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A Survey of the Trematoda (Platyhelminthes: Digenea) Parasitic in Green Turtles, *Chelonia mydas* (L.) from Hawaii

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Abstract.—Ten Hawaiian green turtles (*Chelonia mydas*) with fibropapilloma tumors were collected from three islands (Lanai, Maui, Oahu) and examined for digenetic trematode parasites. A total of 232 worms were recovered representing six genera (*Angiodictyum, Carettacola, Hapalotrema, Learedius, Polyangium, Pyelosoma*). The prevalence of infection does not appear to be affected by the size, sex, or locality of host.

The Hawaiian green turtle population is geographically isolated. The number of productive females has been reduced to only 100–300 annually (Balazs 1980). Neoplasms identified as fibropapillomas are being commonly found on these turtles throughout the Hawaiian Islands. Up to 10% of the nesting females tagged each year at the breeding colony of French Frigate Shoals have these epithelial growths. The papillomas range from a few millimeters to 30 cm in diameter (Fig. 1) (Dailey and Balazs 1987). These disfiguring growths in turtles can result in reduced vision, disorientation, blindness, and physical obstruction to normal swimming and feeding. Consequently, many animals are found on the beach unable to survive in nature. The etiology of fibropapillomas in green turtles remains unknown, however, the presence of trematode ova within the fibrotic portion of the lesions indicates it could be of digenetic trematode origin (Dailey and Balazs 1987). This survey was carried out to document the trematodes parasitizing the Hawaiian green turtles and ascertain the possible effect, if any, of these parasites on the population.

From 1986 to 1988, 10 green sea turtles were collected as stranded animals from the islands of Lanai, Maui, and Oahu. The turtles were brought to the National Marine Fisheries Service holding facilities at Kewalo Basin, Honolulu, Hawaii. Upon determination that the turtles would not survive they were euthanized and necropsied.

The literature on parasites from sea turtles is extensive and scattered. The taxonomic classification and host parasite names used in this study have generally followed those of Yamaguti (1971), Ernst and Ernst (1977), and Blair (1986).

This is the first survey of digenetic trematodes infecting the Hawaiian green turtle population.

Materials and Methods

A thorough examination for parasites was carried out on the lungs, liver, heart, stomach, intestine, and bladder. Worms were placed in tap water and refrigerated

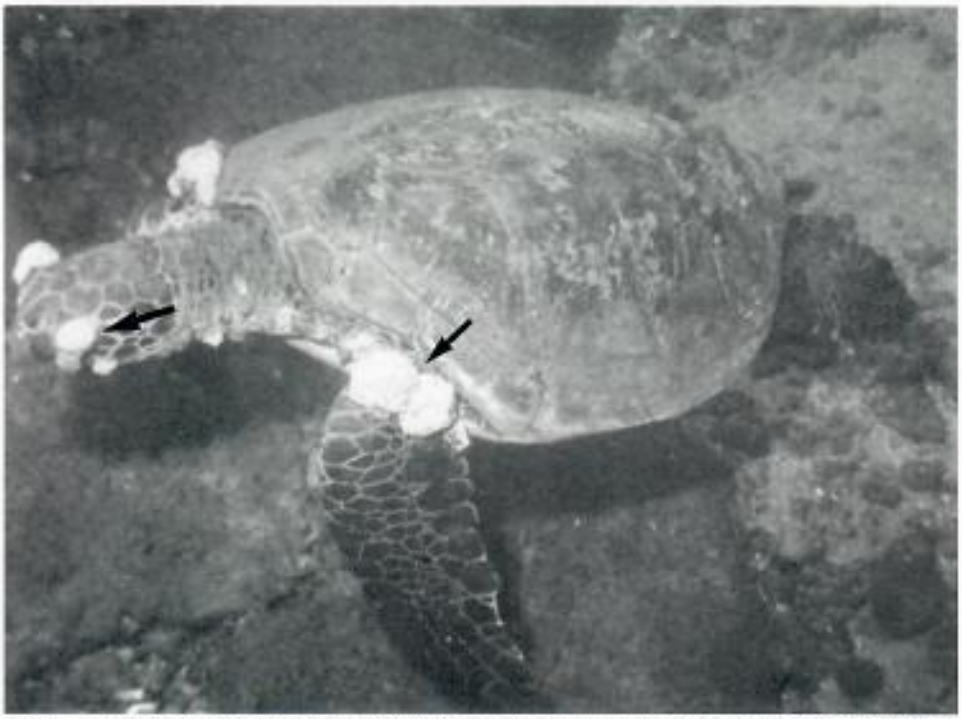

Fig. 1. Fibropapillomas on the eyes and flipper of the green turtle, *Chelonia mydas* from Hawaii.

overnight for egg expulsion, fixed in alcohol-formalin-acetic acid (AFA) solution for two days, then transferred to 70% ethyl alcohol for storage. Whole mounts used for identification were stained in Semichon's acetocarmine, dehydrated in a graded ethanol series, and mounted for examination.

