm long by 370–543 at greatest width; ratio of greatest width to length 1:5.4–6.6. Lips 26–31 long by 57–72 wide. Nerve ring 103 from anterior extremity, 37 in breadth. Esophagus 339–587 long by 93–160 wide. Ventriculus 36–55 long by 86–117 wide; ventricular appendage 438–918 long by 24–80 wide. Intestinal cecum 142–376 long by 79–105 wide; ratio of cecal to ventricular appendage lengths 1:2.4–3.0; ratio of cecal to esophageal lengths 1:1.5–2.3. Vulva without salient lips, opening 525–898 or 26–37% of body length from anterior extremity. Ovaries rarely extending beyond anterior level of vulva, nearly reaching tail, usually occupying posterior $\frac{1}{3}$ of body. Eggs with smooth thin shell, spherical, 21–35 in diameter. Tail 96–247 long

→

Figures 14–19. *Goezia minuta* from inshore lizardfish. 14. Anterior end including intestinal cecum and ventricular appendage. 15. Cross section through posterior portion of ventricular appendage. 16. *En face*. 17. Posterior end of male, ventral view; poor quality of worm may have obscured one pair of postanal papillae. 18. Posterior end of male, lateral view. 19. Female tail, lateral. i: intestine; lc: lateral cord; sv: seminal vesicle; va: ventricular appendage.



including stout digitiform process 31–41 long, terminating with 6 minute spinous structures.

TYPE HOST: *Bagre marinus* (Mitchill), gafftopsail catfish (Ariidae).

OTHER HOSTS: *Arius felis* (Linnaeus), sea catfish (Ariidae); *Synodus foetens* (Linnaeus), inshore lizardfish (Synodontidae).

SITES OF INFECTION: Embedded in wall and free in lumen of stomach.

LOCALITIES: Galveston Bay, Texas (type locality); Gulf of Mexico offshore from Empire, Louisiana (sea catfish); Buttonwood Canal, Everglades National Park, Florida (inshore lizardfish).

SPECIMENS DEPOSITED: Holotype, male, USNM Helm. Coll. No. 39542; other material, USNM Helm. Coll. No. 75687, 3 slides (gafftopsail catfish); No. 75688 (sea catfish); No. 75686, 1 pair and 1 tail mount (lizardfish); Queensland Museum, Brisbane, Australia. SC4041, 2 pairs (lizardfish).

COMPARISONS: The arrangement and number of pairs of caudal papillae, 13–16 preanal, two para-anal (the lower papilla on the left side is double on the holotype), and four postanal (note discussion below about specimens from lizardfish), distinguishes this species.

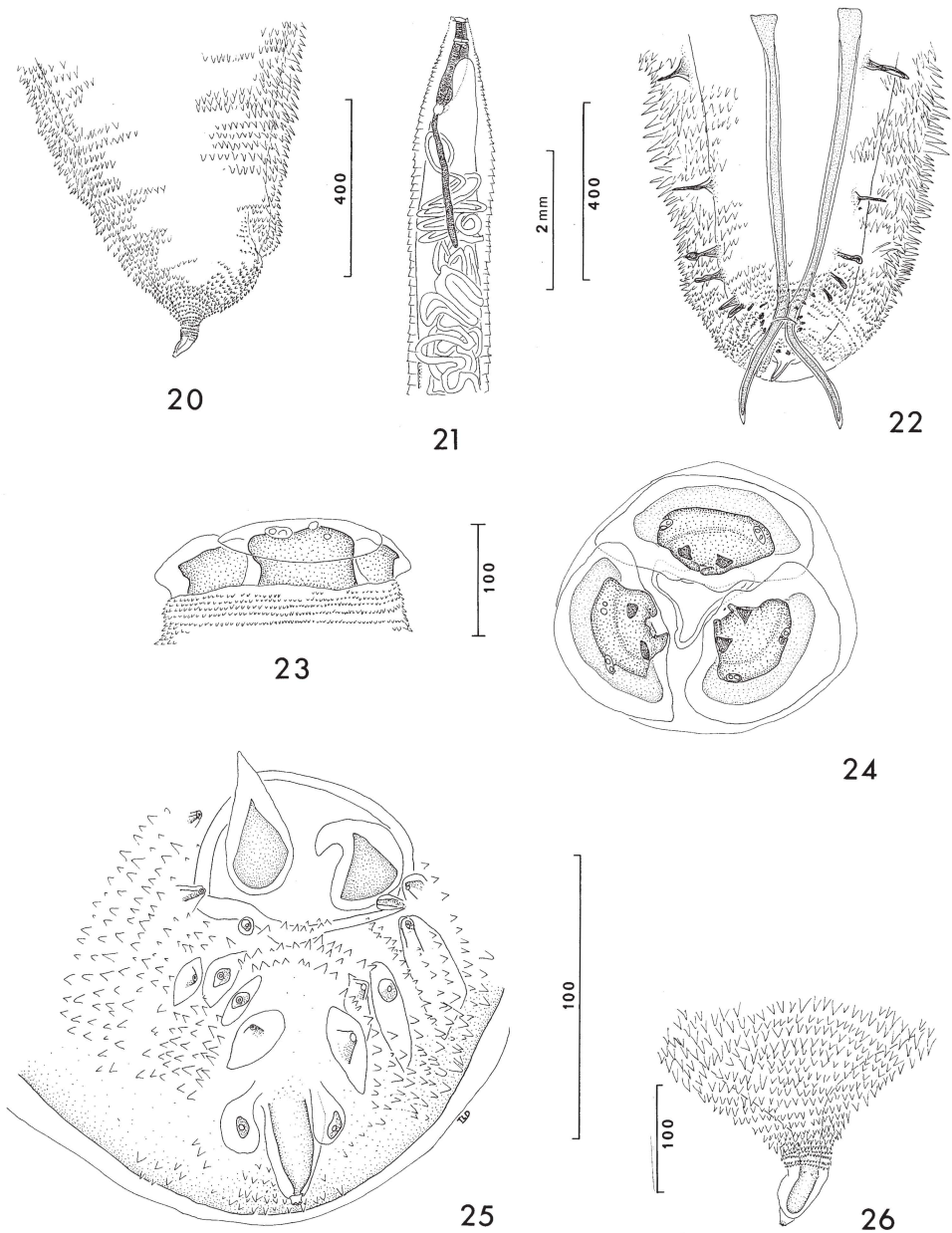
Remarks

The incomplete original description (Chandler, 1935), based entirely on the holotype from Texas, did not include the number or distribution of the characteristic caudal papillae. Chandler's illustration of the posterior end of the male is a dorsal view and shows the length of the spicules unequal rather than equal as stated in the description. The right spicule of the holotype is broken. Some specimens used in the redescription were provided by Pence and were in poor condition. After several attempts, we have been unable to collect additional specimens from marine catfishes.

