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ECTOPARASITES OF EASTERN AND WESTERN ATLANTIC BLUEFIN TUNAS

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SUMMARY

Ectoparasites of Atlantic bluefin tuna, Thunnus thynnus, were collected from fish captured in the western Atlantic from Cozumel Island and the Gulf of Mexico northward and eastward to the Gulf of Maine. Parasitic infestations were correlated with the ages of the host fish. Some fish of Mediterranean origin were examined also.

Two species of ectoparasites, the trematode Nasicola klawei and the copepod Elytrophora brachyptera, have interesting host distributions. The trematode is acquired in "tropical" waters of the western Atlantic in the spring and summer months, while copepod appears to be acquired in "temperate" waters of the eastern Atlantic during the fall and winter months. This permits an insight to the biology of the subadult bluefin tuna, enabling one to distinguish, among fish captured in the western Atlantic, those which had been born in the western Atlantic and those born elsewhere.

The sample sizes used are low, but based on the number of parasites and the incidence of infection, it seems reasonable to postulate an annual influx of Elytrophora-infested bluefin of ages I through V into western Atlantic stocks. The magnitude of the influx is approximately 15%. Some of the Elytrophora-infected fish also show the presence of Nasicola, thus they represent returns to the western Atlantic after a sojourn in the eastern Atlantic.

RESUME

Des ectoparasites du thon rouge de l'Atlantique (*Thunnus thynnus*) ont été prélevés sur des poissons capturés dans l'Atlantique ouest, selon une progression nord-est depuis l'île de Cozumel et le golfe du Mexique jusqu'au golfe du Maine. La contamination parasitaire a été étudiée en relation avec l'âge du poisson porteur. On a également examiné quelques poissons d'origine méditerranéenne.

Deux espèces d'ectoparasites, le trématode *Nasicola Klawei* et le copépode *Elytrophora brachyptera*, montrent un choix intéressant en ce qui concerne l'organisme porteur. Le trématode est contracté dans les eaux "tropicales" de l'Atlantique ouest au cours du printemps et de l'été, alors que le copépode l'est dans les eaux "tempérées" de l'Atlantique oriental pendant les mois d'automne et d'hiver. Ceci a fourni des aperçus sur la biologie du thon rouge sous-adulte, permettant ainsi de distinguer, parmi les poissons capturés dans l'Atlantique ouest, ceux qui sont nés dans cette zone et ceux qui sont nés ailleurs.

Les échantillons sont de faible importance; le nombre de parasites et la fréquence de la contamination permettent de supposer raisonnablement l'existence d'une arrivée annuelle dans le stock de l'Atlantique ouest de thons rouges d'âge 1-5 porteurs d'*Elytrophora*. L'importance de cette arrivé serait de quelque 15%. Quelques poissons porteurs d'*Elytrophora* montrent aussi des traces de *Nasicola*, ce qui indiquerait un retour dans l'Atlantique ouest à la suite d'un séjour dans l'Atlantique est.

RESUMEN

Fueron recogidos ectoparásitos del atún rojo del Atlántico (Thunnus thynnus), de los peces capturados en el Atlántico occidental de la Isla de Cozumel y el Norte del Golfo de México así como hacia el noreste del Golfo de Maine.

Plagas de parásitos fueron correlacionados con las edades de los peces infectados. También fueron examinados algunos peces originales del Mediterráneo.

Es interesante la distribución de estos ectoparásitos, los trematodos (Nasicola klawei) y los copépodos (Elytrophora brachyptera) . El trematodo se adquiere en aguas "tropicales" del Atlántico occidental, en los meses de primavera y verano, mientras que el copepodo parace ser adquirido en aguas "templadas" del Atlántico oriental durante los meses de otoño e invierno. Esto permite una visión de la biología del atún rojo sub-adulto, lo que permite distinguir entre los peces capturados en el Atlántico occidental , aquellos nacidos en dicha zona de los que nacieron en otras aguas.

El tamaño de las muestras son pequeñas, pero basandose en el número de parásitos y la frecuencia de infección, parece razonable postular una afluencia anual de edad de atún rojo infectado de Elytrophora de I a V a los stocks del Atlántico occidental. La magnitud de la afluencia es aproximadamente del 15%. Algunos de los peces infectados de Elytrophora, también muestran la presencia de Nasicola lo que sugiere que han retornado al Atlántico occidental, tras una estancia en el Atlántico oriental.