Voucher specimens were deposited at the Institute of Parasitology, California State University, Long Beach, California.

Results

Ten turtles ranging from 46.0 to 86.1 cm in size, all with tumors, were found infected with a total of 232 worms comprising six genera and seven species of digenetic trematodes (Table 1).

Intestinal Fauna

Angiodictyidae Looss, 1902

Fourteen specimens of *Polyangium linguatula* (Looss, 1899) Looss 1902 were recovered from the small intestine of four turtles (40%). Turtles from the islands of Oahu (3) and Lanai (1) shared the total number of this species collected during the study (Table 1).

This is the first report of this species from *C. mydas* in the eastern Pacific. Previous reports are from Puerto Rico (Dyer et al. 1991), Australia (Blair 1986),

Table 1. Hawaiian green turtles infected with trematode parasites.

Field no.	Host carapace length (cm)	Sex	Location	Parasite	Species/ host	Total no. worms recorded
5/05/86	66.8	Nd	Haleiwa, Oahu	*Learedius learedi*		6
				Hapalotrema sp. (A)	3	7
				Polyangium linguatula		2
6/24/87	58.6	Nd	Keomaku, Lanai	*Hapalotrema* sp. (A)		7
				Polyangium linguatula	3	1
				Angiodictyum longum		2
7/10/87	46.0	Nd	Chuns Reef, Oahu	*Hapalotrema* sp. (A)		8
				Hapalotrema sp. (B)	2	2
8/09/87	55.0	F	Kailua Bay, Oahu	*Hapalotrema* sp. (A)	1	3
8/16/87	55.0	F	Kailua Bay, Oahu	*Hapalotrema* sp. (A)		20
				Hapalotrema sp. (B)	2	14
10/25/87	83.2	M	Pearl Harbor, Oahu	*Hapalotrema* sp. (A)		8
				Hapalotrema sp. (B)	2	2
11/20/87	62.2	F	Kaneohe Bay, Oahu	*Angiodictyum longum*		2
				Polyangium linguatula	2	2
12/20/87	66.2	F	Chuns Reef, Oahu	*Angiodictyum longum*		5
				Carettacola hawaiiensis	5	3
				Hapalotrema sp. (A)		5
				Learedius learedi		4
				Polyganium linguatula		9
1/25/88	83.1	F	Kaneohe Bay, Oahu	*Carettacola hawaiiensis*		10
				Learedius learedi	3	43
				Pyelosoma cochlear		19
5/04/88	86.1	Nd	Kahului Bay, Maui	*Carettacola hawaiiensis*		17
				Hapalotrema sp. (A)	3	5
				Learedius learedi		26
					Total	232

Brazil (Teixeira de Freitas and Lent 1938), and Egypt (Looss 1902). The worms studied during this survey were much larger than those previously described (Table 2). Also, no fine spines were found on the cuticle, the testes were ovoid, not irregular in shape, and the genital pore was more anteriorly placed than in the Australian specimens.

Nine specimens of *Angiodictyum longum* Blair 1986 were recovered from the small intestine of three turtles, two from Oahu and one from Lanai (Table 3). This species was described by Blair (1986) from *C. mydas* taken from Badu Island, Torres Strait, Queensland, Australia. He differentiates this species from the other three (*A. parallelum* (Looss, 1901) Looss 1902; *A. posterovitellalum* Challopadhyaya, 1972; *A. glossoides* Blair 1986) members of the genus by placement of genital pore and anterior extension of vitellaria. The Hawaiian specimens differed from the type material in smaller size (4.75–6.25 × 1.0–1.5 mm) and in possession of a muscular expansion at the posterior end of the esophagus just anterior to the cecal bifurcation.

This report extends the range of this species from Australia, India, and Egypt to the eastern Pacific.

Table 2. Comparison of Hawaiian specimens of *Polyangium linguatula* to other geographical sites.

