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Observations on the ectoparasites of elasmobranchs in San Francisco Bay, California

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There has been considerable documentation of the ectoparasites of elasmobranchs along the Pacific Coast (Moore 1952; Cressey 1966, 1967, 1968; Russo 1975; Robinson 1982; Love and Moser 1983; Moser and Sakanari 1985; Deets and Dojiri 1989; Benz et al. 2002, 2003). While some of this information is specific to leopard shark (*Triakis semifasciata*) and brown smoothhound shark (*Mustelus henlei*) along the California coast, little is known concerning frequency of occurrence of ectoparasites on these and other inshore sharks in San Francisco Bay.

Between 1970 and 1996, I captured 3,790 sharks and rays through the use of long-line, otter trawl, and rod and reel fishing efforts, primarily from South San Francisco Bay. All sharks captured were sexed and measured, and most were checked for parasites over the full length of the body including gill tissues, and buccal and nare cavities, noting location of attachment for each species of parasite. Parasites initially were separated into labeled vials and preserved in 70% ethyl alcohol for later identification by R. Cressey (copepods), E. Burreson (leeches), and J. Sakanari (isopods) who presumably deposited the specimens in their respective collections. I retained a duplicate set to aid field identifications.

Following publication of initial observations of ectoparasites (Russo 1975; *n*=900), I focused on an analysis of an additional 575 sharks between 1976 and 1996, including leopard sharks (*n*=362), brown smoothhound sharks (*n*=130), soupfin sharks (*Galeorhinus galeus*) (*n*=41), and spiny dogfish sharks (*Squalus suckleyi*) (*n*=42). All sharks examined appeared normal in body form and coloration, with no apparent relationship between the number and species of parasites present and the general health of the host sharks.

Male leopard sharks were infected more often than females, with 130 (58.8%) of the 221 males infected compared to 45 (31.9%) of the 141 females with parasites. Conversely, 91 of the male leopard sharks (41.2%) and 96 of the of the female leopard sharks (68.1%) were without parasites. On average, 51.7% of the 362 leopard sharks examined had no ectoparasites.

The copepods *P. bicolor* and *A. oblongus* were the most common crustacean ectoparasites, occurring on 106 male and 54 female leopard sharks. The order of frequency of parasites on leopard sharks (Table 1) was *A. oblongus* (27.3%), *B. lobata* (24.1%), *P. bicolor* (16.8%), *E. coleoptratus* (9.4%), *L. galei* (3.6%). Some individual leopard sharks supported more than 20 *P. bicolor* on both sides of the caudal edges of the first dorsal fin, and occupied nearly every attachment site available.

Table 1.—The occurrence of external parasites *Branchellion lobata* (Bl), *Achtheinus oblongus* (Ao), *Pandarus bicolor* (Pb), *Echthrogaleus coleoptratus* (Ec), and *Lernaeopoda galei* (Lg) on leopard sharks and brown smoothhound sharks from San Francisco Bay, California, 1976–1996.

	Leopard sharks (*n*=362)				Brown smoothhound sharks (*n*=130)			
	Females (*n*=141)		Males (*n*=221)		Females (*n*= 92)		Males (*n*=38)	
Parasite	# sharks	%	#sharks	%	# sharks	%	# sharks	%
Bl	16	11.3	71	32.1	35	38.1	20	52.6
Ao	40	28.4	59	26.7	13	14.1	4	10.5
Pb	14	9.9	47	21.3	7	7.6	1	2.6
Ec	7	5.0	27	12.2	11	12.0	-	-
Lg	7	5.0	6	2.7	-	-	2	5.3
None (Clean)	96	68.1	91	41.2	37	40.2	12	31.6

Brown smoothhound sharks (*n*=130) showed slightly less frequency of copepods in males than females and higher overall rates of infection, as well as fewer individuals free of ectoparasites than did leopard sharks. Forty-nine (37.7%) of male and female brown smoothhound sharks were designated free of external parasites (Table1). Numerous "clean" sharks examined, however, had circular attachment scars thought to have been caused by leeches, but since no live parasites were found, these individuals were categorized as clean. Of the 38 male brown smoothhounds examined, none were found to support *E. coleoptratus*, while none of the 92 females supported *L. galei*.

While *P. bicolor* and *A. oblongus* are typically found on the body, fin edges, and soft tissues around the cloaca and claspers, *L. galei* and *E. coleoptratus* were found on gill arches and, occasionally, in buccal and nare cavities of leopard sharks and brown smoothhound sharks. Although *L. galei* was uncommon among all elasmobranchs examined during this study, they appeared more on leopard sharks than other sharks in South San Francisco Bay and are limited to just a few species of elasmobranchs (Love and Moser 1983).