INTRODUCTION

The occurrence of two kinds of ectoparasites on bluefin tuna in the eastern and western North Atlantic indicate that certain school bluefin tuna in the western Atlantic have a life history different from bluefin tuna of similar age in other areas of the Atlantic. The available data suggest that a similar phenomenon might also prevail in the eastern Atlantic and Mediterranean populations of school bluefin tuna. The parasites are the monogenetic trematode Nasicola klawei (Stunkard) which inhabits the nasal capsules and the caligoid copepod Elytrophora brachyptera Gerstaecker which inhabits the gill chambers. Both parasites have been found in most of the giant bluefin examined from the western Atlantic, whether the fish were caught in tropical, temperate, or boreal waters; most giant bluefin contain both species of parasite. The occurrence of the parasites on school tuna (under age 9) do not present the same picture.

MATERIALS AND METHODS

Parasites were obtained from bluefin tuna collected in 1977-1979 (Table 1). When time permitted, the trematodes removed from the nasal capsules of bluefin tuna were flattened on microscope slides, flooded with 10% formalin, and fixed between glass slides to permit accurate measurements of length and width. Copepods were placed into 10% formalin directly. Preservation was done with 50% isopropanol.

Host age 0 represents western Atlantic fish taken off Miami (20) and off the mouth of Chesapeake Bay (2); ages I through VIII represent western Atlantic fish taken from off North Carolina northward to New England; western Atlantic giants of ages IX and greater were collected off Cozumel, Mexico (1), Gulf of Mexico (14), Bahamas-Florida (8), and Cape Hatteras northeast to Gloucester, Massachusetts (35).

Three terms concerning the parasitic infestation are defined as follows:

Intensity - mean number of parasites found in all host individuals examined (including those which lack parasites).

Incidence - frequency of infested hosts, or 1.0 minus the frequency of uninfested hosts.

Dosage - mean number of parasites found on infested hosts.

RESULTS

Nasicola klawei (Stunkard)

The host fish were carefully examined for this parasite by probing the nasal capsules manually with forceps and by repeated flushings of the recesses of the capsules with a syringe. The total worm count for both capsules was determined and the parasites smoothed and flattened prior to formalin fixation. Body outline areas were estimated by measuring length and width to at least 0.1 mm and multiplying the product of length x width by 0.7854 to allow for the ellipsoidal to cardioid body shape. Data concerning the dosage of the parasite among the host fish by age class are summarized in Tables 2 and 3. Frequency distributions of parasite outline areas versus age of host are given in tables 4 and 5.

The worms in age 0 western Atlantic fish are smallest and represent a recently acquired infestation, probably no older than 2-3 months. The infestation dosage of school tunas (ages 0 through VIII) is fairly uniform,

the mean dosage for all ages is 1.99 worms per infested fish (range in year means 1.44-2.21, 229 parasites from 115 infested fish), and none of the 201 school tunas examined was found to harbor more than 4 parasites.

Age 0 western Atlantic fish become infested somewhere between the spawning grounds in the Gulf of Mexico and their capture point off Miami, but school tunas of greater age apparently do not reenter tropical waters, thus accounting for the fairly uniform dosage in all ages of school bluefins. This does not appear to be a size-limited phenomenon, since there is at least a four-fold increase in fork length from age 0 through age VIII hosts, indicating at least a 16-fold increase in the surface area of the nasal capsules whereas the parasite exhibits only about a 4-fold increase in body outline area during this time. In a sense, the parasite fails to make use of the amount of available habitat.

There appears to be a modest amount of parasite recruitment among school tunas older than 0 years as indicated by the occasional appearance of small worms in older fish (e.g., host age IV in Table 4), but this seems insufficient to increase the infestation above the values found in 0- and I-year-old fish. The parasite may reproduce at a greatly reduced rate outside of tropical waters, or some older school tunas may occasionally enter tropical waters.

The foregoing statements lead to the conclusion that Nasicola klawei must be a long-lived parasite, capable of surviving many years in its host. The incidence of the infestation is then of interest in these western Atlantic school bluefin tuna because even though dosage remains fairly constant, incidence declines from 0.86 at age 0 to 0.18-0.36 in fish of ages V to VIII. A plausible explanation is that the western Atlantic school bluefin stock is augmented by periodic influxes of fish which lack the parasite because they were not born in the Gulf of Mexico.

The Mediterranean Sea does serve as a spawning ground for Atlantic bluefin tuna, and eastern Atlantic bluefin tuna were examined for this study. Sixteen Mediterranean bluefin representing ages 0 (9 specimens), I (2 specimens), III (1 specimens), IV (3 specimens) and V (1 specimens) were found to be free of the nasal parasite; the worm may be absent from Mediterranean bluefin tuna.