	Measurement of specimens from:			
	N = 10 Hawaii	N = 3 Australia	N = 9 Egypt	N = 1 Brazil
Body length	9.2–13.7 (11.7)	4.3–7.9 (66)	4.3–7.9 (6.3)	7.74
Body width	1.8–2.1 (1.9)	1.3–1.5 (1.4)	1.0–1.6 (1.2)	1.63
Oral sucker length	0.21–0.27 (0.24)	0.16–0.18	0.11–0.15 (0.14)	0.16
Oral sucker width	0.34–0.38 (0.36)	0.23–0.24	0.15–0.23 (0.17)	0.2
Esophagus length	2.9–3.3 (3.1)	1.72–1.76	0.67–1.75 (1.26)	1.33
Anterior testes length	0.88–0.99 (0.93)	0.33–0.42 (0.37)	0.34–0.56 (0.46)	0.51
Anterior testes width	0.65–0.79 (0.72)	0.36–0.48 (0.4)	0.39–0.60 (0.50)	0.51
Posterior testes length	0.86–1.02 (0.92)	0.22–0.4 (0.34)	0.38–0.65 (0.51)	0.43
Posterior testes width	0.70–0.80 (0.75)	0.42–0.5 (0.47)	0.41–0.56 (0.49)	0.52
Ovary length	0.27–0.37 (0.33)	0.18–0.25 (0.22)	0.19–0.3 (0.24)	0.26
Ovary width	0.24–0.26 (0.25)	0.2–0.24 (0.22)	0.15–0.24 (0.19)	0.21
Eggs in utero length	0.092–0.12	0.071–0.077	0.079–0.091	0.072–0.082
Eggs in utero width	0.057–0.065	0.044–0.046	0.044–0.064	0.043–0.045
Reference	This paper	Blair (1986)	Looss (1899, 1902)	Teixeira de Freitas and Lent (1938)

Table 3. Prevalence of parasites in Hawaiian green turtles.

Parasite	No. host	% Host	No. worms recorded	% of total worms	Infection site
Angiodictyum longum	3	30	9	3.8	intestine
Carettacola hawaiiensis	3	30	30	12.9	liver
Hapalotrema sp. (A)	7	70	36	15.5	heart
Hapalotrema sp. (B)	3	30	18	7.7	heart
Learedius learedi	4	40	79	34.0	heart
Polyangium linguatula	4	40	14	6.0	intestine
Pyelosoma cochlear	1	10	19	8.1	urinary bladder

Urinary Bladder Fauna

Pronocephalidae Looss, 1902

One turtle from Kaneohe Bay, Oahu, was found infected with 19 specimens of *Pyelosoma cochlear* Looss, 1899. This parasite was originally described from the urinary bladder of *C. mydas* from Egypt. It has also been reported from the same host from Puerto Rico (Dyer et al. 1991) and Panama (Oguro 1936). Five other intestinal species are currently acknowledged in this genus (*P. longicaecum* Luhman, 1935; *P. posterorchis* Oguro, 1936; *P. parvum* Prodhoe, 1944; *P. amblyrhynchi* Ruiz, 1946; *P. renicapite* (Leddy, 1856) Poche, 1926). The diagnosis of the genus Pronocephalidae by Yamaguti (1971) was amended by Threlfall (1979) to include *P. renicapite.*

All *P. cochlear* found in this study were small and sexually immature.

Blood Vascular System Fauna

Spirorchiidae Stunkard 1921

Seventy nine specimens of *Learedius learedi* Price, 1934 were recovered from the hearts of four turtles. Over one-half (43) of these were collected from one animal found stranded at Kaneohe Bay, Oahu (Tables 1, 3). This parasite appears to be ubiquitous as it has been reported from Puerto Rico (Dyer et al. 1991), Panama (Caballero et al. 1955), Florida (Nigrelli 1941), Grand Cayman, British West Indies (Greiner et al. 1980), Bermuda (Rand and Wiles 1985), and Australia (Blair 1979). *Learedius learedi* was originally described from the "edible turtle" or "common turtle" in England in 1862. Smith (1972), in a review article, suggests that the turtle was a *C. mydas* that had been imported into the United Kingdom for turtle soup.

We found no morphological differences between our specimens and those of the original description.

Carettacola hawaiiensis

Thirty specimens of *Carettacola hawaiiensis* were recovered from the liver vessels of three turtles (two from Oahu, one from Maui) (Table 1).