We, however, critically examined 10 female (3.0–7.0 mm long) and six male (3.6–7.0 mm long) specimens from *Synodus foetens* that were fixed in situ with formalin, followed by storage in 40% isopropyl alcohol. Most are representative specimens of those reported by Overstreet (1968). Many features of those worms measured longer than the counterparts in shorter catfish material, but we nevertheless consider them conspecific and provide the following values and Figures 14–19 in case further investigation shows our identification to be wrong or variation to be host-induced. Some specimens had a different ratio of body width to length (1:6–16), ratio of cecal to ventricular appendage lengths (1:2.6–8.0), and ratio of cecal to esophageal lengths (1:1.7–3.0). The vulva opened 33–63% of the body length from the anterior extremity. The actual constant or variable number of postanal papillae could not be confirmed because of the moderate quality of the specimens. Nevertheless, there appears to be three or four pairs of such papillae. The number of preanal papillar pairs (17–20) and the spicule measurements (13–19% of body length; ratio of left to right one 1:0.9–1.0) compared well with values for catfish worms.

Goezia kliksi sp. n. (Figs. 20–26)

DESCRIPTION: Body reaching greatest width about $\frac{1}{3}$ body length from posterior end. Spines longest and separated by greatest distance toward end of an-



Figures 20–26. *Goezia kliksi*. 20. Female tail, allotype, ventral view. 21. Anterior end including intestinal cecum and ventricular appendage, holotype. 22. Posterior end of male, paratype, ventral view. 23. Lateral view of ventral lips. 24. *En face*. 25. Posterior end of male showing postanal papillae, ventral view. 26. Digitiform process of female tail, allotype, lateral view.

terior ¼ of body. Esophagus clavate, 8–10% of body length. Ventriculus narrower than widest level of esophagus, generally broader than long. Nerve ring located within anterior 24–31% of esophagus. Excretory pore not visible. Tail conical, with digitiform process; process with circlet of spinous structures. Phasmids usually conspicuous near base of digitiform process.

MALE (based on 4 mature specimens and 1 tail fragment for papillae and 5 for most described characters): Body 6.0–14.0 mm long by 0.9–1.5 mm at greatest width; ratio of greatest width to length 1:7–11. Cuticular spines absent dorsally from base of digitiform process to posterior extremity of intestine. Lips 37–61 long by 123–160 wide. Nerve ring 309 from anterior extremity, 31–43 in breadth. Esophagus 0.8–1.3 mm long by 154–339 wide. Ventriculus 135–142 long by 154–228 wide; ventricular appendage 1.3–1.8 mm long by 49–92 wide. Intestinal cecum 472–835 long by 123–339 wide; ratio of cecal to appendage lengths 1:1.9–3.3; ratio of cecal to esophageal lengths 1:1.4–1.6. Spicules 8–14% body length, equal in length in 3 of 5 specimens; right spicule 0.8–1.2 mm long by 24–36 wide, longer than left one in 2 specimens; left spicule 0.8–1.2 mm long by 24–36 wide; spicule ratio 1:1.0–1.2. Caudal papillae 17–23 pairs, becoming closer and more medial when approaching anus; preanal pairs 10–16, 1 specimen with a double papilla at number 12 from posterior end; postanal pairs 5; para-anal pairs 2. Posterior end of worm flexed ventrad; tail 105–129 long including digitiform process 36–43 long, usually terminating with 4–6 minute spinous structures.

FEMALE (based on 1 mature specimen): Body 8.0 mm long by 1.0 mm at greatest width; ratio of greatest width to length 1:8. Lips 122 wide. Esophagus 0.8 mm long by 247 wide. Ventriculus 92 long by 154 wide; ventricular appendage 1.2 mm long by 61 wide. Intestinal cecum 537 long by 61 wide; ratio of cecal to appendage lengths 1:2.2; ratio of cecal to esophageal lengths 1:1.5. Vulva not visible. Ovaries directed posteriad, nearly reaching tail, occupying posterior $\frac{1}{3}$ of body. Eggs with smooth thin shell, spherical, 25–35 in diameter. Tail 315 long including stout digitiform process 74 long terminating with apparently 6 spinous structures.

TYPE HOST: *Pogonias cromis* (Linnaeus), black drum (Sciaenidae).

SITES OF INFECTION: Embedded in wall and free in lumen of stomach.

TYPE LOCALITY: Lake Borgne, Louisiana.

SPECIMENS DEPOSITED: Holotype, male, USNM Helm. Coll. No. 75689; allotype, female, No. 75690; paratypes, 1 entire male No. 75691, glycerin jelly mount of tail No. 75691.

ETYMOLOGY: The specific name *kliksi* honors Dr. Michael Kliks, presently of Wisconsin Medical College, for his aid and his interest in our study and the genus *Goezia*.

