Rail as an opportunistic omnivore that occupies a relatively broad feeding niche within marsh ecosystems, mesh well with our observations. It is doubtful that food is a limiting factor for the Light-footed Clapper Rail in marshes that have not been badly degraded.

Barbara W. Massey provided observations that contributed substantially to our understanding of Clapper Rail foraging and made suggestions that greatly improved this paper. We thank the California Department of Fish and Game for storage space and access at Upper Newport Bay and the U.S. Fish and Wildlife Service and U.S. Navy for access to the Seal Beach National Wildlife Refuge. C. T. Collins and J. R. Gustafson are acknowledged for continued support. P. D. Jorgensen and M. Pruett-Jones collected some of the pellets for analysis. Our work was partially supported by state tax check-off funds for research on endangered and threatened wildlife, made available by the California Department of Fish and Game through a contract with California State University, Long Beach.

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EGGSHELL DIFFERENCES BETWEEN PARASITIC AND NONPARASITIC ICTERIDAE[1]

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Key words: Eggshell thickness; eggshell mass; parasitic icterids; Icteridae.

In their recent report Spaw and Rohwer (1987) state that good comparative data on the relative eggshell thickness for both parasitic and nonparasitic species of the family Icteridae are largely lacking and present measurements of several parasitic *Molothrus* species which showed significantly greater shell thickness compared with 17 nonparasitic representatives. These authors suggest that the thicker eggshell may be an adaptation to parasitism, making eggs more resistant to damage by the host species. In this report we call attention to and review additional data from the tables

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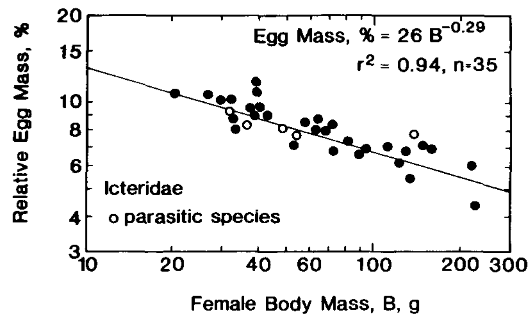

FIGURE 1. Log-log regression of relative egg mass (% of body mass) on female body mass, which shows that the relative egg mass of parasitic and nonparasitic taxa is similar. Data from Schönwetter.

of Schönwetter (1981–1983) who described the egg mass, length and breadth, shell thickness and shell mass for 120 species or subspecies of the family Icteridae, 14 of which are parasitic. He also listed the female body mass and relative egg mass, (egg mass/female body mass × 100%) of 35 species, five of which are parasitic. Analysis of these data is presented below and shows that shell thickness, shell mass, and relative shell mass are significantly larger in parasitic eggs, but that relative egg mass is similar for both parasitic and nonparasitic taxa.

RELATIVE EGG MASS

Figure 1 is a log-log plot of relative egg mass on female body mass for 35 species from the tables of Schönwetter (1981–1983). The parasitic representatives, marked by circles, show no deviation from the regression (see equation) which is nearly identical to the regression for passerine birds in general based on egg mass-female body mass data for 1,244 species where percent egg mass = $26B^{-0.27}$ (Rahn et al. 1985).

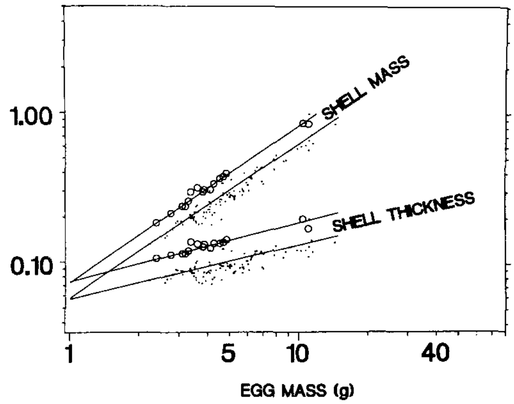

FIGURE 2. Log-log regression of shell mass and shell thickness on egg mass for parasitic (circles) and nonparasitic (dots) taxa of the family Icteridae. Ordinate dimensions are g for shell mass and mm for shell thickness. Regression equations are shown in Table 2.

SHELL MASS AND SHELL THICKNESS

Table 1 lists egg mass, shell mass, and shell thickness for 14 parasitic taxa taken from the tables of Schönwetter. It also lists the dimensions for *Molothrus badius*, the only nonparasitic species of this genus, whose nests, according to Schönwetter, are parasitized by eggs of *M. rufoaxillaris* and whose egg dimensions do not appear to be significantly different from the other parasitic species. The shell mass and shell thickness for the parasitic (circles) and nonparasitic (dots) taxa are regressed on egg mass in Figure 2 and the allometric regression equations are presented in Table 2. The exponents of the parasitic and nonparasitic species for shell mass or shell thickness do not differ significantly ($P > 0.05$), based on the construction of 95% confidence intervals (Draper and Smith 1981). However,

TABLE 1. Egg and eggshell dimensions of parasitic species of the family Icteridae listed by Schönwetter (1981–1983). Also shown are the values for *Molothrus badius badius*, reported to be nonparasitic.