Male leopard sharks and male brown smoothhound sharks had higher infestation rates of the leech *Branchellion lobata* than did females, with male brown smoothhound sharks (52.6%) and male leopard sharks (32.1%) having the highest infestation rate of all four elasmobanchs (Table 1). Sharks infested with this leech often had several leeches in various locations around male claspers, near the cloaca in females, in the nare cavities, at the caudal-basal attachment of dorsal and pectoral fins, or directly attached to eyes. Males of leopard sharks and brown smoothhound sharks showed substantially higher rates of infection, especially by young leeches, than females, which is possibly due in part to the increased availability of the soft tissues of the spermatic sulcus of male claspers. On 15 April 1977 an all-male aggregation of 29 leopard sharks was captured, and leeches were attached to the spermatic sulcus of 21 (72.4%) of those individuals. Leeches were also attached to one or both eyes of juvenile and adult leopard sharks and brown smoothhound sharks and, in one incident, several leeches completely covered the right eye of an adult female brown smoothhound shark (46.9 cm TL). No copepods were ever found attached to the eyes of any shark species in this study, in contrast to the report of Benz et al (2002) involving Pacific sleeper sharks (*Somniosus pacificus*). The common isopod *Lironeca vulgaris*, which is often found on teleosts, was also found on gill tissues and in buccal cavities of some leopard sharks subsequent to Russo (1975), but the number of specimens found was not included in this report, due to the mobility of the isopod (Robinson 1982, Moser and Sakanari 1985).

Soupfin sharks (*n*=41) and spiny dogfish sharks (*n*= 42) varied in infestation rates involving leeches and the copepods *A. oblongus*, *P. bicolor* and, to a lesser extent, *E. coleoptratus* and *L. galei*. Indeed, the latter was practically non-existent among those species (Table 2), when compared to levels of infestation among leopard sharks and brown smoothhound sharks (Table 1).

Table 2.—The occurrence of external parasites *Branchellion lobata* (Bl), *Achtheinus oblongus* (Ao), *Pandarus bicolor* (Pb), *Echthrogaleus coleoptratus* (Ec), and *Lernaeopoda galei* (Lg) on soupfin sharks and spiny dogfish sharks from San Francisco Bay, California, 1976–1996.

	Soupfin sharks (*n*=41)				Spiny dogfish sharks (*n*=42)			
	Females (*n*=28)		Males (*n*=13)		Females (*n*=31)		Males (*n*=11)	
Parasite	# sharks	%	# sharks	%	# sharks	%	# sharks	%
Bl	6	21.4	3	23.1	5	16.1	2	18.2
Ao	8	28.6	2	15.4	3	9.7	1	9.1
Pb	9	32.1	5	38.5	9	29.0	1	9.1
Ec	4	14.3	2	15.4	2	6.5	-	-
Lg	-	-	-	-	-	-	1	9.1
None (Clean)	7	25.0	3	23.1	18	58.1	7	63.6

Soupfin sharks had the highest rates of infestation by *P. bicolor* among shark species considered in this report. One female soupfin shark (81.3 cm TL) had 52 *P. bicolor* on various parts of the body. Neither male brown smoothhounds (*n*=38) nor male of spiny dogfish sharks (*n*= 11) were determined to be infested by *E. coleoptratus*. This parasite appeared on female (14.3%) and male (15.4%) soupfin sharks, but only female spiny dogfish sharks (6.5%) supported any specimens.

No male or female soupfin sharks (*n*=41 total) and no female spiny dogfish sharks (*n*=31) were infested by *L. galei*, but one of 11 male spiny dogfish sharks had several *L. galei*. Finally, males of both soupfin sharks and spiny dogfish sharks had only slightly higher rates of infection by leeches than females (Table 2), compared to leopard and brown smoothhound sharks (Table 1). Leopard shark females (68.1%), spiny dogfish males (63.6 %), and spiny dogfish females (58.1 %) exhibited the highest parasite-free rates, respectively.

Finally, eight of 13 big skates (*Raja binoculata*) that were examined were infested with two additional copepods (*Pseudocharopinus dentatus* and *Trebius latifurcatu*s) that I had not previously found on other elasmobranchs in San Francisco Bay. Both of these copepods are known to occur only on a few other hosts along the Pacific coast (Love and Moser 1983, Deets and Dojiri 1989), but *R. binoculata* represents a new host record for *T. latifurcatus*. Both these parasites have the ability to rapidly move over the skin of their hosts to different attachment sites making them difficult to count or collect them.

The disparate rates of infection by leeches and copepods shown here raise several questions regarding host selection, frequency of occurrence, and ease of attachment as they relate to the behavior of host sharks. This is especially so concerning the abundance of leeches on leopard sharks and brown smoothhound sharks, and *P. bicolor* on soupfin sharks. The frequency and distribution of the parasites identified in this study should be examined on these same hosts in additional geographic areas for a more complete understanding of those relationships.

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