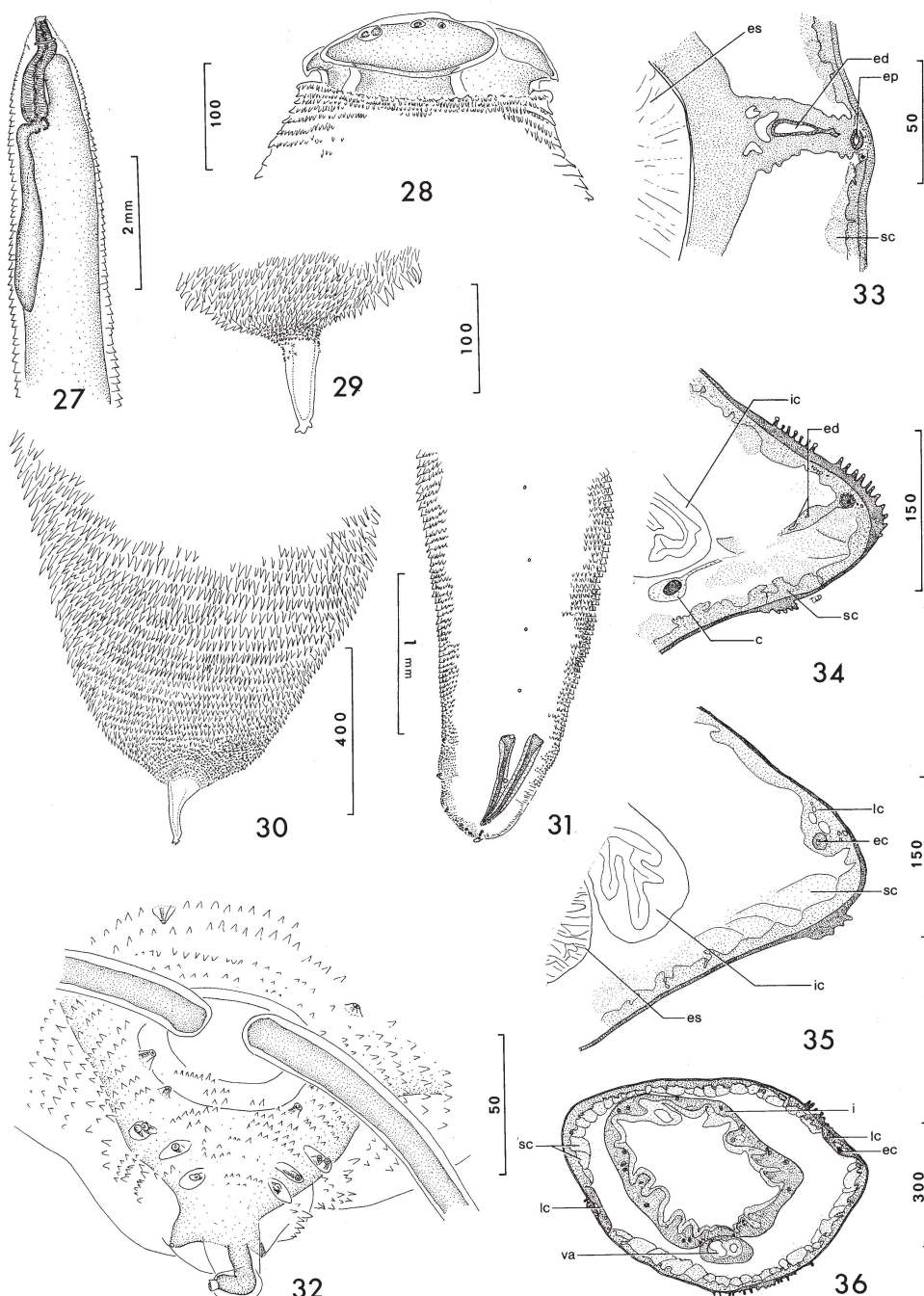
COMPARISONS: The primary distinguishing characteristic of *Goezia kliksi* is the presence of five single pairs of postanal papillae. The species is most similar to *G. pelagia*, which has four pairs of postanal papillae, one of them doubled, and a more arcuate arrangement of the most posterior three preanal papillar pairs.

Goezia sinamora sp. n.

(Figs. 27–36)

Goezia sp. Rogers, 1970; Ware, 1971; Gaines and Rogers, 1972.

DESCRIPTION: Body reaching greatest width about midbody. Spines longest and separated by greatest distance toward end of anterior $\frac{1}{4}$ of body. Esophagus clavate, 8–18% of body length. Ventriculus narrower than widest portion of esophagus, generally broader than long. Nerve ring located within anterior 17–29% of esophagus. Lateral cords short and inconspicuous in cross section. Excretory pore immediately anterior to or at level of nerve ring; excretory system



Figures 27–36. *Goezia sinamora*. 27. Anterior end including intestinal cecum and ventricular appendage. 28. Lateral view of ventral lip. 29. Digitiform process of female tail, ventral view. 30. Female tail, ventral view. 31. Posterior end of male, lateral view. 32. Posterior end of male showing postanal papillae, ventral view. Figures 33–35. Cross sections showing excretory system. 33. Excretory duct in ventral cord and excretory “pore” immediately before opening. 34. Excretory canal in left lateral cord at level of intestinal cecum (Fig. 35) and ventricular appendage (Fig. 36). c: excretory cell; ec: excretory canal; ed: excretory duct; ep: excretory pore; es: esophagus; i: intestine; ic: intestinal cecum; lc: lateral cord; sc: somatic muscle cell; and va: ventricular appendage.

with duct extending mesially from pore to single cell body; cell body free in pseudocoel, located adjacent to intestinal cecum; excretory canal joining excretory duct at approximately duct midpoint, extending posteriorly along left lateral cord to at least beyond midbody (posterior of worm not sectioned), approximately 12 in diameter along entire length. Tail conical, with digitiform process; process with or without spinous structures. Phasmids conspicuous near base of digitiform process.

MALE (based on 5 mature specimens for postanal papillae and on 19 for most other characters): Body 4.4–13 mm long by 0.5–1.5 mm at greatest width; ratio of greatest width to length 1:5.8–9.1. Cuticular spines absent dorsally from base of digitiform process to middle of retracted spicules. Lips 26–67 long by 166 wide. Nerve ring 203–284 from anterior extremity, 16–78 in breadth. Esophagus 0.6–1.1 mm long by 166–346 wide. Ventriculus 61–141 long by 67–236 wide; ventricular appendage 0.8–2.6 mm long by 43–250 wide. Intestinal cecum 296–819 long by 191–401 wide; ratio of cecal to ventricular appendage lengths 1:1.6–5.0; ratio of cecal to esophageal lengths 1:1.4–2.2. Spicules 4–20% of body length; right spicule 0.5–1.0 mm long by 12–37 wide; left spicule 0.5–1.1 mm long by 12–37 wide; spicule ratio 1:0.7–1.3. Caudal papillae 18–21 pairs; preanal pairs 13–16; para-anal pairs 2; postanal pairs 3, with 3rd pair from posterior end double. Tail flexed ventrad, 90–362 long including digitiform process 24–92 long, terminating with or without circlet of minute spinous structures.

