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Gastrointestinal Parasites in the Waved Albatross (*Phoebastria irrorata*) of Galápagos

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ABSTRACT: Using a fecal flotation technique, we detected three genera of endoparasites in the critically endangered Waved Albatross (*Phoebastria irrorata*) of Galápagos. These genera were *Contracaecum*, *Tetrabothrius*, and *Cardiocephaloides*. Juvenile albatrosses were more likely to be infected than adults, but we found no effect of sex or mass on infection probability.

The Waved Albatross (*Phoebastria irrorata*) is a long-lived, pelagic seabird endemic to Ecuador. The vast majority (~99.9%) of birds breed on Española Island, Galápagos Archipelago. The species is considered critically endangered, given its limited geographic distribution and recent declines in population size and apparent survival (International Union for Conservation of Nature 2013). Although the principal threat is mortality as bycatch in fisheries in continental coastal waters (Awkerman et al. 2006), the El Niño Southern Oscillation-mediated effects on vital rates and pathogens may also contribute to observed declines.

Disease can have disastrous consequences for vulnerable albatross populations by hastening mortality or reproductive failures that contribute to demographic change (Weimerskirch 2004). Disease in albatrosses is not well documented, in part, because it can be difficult to detect in species that spend only a short time on land, often on remote islands. Ectoparasites are most often described affecting albatrosses, though bacteria, viruses, fungi, and endoparasites are also represented (Barbosa

and Palacios 2009). Ectoparasites are present in nests and on breeding adult Waved Albatrosses (K.P.H. pers. obs.), but endoparasites have not been considered in detail.

We surveyed live Waved Albatrosses for gastrointestinal parasites and tested effects of sex, age (juvenile or adult), and mass on the probability of infection with one or more parasites. We expected males to be more frequently infected, given an apparently broader foraging range (S. Cruz unpubl. data), stronger association with fisheries (Awkerman et al. 2006), and generally larger body size. We also hypothesized that adults would be more frequently parasitized given their greater cumulative exposure.

We collected cloacal swab samples from 229 Waved Albatrosses. Birds not already carrying a band were banded, and weight, tarsus, and culmen measurements were taken to determine sex (Awkerman et al. 2007). We collected samples from 205 adults in May (78 males, 82 females, and 45 undetermined sex) and 24 juveniles in November 2011 from breeding colonies on Española (1°23'S, 89°35'W). Swab samples were fixed in 10% formalin, stored in cryovials at 4 C, and analyzed in laboratories at the Charles Darwin Foundation and the International Zoonosis Center at Central University of Ecuador (Quito). Samples were processed by using a modified McMaster flotation technique (Sloss and Kemp 1978) and microscopy; samples were of insufficient

volume to quantify the intensity of infection. Any parasite proglottids or eggs that were encountered were measured by using an eyepiece micrometer, recorded digitally, and identified to genus using descriptive information on the life history and morphology of parasite genera infecting this and other marine bird taxa (Cordero del Campillo et al. 1999; Garbin et al. 2007; Fredes et al. 2008; J. Mendoza and L. Sánchez pers. comm.).

We explored the associations between infection status and sex, age, and mass in three separate logistic regression analyses. We considered two models in each analysis: one incorporating an effect of the predictor variable of interest and a second model of no effect (i.e., null model). We used the small sample size-corrected version of Akaike's information criterion and their differences to rank the two models (Burnham and Anderson 2002). We used Akaike weights (w_i) as measures of the probability of each model and their ratio (evidence ratio [ER]) for inference.

Of 229 samples analyzed, 32 (14%) were positive, including 25 adults (12%) and seven (29%) juveniles. We detected evidence of three genera of gastrointestinal parasite: eggs (57 μ long by 47 μ wide, on average) of the genus *Contracaecum*

(Nematoda) in 13 samples (41%); eggs and proglottids (71 \times 52 μ and 20 \times 5 mm, on average, respectively) of the genus *Tetrabothrius* (Cestoda) in seven albatrosses (22%); and eggs (52 \times 45 μ , on average) of the genus *Cardiocephaloides* (Trematoda) in 12 hosts (38%). No sample had evidence of parasitism with two genera. The model incorporating an effect of age was three times more likely than the model of no effect ($w_i=0.75$ and ER=3.04; Table 1); juveniles were more likely to have an endoparasite than adults. The models of no effect were higher ranked than those incorporating sex or mass effects (Table 1).

Our findings corroborate reports of several species of *Tetrabothrius* infecting albatrosses (overview in Schmidt 1986), including *Tetrabothrius strangulatus* found among specimens collected from a Waved Albatross (Baylis 1914). *Contracaecum* spp. are commonly seen in fish-eating birds, including albatrosses (e.g., Garbin et al. 2007) and other species of marine birds from Galápagos (Carrera-Játiva et al. 2014). Intermediate stages of *Contracaecum* spp. could be present in some species of widely distributed crustacea or fish (Cordero del Campillo et al. 1999) on which these birds feed. *Cardiocephaloides brandesii* has been reported

TABLE 1. Pairs of logistic regression models and rankings examining the effects of sex, age (juvenile or adult), and mass on the probability of detecting an endoparasite in a sample collected from a Waved Albatross (*Phoebastria irrorata*).

Model ^a	<i>n</i>	<i>K</i>	-2LL	AICc	Δ AICc	w_i	ER
Sex							
No effect	161	1	124.68	126.71	0.00	0.73	0.36
Effect		2	124.33	128.74	2.03	0.27	
Age							
No effect	229	1	185.26	187.28	2.23	0.25	3.04
Effect		2	181.00	185.05	0.00	0.75	
Mass							
No effect	165	1	125.79	127.82	0.00	0.73	0.37
Effect		2	125.72	129.80	1.99	0.27	

^a The sample size (*n*), number of parameters (*K*), -2 times the log likelihood (-2LL), and bias-corrected Akaike information criterion values (AICc) are listed. Models are ranked by their AICc differences (Δ AICc) relative to the best model in the pair of models. The Akaike weights (w_i) are model probabilities given the model set, and the data and the evidence ratio (ER) is the ratio of the weights of the two models of interest. For example, the model incorporating an age effect is approximately three times more likely than the model without an age effect.

from a dead Waved Albatross in the field (J. Mendoza and L. Sánchez pers. comm.), but to our knowledge, this is the first report of this genus from live albatrosses.

We found support for the idea that juveniles were more likely to be infected with gastrointestinal parasites than breeding-age adults (≥ 5 yr old). This could be linked to the species' foraging ecology: parents feed chicks with regurgitant, including fish, squid, and crustaceans (Harris 1973), groups that serve as intermediate hosts for parasites from all three of these genera (Cordero del Campillo et al. 1999). We detected parasites in juveniles more often, perhaps because their immune response may not be as well developed as adults, if maternally derived protection has waned (Boulinier and Staszewski 2008) and their own immune systems had not fully developed when we sampled them at ~ 5 mo of age.

The health of pelagic species, such as albatrosses, may serve as an early indicator of a marine ecosystem's resilience to change (Piatt et al. 2007). Our findings provide a foundation for future work on the implications of parasitism for Waved Albatrosses and the marine ecosystems they inhabit.

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