The parasite was found in eastern Atlantic school bluefin tuna from the Bay of Biscay. Five of the 53 fish examined were parasitized (Tables 3, 5). The 5 specimens yielded 10 worms for a mean dosage of 2.00, comparable with western school bluefin data, the sizes of the Biscay worms compare favorably with those from western Atlantic school bluefin of the same ages as the Bay of Biscay hosts. I conclude that parasitized bluefin tuna sampled in the Bay of Biscay may have been spawned in the Gulf of Mexico.

Elytrophora brachyptera Gerstaecker

None of the age-0 and age-I bluefin tuna sampled from the western Atlantic were found to contain this copepod (N_{host} = 22 for age-0, 25 for age-I) (Tables 6 and 8). None were found in age-0 Mediterranean fish (N_{host} = 9), but the parasite was found in 9 of 16 age-I bluefin from the eastern Atlantic and the Mediterranean for an incidence of 0.56 in that age group (Tables 7 and 9). For older western Atlantic school bluefin, 24 fish ages II through VI contained 129 copepods with 1-22 parasites apiece for a mean dosage of 5.38 and an incidence of 0.19; for ages II and III, 20.5% of the western Atlantic fish were infested (N_{host} = 88). Tables of Poisson Probabilities indicate that a dosage of 5.38 is the expected value for a host population in which nearly 100% of the fish are

infested which is inconsistent with the observed incidence of 19% for the parasite in western Atlantic hosts II to VI years old. These parasitized fish may have originated from a highly-infested population outside the western Atlantic, possibly from the eastern Atlantic. Twenty-one of the 44 eastern Atlantic and Mediterranean bluefin of ages II-VI were parasitized for an incidence of 0.48 or 48%.

DISCUSSION

The distributions of the two parasites in western Atlantic school bluefin tuna is non-random, suggesting that the western Atlantic bluefin stock consists of fish that were born in the Gulf of Mexico and those born elsewhere, perhaps in the Mediterranean. If the parasites were distributed completely at random in a homogeneous host stock, and considering the numbers of fish infested, then 9.67 fish of ages II-VI should have been found with both parasites (52 with N. klawei x 24 with E. brachyptera / 129 total hosts). Instead, only 3 fish were found to contain both parasites.

It appears that Nasicola klawei (Stunkard) could be utilized as a biological tag to identify those bluefin tuna under the age of nine years which were produced in tropical waters, namely the Gulf of Mexico in the western Atlantic. Elytrophora brachyptera Gerstaecker appears to be acquired by bluefin tuna in temperate waters of the eastern Atlantic. Its absence from tuna younger than age II in the western Atlantic and its low incidence in western Atlantic fish suggests that infested bluefin probably acquired the parasite while in the eastern Atlantic, and perhaps only 15-20% of the western Atlantic school bluefins are annually recruited from the eastern Atlantic.

The accompanying table (10) summarizes what may be tentatively inferred about school tuna components on both sides of the Atlantic, based on ectoparasites. Further study is indicated to strengthen the data and permit more concrete conclusions.

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Table 1. Age, size, number, and origin of Atlantic bluefin tuna examined in 1978 and 1979 for ectoparasites.

		Number examined	
Age	Fork Length (cm)	Western Atlantic	Eastern Atlantic
0	under 50	22	9 (Mediterranean)
I	51-65	25	16 (2 Mediterranean, 14 Bay of Biscay)
II	66-85	62	24 (Bay of Biscay)
III	86-105	26	1 (Mediterranean)
IV	106-120	24	6 (3 Mediterranean, 3 Bay of Biscay)
V + VI	121-155	17	13 (1 Mediterranean, 12 Bay of Biscay)
VII + VIII	156-180	25	0
IX + (Giants)	180 ++	58	0
		259	69

Table 2. Number of Nasicola klawei found on bluefin tuna sampled from the western Atlantic, 1978-1979.

Host Age	Number of Parasites																					Infestation		
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Intensity	Incidence	Dosage
0	3	3	11	4	1																	1.86	0.86	2.16
I	6	4	9	4	2																	1.68	0.76	2.21
II	24	15	10	13																		1.21	0.62	1.95
III	18	3	3	2																		0.58	0.31	1.88
IV	5	10	3	2	4																	1.58	0.79	2.00
V-VI	14	1	1	1																		0.35	0.18	2.00
VII-VIII	16	6	2	1																		0.52	0.36	1.44
Giant (IX up)	4	6	8	4	6	5	6	2	3	2	1	3			1	3	1	2			1	5.98	0.93	6.43

Table 3. Number of Nasicola klawei found on bluefin tuna sampled from the eastern Atlantic, 1979*.