FEMALE (based on 14 mature specimens): Body 5.7–16.0 mm long by 0.7–1.8 mm at greatest width; ratio of greatest width to length 1:6.0–11.0. Lips 31–61 long by 120–166 wide. Nerve ring 143–321 from anterior extremity, 36–67 in breadth. Esophagus 0.8–1.4 mm long by 185–395 wide. Ventriculus 61–267 wide; ventricular appendage 1.5–3.2 mm long by 43–267 wide. Intestinal cecum 0.3–1.0 mm long by 247–583 wide; ratio of cecal to ventricular appendage lengths 1:1.9–3.3; ratio of cecal to esophageal lengths 1:0.7–3.2. Vulva without salient lips, opening 3.0–3.4 mm or 42–43% of body length from anterior extremity. Eggs nearly spherical, 31–69 in diameter. Tail 154–300 long including digitiform process 37–129 long, terminating with circlet of 6 minute spinous structures.

TYPE HOST: *Tilapia aurea* (Steindachner), blue tilapia (Cichlidae).

OTHER HOSTS: *Micropterus salmoides* (Lacépède), largemouth bass (Centrarchidae); *Morone saxatilis* (Walbaum), striped bass (Percichthyidae).

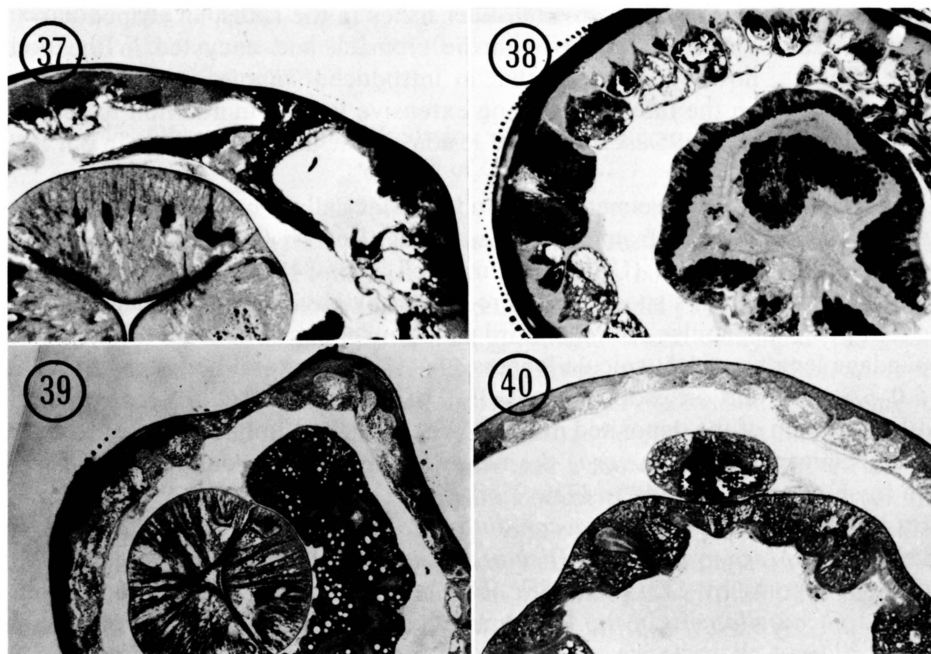
SITES OF INFECTION: Embedded in wall and free in lumen of stomach.

LOCALITIES: Lake Parker, Polk County, Florida (type); Busch Gardens, Tampa, Florida.

SPECIMENS DEPOSITED: Holotype, male, USNM Helm. Coll. No. 75683; allotype, female, No. 75684; paratypes, No. 75685 (pair).

ETYMOLOGY: The Greek *sinamora* means “injurious” and refers to the ability of the species to harm some hosts.

COMPARISONS: The primary diagnostic feature of this species is the combination of 13–16 preanal, two para-anal, and three postanal pairs of papillae with the third pair from the posterior end doubled. On the basis of the number of preanal papillae, *Goezia sinamora* most closely resembles *G. minuta*, *G. kliksi*, and *G. pelagia*, all American species. *Goezia sinamora* differs from *G. minuta* by possessing a pair of doubled postanal papillae and from *G. kliksi* and *G. pelagia* in number of postanal papillae. Based on presence of the single specifi-



Figures 37–40. Figures 37–38. 37. Cross sections of *Goezia pelagia*. Esophageal level immediately posterior to nerve ring showing lateral cord with included nerve tissue. 38. Intestinal level immediately below level of ventricular appendage. Note tall lateral cords and tall somatic musculature; intestine is typically irregular. Figures 39–40. Cross sections of *G. sinamora*. 39. Esophageal level immediately posterior to nerve ring with intestinal cecum shown in figure. Note the nonprojecting lateral cords. 40. Intestinal level showing distal portion of ventricular appendage. Note short somatic cells relative to the tall ones in Figure 38. (Lateral cord not shown.)

cally located pair of double postanal papillae, *G. sinamora* most closely resembles *G. pelagia*; however, it additionally differs from that species by having shorter lateral cords, shorter somatic musculature, and a more circular gut lumen in cross section (Figs. 37–40). This latter feature, however, may be a transitory condition.

Remarks

Although numerous specimens were obtained from fish in the fresh water of Lake Parker, the parasite was suspected by Gaines and Rogers (1972) as probably introduced from larvae in marine herring used to feed hatchery-reared striped bass. The worm occurred only in Lake Hollingsworth, Lake Parker, Lake Hunter, and Lake Bentley; those lakes were all stocked with striped bass from Richloan State Hatchery. According to Ware (personal communication) who was involved in the work, a misunderstanding occurred. Rather than being fed blueback herring, *Alosa aestivalis*, from the St. John's River system, the hatchery-reared striped bass were fed, and were probably infected from eating gizzard shad, *Dorosoma cepedianum*, caught directly from Lake Parker. Consequently, rather than being introduced into the four lakes, the nematode probably was already established in and restricted to those lakes.

According to Rogers (personal communication), *G. sinamora* commonly in-

fected striped bass as well as several other fishes in the lakes. In striped bass, a few individual worms passed through the stomach and encysted in the body cavity. Rogers, however, noticed that in introduced *Tilapia aurea*, the worm penetrated through the intestine causing extensive lesions in addition to forming nodules in the stomach. Descriptions of lesions in the stomach appear in our later section on biology.