Carettacola was a monotypic genus (*C. bipora*) described by Manter and Larson (1950) from the intestinal washings of a loggerhead turtle (*Caretta caretta*) captured in Florida. The authors state that the worm was "probably originally from some blood vessel" (Smith 1972).

The findings in this study document the first report of a spirorchid blood fluke from a marine turtle liver.

Hapalotrema spp.

Two undescribed species of the genus *Hapalotrema* (listed as A, B in Table 1) were found to be the most prevalent (70% for *Hapalotrema* sp. A) worm in this study (Table 3). The genus *Hapalotrema* contains six previously described species (*H. loossi* Price, 1934; *H. mistroides* (Manticelli, 1896) Stiles and Hassall, 1908; *H. orientale* Takeuti, 1942; *H. synorchis* Luhman, 1935; *H. mehrai* Rao, 1976; *H. postorchis* Rao, 1976) all found in the hearts of turtle hosts. *Hapalotrema loossi, H. mehrai* and *H. postorchis* are the only species in the genus that have been previously reported from *C. mydas*. The specimen from that report was *H. loossi*, collected from India (Rao 1976). The others (*H. mistroides, H. synorchis* and *H. orientale*) are reported from loggerhead (*C. caretta*) and leatherback (*Eretmochelys squamosa*) turtles respectively (Smith 1972).

Discussion

Parasites from *Chelonia mydas* have been previously listed by other authors (Blair 1979; Caballero et al. 1955; Dyer et al. 1991; Greiner et al. 1980; Glazebrook et al. 1989). However, this is the first study of this kind on the Hawaiian green turtle population. The prevalence of infection does not appear to be affected by size, sex, or locality. The distribution of infection by various species appears to be random, as shown by the two turtles from Chuns Reef, Oahu, in Table 1. In number 7/10/87, the turtle was 46 cm in carapace length and was infected with both species of *Hapalotrema* (A and B). In number 12/20/87, a larger turtle (66.2 cm) also collected at Chuns Reef, Oahu, the authors recovered five different genera of trematode parasites; however, only one species (*Hapalotrema* (A)) of the genus *Hapalotrema* was present. Given the gaps of knowledge in the green sea turtle life history, which involves migrations to various breeding and foraging habitats, this finding is not surprising. It is also not surprising that the complete life cycle for a marine spirorchid, infecting sea turtles, has, to date, not been elucidated, given the complexity of marine ecosystems. The traditional cycle for spirorchids in fresh water turtles that involve a snail intermediate host (Smith 1972) may not apply here. Studies to date on snails from infected green turtle habitats have been negative for any spirorchid trematode larvae (Greiner et al. 1980; MDD, this study).

The spirorchid findings in this study conform to the survey reports previously published. Glazebrook et al. (1989) working on sea turtles from the Great Barrier Reef in Australia, summarized the findings of cardiovascular flukes found in three genera of turtles (*Chelonia, Eretmochelys, Caretta*). He lists eight genera of digenetic trematodes of the family Spirorchiidae reported from the cardiovascular system of turtles, the most common site being the heart. The Hawaiian green turtles in this study were found to have three genera (*Learedius, Hapalotrema, Carettacola*) of cardiovascular flukes, two of which inhabited the heart and one the liver. The microscopic changes caused by these parasites in the host system were also outlined by Glazebrook et al. (1989). They state that "multiple diffuse egg granulomas were a prominent feature of most organs, the spleen and lungs being predilection sites." Similar findings were observed during this study where

large egg masses were recovered from the lungs and liver. An acute and chronic vasculitis accompanied by metastasis of trematode eggs was found by Wolke et al. (1982) while looking at loggerhead turtles from Florida to Massachusetts. These authors also found trematode eggs and associated inflammatory response in the gut, liver, spleen, kidney, heart, stomach, and testes. This and other reports of parasite egg distribution throughout the body of the sea turtle via its blood vascular system would help explain the finding of eggs in fibropapilloma tumors. Whether or not the response to these eggs by the host animal causes these tumors is still not clear. However, the consistent finding of a large number and variety of trematode worms in Hawaiian sea turtles would indicate that these parasites may play a role in the general health and subsequent survival of members of this population.

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Literature Cited

Balazs, G. H. 1980. Synopsis of biological data on the green turtle in the Hawaiian Islands. U.S. Dept. Commerce, NOAA Tech. Memo. NMFS, NOAA-TM-NMFS-SWFC-7, 141 pp.

Blair, D. 1979. Study of helminth parasites of sea turtles in Queensland, Applied Ecology, Canberra. Unpub. report.