Species and subspecies	Egg mass (g)	Shell mass (g)	Shell thickness (mm)	*n*
Molothrus badius badius	4.10	0.320	0.127	35
Molothrus rufoaxillaris	3.64	0.320	0.134	92
Molothrus bonariensis cabanisii	4.90	0.400	0.143	4
Molothrus bonariensis aequatorialis	3.90	0.310	0.133	17
Molothrus bonariensis venezuelensis	3.85	0.300	0.128	25
Molothrus bonariensis minimus	2.78	0.215	0.113	29
Molothrus bonariensis riparius	3.40	0.300	0.138	1
Molothrus bonariensis bonariensis	4.12	0.327	0.131	295
Molothrus aeneus loyei	4.15	0.310	0.125	61
Molothrus aeneus ossimilis	4.85	0.369	0.135	1
Molothrus ater artemisiae	3.22	0.239	0.115	41
Molothrus ater obscurus	2.40	0.185	0.107	50
Molothrus ater ater	3.12	0.240	0.115	181
Scaphidura oryzivora impacifica	10.59	0.870	0.197	4
Scaphidura oryzivora oryzivora	11.20	0.860	0.170	84

TABLE 2. Regression equations of shell mass and shell thickness on egg mass of parasitic and nonparasitic species or subspecies of the family Icteridae from the tables of Schönwetter (1981–1983). The form of the equation is $Y = aWb$, where a = constant, b = exponent, W = egg mass, g, ± SE = standard error of exponent, $\underset{\div}{\times}$SEE = antilog of standard error of regression by which each predicted value is multipled or divided, r^2 = coefficient of determination, and n = number of observations.

Dependent variable		Regression parameter					
		a	b	±SE	$\underset{\div}{\times}$SEE	r^2	n
Shell mass (g)	Parasitic	0.0784	1.009	0.03	1.06	0.99	14
	Nonparasitic	0.0579	1.028	0.03	1.12	0.92	106
Shell thickness (mm)	Parasitic	0.0810	0.344	0.04	1.06	0.88	14
	Nonparasitic	0.0574	0.355	0.03	1.12	0.59	106

the constants are significantly different ($P < 0.05$), indicating that eggs of parasitic species have greater shell mass and thicker shells than those from nonparasitic species of equivalent egg mass. For example, a 4.70-g parasitic egg has a shell 31% heavier and 39% thicker than a 4.70-g nonparasitic egg.

RELATIVE SHELL MASS

Relative shell mass is defined as (shell mass/egg mass) × 100 and expressed as percent. When relative shell mass for both the parasitic and nonparasitic Icteridae are regressed against egg mass, the slopes are not significantly different from zero, indicating that relative shell mass is independent of egg mass. Therefore, the mean values of relative shell mass for both groups can be compared directly. The mean for parasites was 7.96 (0.43) %, which is significantly greater than the mean of 6.10 (0.71) % for nonparasites ($P < 0.001$ in a t-test performed after arcsine transformation of the data).

COMMENTS

In his introduction to the tables of the family Icteridae (Vol. 3) and in his general summary of egg dimensions (Vol. 4) Schönwetter (1981–1983, 1985–1986) discusses at some length the differences in shell dimension between parasitic and nonparasitic taxa among the Cuculidae and Icteridae. For the latter group he gives shell mass as 7.88% for parasitic and 6.28% for nonparasitic species, which are similar to the means we calculated. He also gives the mean relative shell mass for 20 host species, namely, 6.18%. Schönwetter was well aware of the existence of differences in shell thickness and shell mass. However, he also realized that one should not merely compare their mean differences because both shell thickness and shell mass are also related to egg mass. To adjust for this factor we regressed his values on egg mass (Fig. 2, Table 2). When these two dimensions are merely averaged, their significant difference disappears.

How significant is a 39% increase in shell thickness in protecting the shell from damage? The first gross sign of shell deformation, when a force F (kg) is applied to an egg, was measured by Ar et al. (1979) in 47 species ranging in mass from 0.86 g to 1,460 g. They showed that $F\,(\text{kg}) = 17.5 \times L^2$ where L = shell thickness (mm). From Table 2 one calculates a shell thickness of 0.137 and 0.099 mm, respectively, for a 4.7-g egg of a parasitic and a nonparasitic species. Substituting these two values into the above equation predicts the breaking strength for parasitic eggs to be 92% greater than in nonparasitic eggs.

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