A male and female specimen deposited by MacCallum on 1 July 1911 as *Lecanocephalus annulatus* from *Morone saxatilis* (*Roccus lineatus*) in the United States National Museum (USNM Helm. Coll. No. 34538) appeared to be *G. sinamora*. MacCallum's specimens were similar by having two para-anal papillae and four postanal papillae, with the third pair double; a ratio of cecal to ventricular appendage lengths of 1.5; spicule lengths 11–15% of the total body length, which is 6.0–6.5 mm; and an esophagus 12–13% of the body length. Because of the brittle condition of the deposited male, we could confirm only 11 preanal papillae. If the specimen is *G. sinamora*, the range of the species would extend at least from fresh water of Florida to New York.

By today's standards, *Goezia annulata* was inadequately described by Molin (1859a) from *Morone labrax* (= *Dicentrarchus l.*) offshore from Trieste, Italy; additional reports by Stossich (1887, 1898), Sonsino (1890, 1891), and others reported *G. annulata* from the type and other hosts in the Mediterranean Sea, but still did not characterize specimens for modern comparisons. Linton (1901, 1905) and MacCallum (1921) reported *G. annulata* from various marine fishes in the North Atlantic. Possibly none of these American reports from different regions refers to *G. annulata* because, based on material of poor condition from the USNM, there appears to be more than one species reported as that synonym and the genus is more speciose than previously assumed. Also, very few ascaridoids occur in both the western North Atlantic and the Mediterranean Sea, and those infect pelagic fishes. At least some of the material reported by MacCallum (1921) as *Lecanocephalus annulatus* appears to be *G. sinamora* and probably so are other worms from the striped bass identified as *L. annulatus* by MacCallum (USNM 34538, 35452, and 35453) and by Linton (USNM 6628) and as *Goezia* sp. by Beckland (USNM 71347). The specimens deposited by MacCallum, according to measurements of features other than spicules and hosts, correspond to his report (1921). Linton (1901) illustrated the anterior and posterior ends of a specimen, but deposited the middle portion. Even though we doubt *G. annulata* occurs in North America, not all worms identified as such can be referred to *G. sinamora* either. At least, males from *Urophycis tenuis* (USNM 35454) and *Haemulon album* (USNM 35456) cannot. Specific identification of two females from *Centropristis striata* listed as *G. annulata* (USNM 34588) could not be made without corresponding males.

Supplemental data for *G. spinulosa*, the only other species reported from the Americas, were recently reported by Santos et al. (1979) using specimens from *Arapaima gigas*, the type host collected in Brazil. This species has caused taxonomic confusion (see Rasheed, 1965). Freitas and Lent (1946) provided supplemental data on specimens from *Astronotus ocellatus* in Ceará, Brazil, which may or may not be conspecific. We examined specimens (USNM 36939) from that same host and locality, and they are unlike any of our material. They also differ from the material described by Freitas and Lent (1946); for example, in a pair we

examined, the intestinal cecum and ventricular appendage measured 31–43 μm and 1.6–1.7 mm compared with 0.4–0.7 mm and 2.2–2.9 mm for worms described with the same approximate lengths.

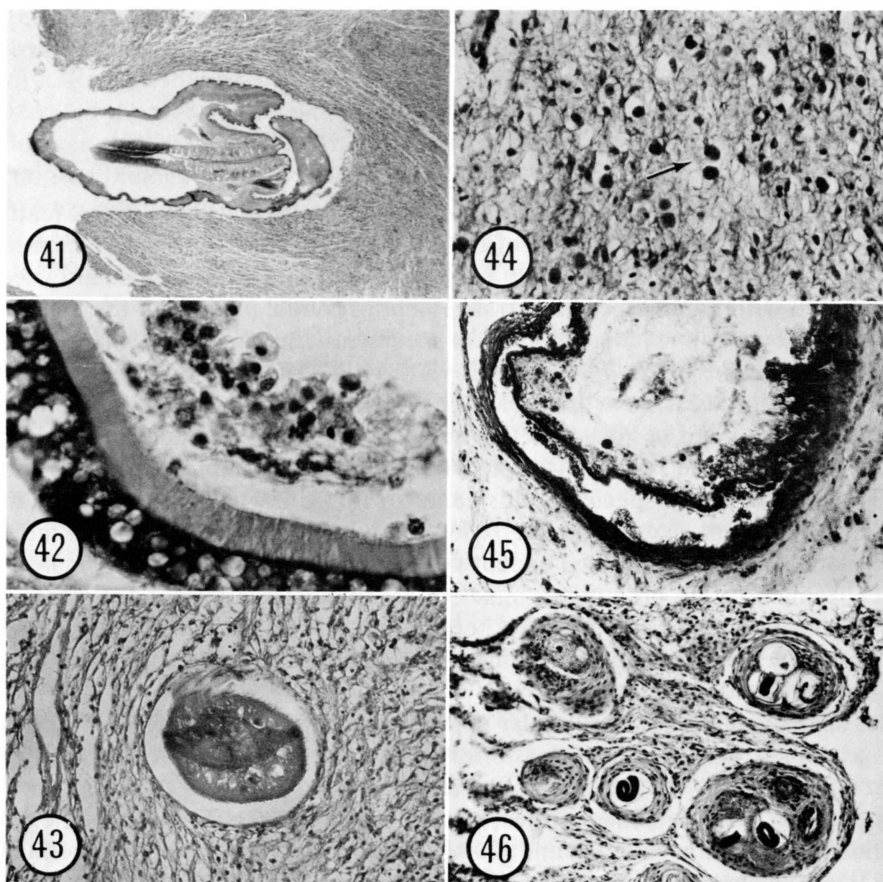
Observations and Discussion of Taxonomic and Biological Aspects of *Goezia* spp.

Differentiating most species of *Goezia* remains problematical. Several features such as ratios dealing with lengths of the intestinal cecum, ventricular appendage, esophagus, spicules, and total body may be helpful, but they are usually used in conjunction with the number and arrangement of caudal papillae in the males. As an example, we cannot identify female specimens found in *Ophichthyes gomesi* and *Micropogonias undulatus* from Davis Bayou, Mississippi, *Epinephalus nigritus* from Southwest Pass of the Mississippi River, Louisiana, and *Sciaenops ocellata* from a pond in Palacios, Texas, because no concurrent males were collected. However, we list the hosts to provide a more complete record of hosts and localities in which species of this genus occur. Unfortunately, not even male papillae have been adequately assessed. Observing all the papillae on an individual usually presents difficulty except on well-fixed specimens, and males are scarce; females often outnumber males in a nodule. Descriptions for papillae in most of the species we report have been based on few specimens, but as more specimens were examined, the number of papillae and the position of double papillae remained consistent.