Host Age	Number of parasites					Infestation		
	0	1	2	3	4	Intensity	Incidence	Dosage
I	12		1		1	0.43	0.14	3.00
II	22	1	1			0.13	0.08	1.50
IV	3					0.00	0.00	0.00
V-VI	11	1				0.08	0.08	1.00

*None of the 16 Mediterranean hosts examined for this study were found to harbor the parasite. Data in the table all pertain to bluefin tuna from the Bay of Biscay.

Table 4. Nasicola klawei, body outline area*

Worm Size, mm, mid-value of cell	Age of western Atlantic host							
	0	I	II	III	IV	V-VI	VII-VIII	IX up
10	4							
30	17				1			
50	15	2	3					6
70	2	11	6	1		2		3
90		14	23	4	4			6
110		7	16	5	3			11
130		4	10	5	15	1		18
150			10		4			11
170			1		8	2	1	17
190					2	1		13
210								18
230								19
250								15
270								15
290								10
310								4
330								1
par	38	38	68	15	37	6	1	167
outline area, mm	38.17	89.93	107.37	111.36	134.14	131.30	168.56	191.95
Range, mm	3.0-64.9	55.4-137.9	47.1-163.9	71.4-136.8	29.7-181.5	65.6-189.5		41.8-327.0

*Area = length x width x 3.141593

Table 5. Nasicola klawei, body outline area*

Worm Size, mm, mid-value of cell	Age of eastern Atlantic host** I	II	V-VI
70	2		
90		1	
110	1	1	
130	3	1	
150			1
par	6	3	1
X outline area, mm	106.44	111.13	
Range, mm	68.6-132.5	93.9-134.7	142.08

*Area = length x width x 3.141593/4

**Fish sampled from Bay of Biscay at St. Jean-de-Luz, France.

Table 6. Elytrophora brachyptera females from western Atlantic hosts, total length.*

Host locality, N host infested, age	Mid-value of cell, mm 7.75	8.25	8.75	9.25	9.75	10.25	10.75	11.25	11.75	12.25	Parasites N	$\bar{x}$	Range
ages 0-VI													
0 of 22 age 0													
0 of 25 age I													
12 of 62 age II		1			2	7	13	10	3		36	10.74	8.1-12.0
6 of 26 age III						2	5	6		1	14	11.01	10.3-12.0
4 of 24 age IV			1			1	6	10	3		21	11.03	8.5-11.9
2 of 17 age V-VI						1	1	2	1	2	7	11.39	10.4-12.2
VII-VIII not sampled													
Cumulative, 24 of 176		1	1		2	11	25	28	7	3	78	10.92	8.1-12.2
Frequency, ages 0-VI		.013	.013		.026	.141	.321	.359	.090	.038			
Giants													
Cozumel, 1 giant		7	11	18	4	1	8	24	18		91	10.30	8.1-12.0
G.Mexico, 8 giants	1	11	31	69	25	24	51	59	26	1	298	10.15	7.6-12.0
Fl-Bahamas, 3 giants	1	3	7	8	5	19	57	56	17	1	174	10.73	7.8-12.2
New England, 10 giants		15	36	65	17	4	24	41	8		210	9.80	8.0-12.0
Cumulative, 22 giants	2	36	85	160	51	48	140	180	69	2	773	10.20	7.6-12.2
Frequency, 22 giants of 22 examined	.003	.047	.110	.207	.066	.062	.181	.233	.089	.003			

*Ramal setae not included in total length measurement.

Table 7. Elytrophora brachyptera females from eastern Atlantic hosts, total length.*

Host locality, N host infested, age	Mid-value of cell, mm 8.75	9.25	9.75	10.25	10.75	11.25	11.75	Parasites N	$\bar{x}$	Range
Biscay Bay, 8 of 14 age I	2	5			2	1		10	9.64	8.7-11.3
Biscay Bay, 7 of 24 age II			5	4	3	9	1	22	10.66	9.7-11.5
Biscay Bay, 2 of 3 age IV			2		3	2		7	10.66	9.6-11.3
Biscay Bay, 11 of 12 age V-VI		1	2	8	14	9	4	38	10.78	9.3-11.6
Mediterranean, 0 of 9 age 0										
Mediterranean, 1 of 2 age I				1				1		10.1
Mediterranean, 0 of 1 age III										
Mediterranean, 0 of 3 age IV										
Mediterranean, 1 of 1 age V-VI		2						2	9.35	9.2-9.5
Cumulative, 30 of 69 ages 0-VI	2	8	9	13	22	21	5	80	10.55	8.7-11.6
Frequency	.025	.100	.113	.163	.275	.263	.063			

*Ramal setae excluded from measurement.