———. 1986. A revision of the Subfamily Microscaphidiinae (Platyhelminthes:Digenea:Microscophidiidae) parasitic in marine turtles (Reptilia: Chelonia). Aust. J. Zool., 34:241–277.

Caballero y C., E., D., C. D. y Zerecero, and R. G. Grocott. 1955. Helmintos de la Rupublica de Panama. XV. Trematodos de *Chelone mydas* (L.), tortuga marina comestible de Oceano Pacifico del Norte. 2a parte. An. Inst. Biol. Univ. Mex., 26:149–191.

Dailey, M., and G. Balazs. 1987. Digenetic trematodes as possible etiologic agents for fibropapillomas in Hawaiian green turtles (*Chelonia mydas*). Proc. 18th Ann. Conf. and Workshop of Int. Assoc. for Aquatic Animal Med., Monterey, Calif., 46–50 pp.

Dyer, W. G., E. H. Williams, Jr., and Lucy Bunkley Williams. 1991. Some Digeneans (Trematoda) of the green turtle, *Chelonia mydas* (Testudines: Cheloniidae) from Puerto Rico. J. Helminthol. Soc. Wash., 58:176–180.

Ernst, E. M., and C. H. Ernst. 1977. Synopsis of helminths endoparasitic in native turtles of the United States. Bulletin of the Maryland Herpetological Society, 13:1–75.

Glazebrook, J. S., R. S. F. Campbell, and D. Blair. 1989. Studies on cardiovascular fluke (Digenea: Spirorchiidae) infections in sea turtles from the Great Barrier Reef, Queensland, Australia. J. Comp. Path., 101:231–249.

Gohar, N. 1934. Liste destrematodes parasites et de leurs hotes vertebres signales dans la Vallee du Nil. Annls. Parasit. Hum. Comp., 12:322–331.

Greiner, E. C., D. J. Forrester, and E. R. Jacobson. 1980. Helminths of mariculture-reared green turtles (*Chelonia mydas mydas*) from Grand Cayman, British West Indies. Proc. Helminthol. Soc. Wash., 47:142–144.

Looss, A. 1902. Aeber neue und bekannte Trematoden aus Seeschildkröten. Nebst Erörterungen zur Systematik und Nomenclatur. Zool. Jahrb. Abt. Syst. Oekol. Geogr. Tiere., 16:411–894.

Manter, H. W., and M. I. Larson. 1950. Two new blood flukes from a marine turtle, *Caretta caretta*. J. Parasit., 36:595–599.

Nigrelli, R. F. 1941. Parasites of the green turtle, *Chelonia mydas* (L.), with special reference to the rediscovery of trematodes described by Looss from this host species [Abstract]. J. Parasit., 27 (Suppl.), 15–16.

Oguro, Y. 1936. Einige neue und bekannte Pronocephaliden aus japanischen Seeschildkröten. J. Sc. Hiros. Univ., 5:1–28.

Rand, T. G., and M. Wiles. 1985. Histopathology of infections by *Learedius learedi* Price, 1934 and *Neospirorchis schistosomatoides* Price, 1934 (Digenea: Spirorchiidae) in wild green turtles, *Chelonia mydas* L., from Bermuda. J. of Wild. Dis., 21:461–463.

Rao, S. L. 1976. On two new blood flukes (Trematoda, Spirorchidae) from the heart of *Chelone mydas* L. Acta Parasitologica Polonica, XXIV:119–124.

Smith, J. W. 1972. The blood fluke (Digenea: Sanguinicolidae and Spirorchidae) of cold-blooded vertebrates and some comparison with schistosomes. Helminthological Abstracts, Series A, Vol. 41, Pt. 2., 161–204.

Teixeira de Freitas, J. F., and H. Lent. 1938. Sobre alguns trematodeos parasitos de *Chelone mydas* (L.) principalemente Paramphistomoidea. Mem. Inst. Oswaldo Cruz, Rio de J., 33:79–88.

Threlfall, W. 1979. Three species of Digenea from the Atlantic leatherback turtle (*Dermochelys coriacea*). Canadian J. of Zool., 57:1825–1829.

Wolke, R. E., D. R. Brooks, and A. George. 1982. Spirorchidiasis in loggerhead sea turtles (*Caretta caretta*). Pathology, 18:175–185.

Yamaguti, S. 1971. Synopsis of digenetic trematodes of vertebrates. 2 volumes. Keigaku Publishing Co., Tokyo, 1074 pp.

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