The shape and length of cuticular spines appeared to vary with age, position, and individual. Consequently, we do not consider those means reliable to differentiate the species we examined. Spinous structures on the tail's tip may be characteristic, but, for some species, certain individuals do not possess them and on those that do the number and shape may vary. Observations of additional well-fixed specimens of all species will probably provide additional characters for differentiation. This is especially true for cross sections of the somatic musculature, lateral cords, alimentary tract, and other features (e.g., see Figs. 37–40). The consistency of those characters for *G. pelagia* as figured held strong for four of five examined specimens. In the fifth, the hypodermal and muscle cells were somewhat shorter, but not as short as the two sectioned specimens of *G. sinamora*.

Species of *Goezia* attach firmly to the stomach wall of hosts; however, evidence of worms associated with food in some hosts also containing lesions suggests that at least some species can detach, leave their site of attachment for various periods, and return to the same site. Presumably those species feed on both the host and its partially digested food.

Goezia sinamora, a species implicated in mortality of striped bass by Gaines and Rogers (1972), occurs within fibrous nodules. The worm in Figure 41 is one of six large healthy specimens from a 10-mm-wide by 7-mm-deep nodule in the stomach of *Tilapia aurea*. That individual had its anterior portion retracted within its trunk, with the spiny cuticular rings projected into the nodule. Perhaps the retracted position allows for both feeding and attachment. While the median part of the trunk remains stationary, the uncontorted portion with lips and esophagus may thrust into host tissue, rasp off this nodular tissue, and accumulate that tissue and host exudate. However, that was the only sectioned retracted specimen, and it did not have conspicuous protractor or retractor muscles. In any



Figures 41–46. Sections through nodule in stomach of *Tilapia aurea* caused by *Goetzia sinamora*. 41. Anterior of worm retracted within its trunk. Note lips and esophagus of worm and loose connective tissue of nodule. Harris' hematoxylin and eosin (H and E), $\times 30$. 42. Host cells in intestine of nematode. H and E, $\times 560$. 43. Larval specimen burrowed into nodule from central cavity. H and E, $\times 172$. 44. Region of minimal inflammation adjacent to a region of intensive response not shown; note granular cells with arrow pointing to one. McManus' method for glycogen with hematoxylin (PASH), $\times 135$. 45. Degenerating dead worm with PAS-positive substance within worm and between worm and collagenous capsule. Gomori's trichrome method, $\times 133$. 46. Tubercles with embryonated eggs deep within nodule. H and E, $\times 134$.

event, intestinal contents were primarily exudate, rich with red blood cells and chronic inflammatory cells (Fig. 42); necrotic tissue, some infiltrated with bacteria, also occurred.

The figured worm (Fig. 42) has probably been attached for a long period since the nodule was thick. Connective tissue laden with collagen (as demonstrated by Gomori's trichrome method) incorporated a considerable chronic inflammatory infiltrate including eosinophils. Some regions along exposed luminal surfaces of the nodule were necrotic and massed with bacteria. Intensely inflamed mucosal tissue immediately adjacent to the nodule sloughed into the nodule.

A juvenile form of the same species 106 mm in diameter at a midbody cross

section burrowed into the nodular tissue from the cavity (Fig. 43). It fed on exudate and elicited no additional inflammatory response. The typically low grade inflammation of repairing tissue was characterized in some areas by granular cells (Fig. 44; see Chaicharn and Bullock, 1967).

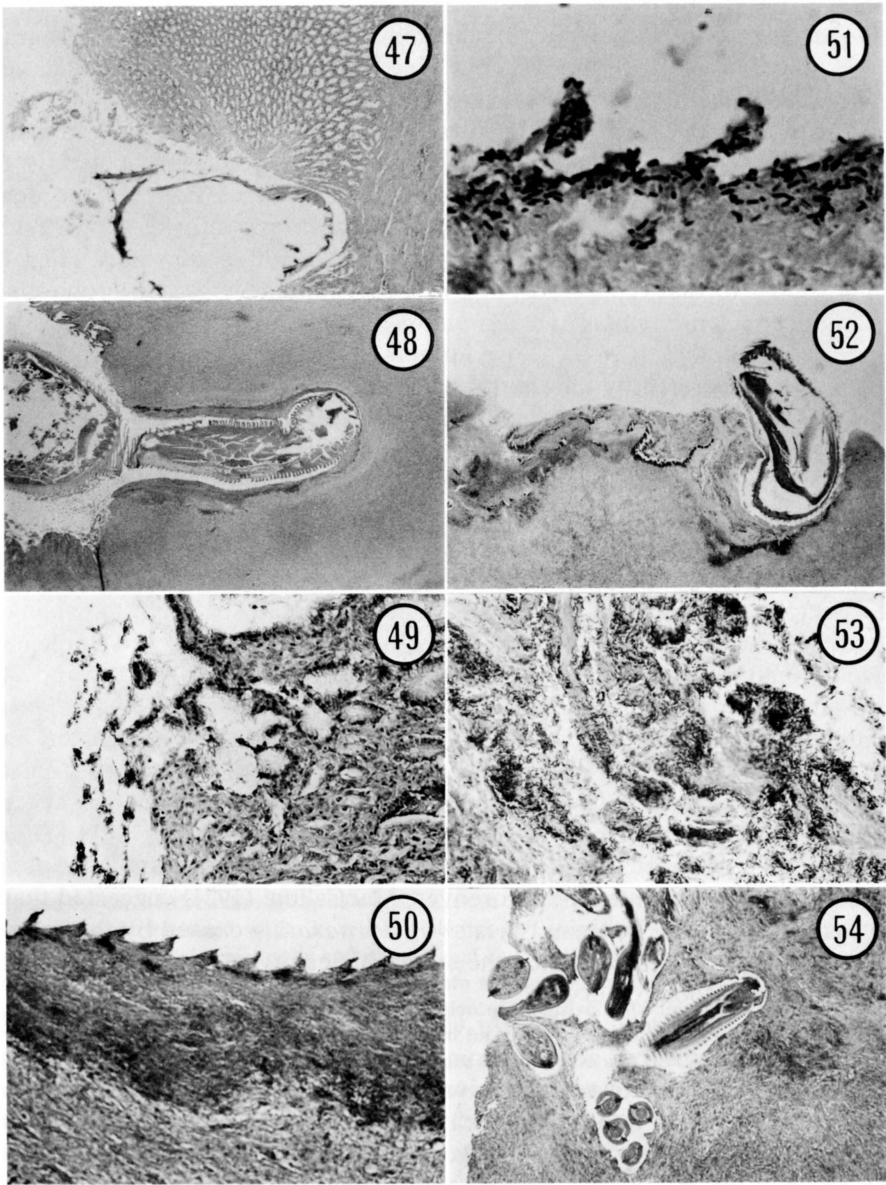
Deep within the nodular tissue occurred two dead specimens being degraded by host cells. They were encapsulated by epithelioid fibroblasts distinctly demarcated from the densely collagenous matrix. The space between the dense layer and the worm and also within the worm itself was partially filled by a PASH (periodic acid Schiff technique with hematoxylin) positive substance (Fig. 45) possibly similar to that reported from a proboscis and degenerated proboscis of the acanthocephalan *Pomphorhynchus bulbocolli* Linkins in Van Cleave, 1919 by Chaicharn and Bullock (1967). Those authors characterized that substance and assumed it was secreted by fibroblasts lining the capsule. Also distant from the living worms were numerous epithelioid tubercles encasing foreign matter, some of which appeared to be embryonated eggs of *Goezia sinamora* (Fig. 46).