Table 8. Elytrophora brachyptera males from western Atlantic hosts, total length.*

Host locality, N_{host} infested, age	Mid-value of cell, mm								Parasites N	$\bar{x}$	Range
	6.25	6.75	7.25	7.75	8.25	8.75	9.25	9.75			
0 of 22 age 0									0		
0 of 25 age I									0		
12 of 62 age II					10	12	4	1	27	8.65	8.1-9.6
6 of 26 age III	1					1	3		5	8.60	6.4-9.3
4 of 24 age IV		1		2	2	1	8		14	8.60	6.8-9.5
2 of 17 age V-VI						2	1		3	8.89	8.6-9.3
VII-VIII not sampled											
Cumulative, 24 of 176 ages 0-VI	1	1		2	12	16	16	1	49	8.65	6.4-9.6
Frequency, ages 0-VI	.020	.020		.041	.245	.327	.327	.020			
Giants											
Cozumel, 1 giant		5	8	1	2	7	7		30	7.98	6.7-9.1
G.Mexico, 8 giants	4	21	39	14	18	40	23	7	166	8.02	6.2-9.8
Fl-Bahamas, 3 giants	1	3	3	3	15	43	9	2	79	8.53	6.3-9.5
New England, 10 giants	4	32	28	1	6	32	6	1	110	7.66	6.3-9.7
Cumulative, 22 giants	9	61	78	19	41	122	45	10	385	8.02	6.2-9.8
Frequency, 22 giants of 22 examined	.023	.158	.203	.049	.106	.317	.117	.026			

*Ramal setae not included in total length measurement.

Table 9. Elytrophora brachyptera males from eastern Atlantic host, total length*

Host locality, N_{host} infested, age	Mid-value of cell, mm					Parasites N	$\bar{x}$	Range
	7.25	7.75	8.25	8.75	9.25			
Biscay Bay, 8 of 14 age I		2	3	1		6	8.21	7.7-8.7
Biscay Bay, 7 of 24 age II		2	3	4	4	13	8.62	7.8-9.4
Biscay Bay, 2 of 3 age IV	1		3	2	1	7	8.38	7.4-9.1
Biscay Bay, 11 of 12 age V-VI	1	4	8	12	3	28	8.45	7.4-9.2
Mediterranean, 0 of 9 age 0						0		
Mediterranean, 1 of 2 age I	1		1	1		3	8.47	7.7-9.2
Mediterranean, 0 of 1 age III						0		
Mediterranean, 0 of 3 age IV						0		
Mediterranean, 1 of 1 age V-VI						0**		
Cumulative, 30 of 69 ages 0-VI	3	8	18	20	8	57	8.46	7.4-9.4
Frequency	.053	.140	.316	.351	.140			

*Ramal setae excluded from measurement.
**This host contained only female copepods.

Table 10. Possible composition of certain tuna schools

Age	Western Atlantic	Eastern Atlantic* (Bay of Biscay)
0	86% with Nasicola, 0% with Elytrophora. All of western Atlantic origin, no eastern Atlantic component.	No information
I	76% with Nasicola, 0% with Elytrophora. At least 90% of western Atlantic origin, possibly 10% eastern Atlantic component.	14% with Nasicola, 57% with Elytrophora. At least 85% of eastern Atlantic origin, possibly 15% western Atlantic component.
II	62% with Nasicola, 19% with Elytrophora. About 75% of western Atlantic origin, 25% eastern Atlantic component.	8% with Nasicola, 29% with Elytrophora. About 85% of eastern Atlantic origin, possibly 15% western Atlantic component.
III	31% with Nasicola, 23% with Elytrophora. About 50% of western Atlantic origin, 50% eastern Atlantic component.**	No information.
IV	79% with Nasicola, 17% with Elytrophora. About 90% of western Atlantic origin, 10% eastern Atlantic component, some "returns" to western Atlantic.	0% with Nasicola, 67% with Elytrophora. Evidently nearly 100% of eastern Atlantic origin.
V-VI	18% with Nasicola, 12% with Elytrophora. At least 20% of western Atlantic origin, but Nasicola may be dying off so percentage may actually be higher. Eastern Atlantic component probably under 20%.	8% with Nasicola, 92% with Elytrophora. About 90% of eastern Atlantic origin, 10% western Atlantic component.

*The scanty data on Mediterranean fishes suggest there may be no western Atlantic component, but further study is indicated.

**The copepods probably die after their second summer on the host, as indicated by the bimodal size groupings of male and female parasites from giant tunas, Tables 6 and 8. School tunas may not be regularly exposed to the infestive stage of the parasite.