Ware (1971) and Gaines and Rogers (1972) reported on the same extensive infections and mortalities of striped bass which presumably resulted from *G. sinamora* in four lakes in Florida, one the locality of our material. They reported a rapid decrease in the physical condition (coefficients indicated as K-factors) of most infected fish to values between 1.8 and 1.4. Death became impending at those values, whereas infected fish with K-factors between 1.8 and 2.0 usually survived. Healthy fish exhibited values above 2.0. Those authors also reported hemorrhagic ulcerlike depressions in the striped bass which presumably became scarified. Some individuals penetrated through the stomach wall into the body cavity, and the bacterium *Aeromonas* sp. was cultured from at least one stomach.

If *G. sinamora* indeed caused the mortalities, perhaps the reason was because the introduced *Morone saxatilis* was a poorly receptive host. Similarly, *Tilapia aurea* was an introduced species, and it also evoked a considerable response, including lesions in the intestine. Moreover, MacCallum (1921) suggested that in some cases the swollen irritating "nests" in *M. saxatilis* caused by the same or similar species of *Goezia* restricted the stomach's cavity such that the fish could not ingest enough food to survive.

Host response to species of *Goezia* varies among both identical and different hosts, and we describe four nodules from cobia with *G. pelagia* to illustrate some of this variation in terms of a progressive condition. We observed neither severe damage nor penetration into the body cavity as reported for *G. sinamora*. In the first case, the illustrated nonretracted worm (Fig. 47) penetrated the mucosa and nearly reached the muscularis. Some hemorrhaging occurred without an appreciable leucocytic inflammatory response, and slight autolysis of the gastric glands occurred. Consequently, postmortem migration by the worm was possible, but questionable because near the worm's anterior end a thin epithelioid lining had become established between the worm and the gastric glands. Also, considerable necrotic debris had sloughed into the nodular cavity, and some was being engulfed by giant cells and macrophages. That material plus exudate occupied the worm's intestine.

An extensive vascularized, dense, collagenous capsule characterized the second case (Fig. 48). The worm penetrated deep into the muscularis and evoked a chronic inflammatory response extending about 1 mm from the capsule. Eosin-



Figures 47–54. Sectioned *Goezia pelagia* and associated nodules in the stomach of *Rachycentron canadum*. 47. Anterior of worm penetrating through mucosa and nearing muscularis; note absence of fibrotic nodule and inflammatory response. H and E, $\times 29$. 48. Another worm with associated nodule; note narrow dense collagenous capsular layer adjacent to anterior of worm. H and E, $\times 13$. 49. Degenerating mucosa at margin of nodule near trunk of worm. H and E, $\times 137$. 50. Bacterial laden, plicated lining of capsule where cuticular rings of worm inserted. H and E, $\times 132$. 51. Similar region as in Figure 50, but in different nodule. Bacteria in photo restricted to plications; however, large nests of bacteria occurred elsewhere in capsule. Taylor's bacteria method, $\times 558$. 52. Nodule with thicker and more irregular layer separating worm from portion with loose connective tissue. H and E, $\times 16$. 53. Close-up of irregular layer showing less restricted localization of bacteria than in previous nodules. Taylor's bacteria method, $\times 136$. 54. A few individuals of the related *Thynnascaris inquires* burrowing into nodule of *G. pelagia*; note one worm entering the capsular layer. H and E, $\times 51$.

ophils were not abundant in any of the sections. Mucosa still remained in contact with the midportion of the worm, but it was inflamed, degenerating, laden with bacteria, and sloughing (Fig. 49). The exposed wall lining the capsule had plications depicting a mirror image of the worm's cuticular rings which had fit there before the tissue was fixed (Fig. 50). Some regions of the wall were heavily infiltrated by both coccoid and rod-shaped bacteria.

The third case portrayed a more extensive collagenous capsule, and focal masses of bacteria involved most of it (Fig. 51, also see Fig. 53). The capsule extended into and separated the worm from the mucosal tissue. Tissue internal to the capsule had an abundance of inflammatory cells.

In the last case, the collagen-rich irregular region was thicker than in previous cases (Fig. 52). Much of it, however, was necrotic and bacteria occurred focally in large numbers throughout (Fig. 53). This tissue was continually sloughing into the cavity. Taylor's method for bacteria demonstrated primarily gram-negative rods, but coccoid-shaped and gram-positive rod forms as well as fungi also occurred. Although the number of bacteria was enormous, few individuals invaded beyond the irregular capsule. Eggs of *G. pelagia* which had undergone few divisions occurred deep in the capsule. A degenerated worm was situated near the base of the nodule, and it had scavenging cells attached. It, however, lacked an associated chronic inflammatory response.

A group of several specimens of *Thynnascaris iniquies* (Linton, 1901) also occurred in the nodule (Fig. 54). These relatively small ascaridoid worms appeared to be more active burrowers than *G. pelagia*, and they did occasionally invade the muscularis. They, however, were not observed to pass through the capsule surrounding *G. pelagia* or to induce capsular formation about themselves.

Probably the four cases from cobia progress from a recent invasion to a well-established nodule. Even though representing different stages of penetration and repair, the leucocytic response was always restricted to near the capsule and no damage to the hosts was apparent beyond the nodules except in the mucosa near the nodule margins.

Many invading helminths evoke extensive responses. Caryophyllids cause lesions that differ according to the type of scolex (Mackiewicz, 1972). Several of these cestodes not possessing loculi or bothridia cause nodules, and some of these elicit an extensive inflammatory infiltration. Piscine reactions to acanthocephalans also vary according to the species of worm and its sex (Chaicharn and Bullock, 1967). The female, but not male, of *Octospinifer macilentus* Van Cleave, 1919 provides a comparative example. Its penetration resulted in a nodule without a capsule. Chaicharn and Bullock observed neither inflammation nor bacteria; granular cells occurred abundantly among the collagen. For fish, information on tissue response toward nematodes is sparse (Williams, 1967). Hauck and May (1977) and Iversen and Kelley (1974) described the response to larval and adult ascaridoids, respectively. In both cases the inflammation was much more intense than we report, but the latter of those may be a response to mechanical injury in addition to or separate from the worms. *Contracaecum* spp. penetrating the stomachs of a sea lion or pelican (Liu and Edward, 1971) and larval anisakids within ulcerated nodules in stomachs of marine mammals almost always evoke an extensive inflammatory response (e.g., Vik, 1964; Young and Lowe, 1969).

The above examples urge us to speculate that *Goezia* spp. in most hosts seem

to demonstrate well-adapted host-parasite relationships. The fibrotic nodules remain for a considerable time, but inflammation is restricted to near the worm and subsides with time. The nodule usually prevents the worm from penetrating through the serosal tissue, and the capsule acts as a barrier to bacterial invasion. The capsule's continuous growth and degeneration probably provides a constant source of food for the worm. Introduced hosts seem more susceptible to disease than natural hosts.

Overstreet (1968) reported ecological aspects of *G. minuta* from the inshore lizardfish that passed through Buttonwood Canal, Florida. Herein we report additional data and rework some of those presented originally. The worms caused a fibrotic nodule in the stomach wall grossly similar to those described above; they were usually located near the pyloric ceca and filled with mucus. Fish fixed immediately upon capture had worms attached within the cyst, free in the stomach, and attached to or encased in partially digested food items. Probably they ate the host's partially digested prey as well as the host's exudate. On occasion, as many as 10 worms occurred within a cyst. Monthly samples were taken for 2 years, and overall, 49.8% of the fish harbored an average of 3.0 worms each. Twice as many fish had infections in 1963 as in 1964, and the highest monthly average was 5.5 worms per infected fish in January 1963. Fish as short as 37 mm FL long were examined, but worms occurred in fish only 80 mm and longer. Considering those fish between 10 and 30 cm long, more had concurrent infections with *G. minuta* and two hemiurid digeneans than expected by chance alone. Possibly products from *G. minuta* or the host's response to the nematode was advantageous for the other worms. In any event, considering the relatively low density of *Synodus foetens* in the immediate region (Roessler, 1970), the relatively high prevalence of fish infected with *G. minuta* deserves note. *Goezia minuta* was not evident in several other examined fishes from that locality in the Everglades National Park or in lizardfish from nearby Biscayne Bay (Overstreet, unpublished data).

An experimental life cycle for a species of *Goezia* has not been established. Similarities among cycles for other piscine ascaridoids, however, suggest that it is basically the same as proposed for species of *Thynnascaris* Dollfus, 1933 (see Norris and Overstreet, 1976). A crustacean may or may not be necessary depending on the species, and paratenic hosts are often critical in maintaining a worm population. These could be fishes or invertebrates. Freitas and Lent (1946) reported what they believed to be a second-stage larva of *G. spinulosa* in the copepod *Diaptomus* sp. It had a cuticle devoid of spines. Larval specimens have been observed also in fish (e.g., Johnston and Mawson, 1951; Sprent, 1978), sometimes in a degenerate state. Gaines and Rogers (1972) reported them from the mesentery of some striped bass, but that location may reflect that the bass is an abnormal host. However, Jackson et al. (1978) also retrieved 20 specimens from the viscera of a striped bass in a Washington, D.C., fish market. According to Bier (personal communication), these were probably fourth-stage larvae with some gonadal development. We found in washings from spotted seatrout viscera a third-stage larva that had cuticular spines. Only one of several hundred seatrout examined had the infection. The 1.7 mm long worm had a ventricular appendage 29 times longer than the intestinal cecum and over three times that of the esoph-

agus. Third-stage larvae also penetrate into nodules occupied by adult worms (Fig. 43), but these probably ultimately mature or die in the nodules.

Acknowledgments

We gratefully acknowledge the assistance of the following persons: Dr. M. Kliks at Wisconsin Medical College for his interest in this project and donation of several specimens; Dr. D. B. Pence at Texas Tech University for specimens of *G. minuta*; Dr. J. F. A. Spret at the University of Queensland, Australia, for loan of specimens of *G. minuta*; Dr. C. R. Gilbert at Florida State Museum in Gainesville for loan of and permission to remove stomachs from specimens of *Synodus foetens*; Fishery Biologist Ms. K. J. Foote at Kissimmee Basin Wetlands, Florida, and Dr. W. A. Rogers at Auburn University Agricultural Experiment Station for specimens of *G. sinamora*; Dr. J. R. Lichtenfels for specimens deposited at the U.S. National Museum Helminthological Collection; Mr. R. L. Colura at Texas Parks and Wildlife Service for the specimen from *Sciaenops ocellata*; Dr. E. D. Stoddard at Florida Department of Agriculture and Consumer Services and Mr. J. Olsen of Busch Gardens in Tampa, Florida, for specimens from the hybrid bass; Dr. E. W. Cake, Mr. R. R. Lukens, Mr. T. E. Mattis (all GCRL), Mr. L. A. Covington of Ocean Springs, Mississippi, and Mr. F. Crooke of Pensacola, Florida, for their aid in collecting fish; and Mrs. R. Buxton, Mr. R. G. Palmer, Mrs. L. B. O'Toole, and Ms. T. A. Miller (all GCRL) for technical assistance.

This study was conducted in part in cooperation with the U.S. Department of Commerce, NOAA, National Marine Fisheries Service, under PL 88-309 Project No. 2-325-R and HEW/Public Health Service, Food and Drug Administration Contract No. 223-76-2141.

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