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MORPHOMETRICS, METABOLIC RATE AND BODY TEMPERATURE OF THE SMALLEST FLIGHTLESS BIRD: THE INACCESSIBLE ISLAND RAIL[1]

PETER G. RYAN, BARRY P. WATKINS, AND W. ROY SIEGFRIED
Percy FitzPatrick Institute of African Ornithology, University of Cape Town, Rondebosch 7700, South Africa

Key words: Atlantisia rogersi; *body temperature; flightlessness; Inaccessible Island; metabolic rate.*

The Inaccessible Island Rail *Atlantisia rogersi* is restricted to Inaccessible Island (37°15′S, 12°30′W), a 12-km^2 island in the Tristan da Cunha Island group, central South Atlantic Ocean. It is the only extant member of its genus (Olson 1973) and it is generally accepted to be the smallest flightless bird in the world (Collar and Stuart 1985), although there are few published morphometric data (Lowe 1928, Hagen 1952). The wings and tail are greatly reduced, and the feathers have few barbules, resulting in a soft, hair-like plumage unique among rails (Lowe 1928). Little is known of the ecology of the Inaccessible Island Rail (Collar and Stuart 1985). It is widespread at Inaccessible Island, occurring in almost all habitats, but spends much of its time in runs and burrows (Lowe 1928, Hagen 1952). We present morphometric data for Inaccessible Island Rails and examine their metabolic rate and body temperature to assess the extent to which their lifestyle has modified their energy metabolism.

MATERIALS AND METHODS

We caught Inaccessible Island Rails using mist nets, scoop nets, or by hand during September–October 1987 and October–November 1988. We measured, aged, and sexed birds (after Elliott 1957, Richardson 1984), and recorded linear measures with Vernier calipers (for bill measurements, to the nearest 0.1 mm) or a stopped wing rule (for flattened wing chord and tarsus, to the nearest 0.5 mm). Mass was recorded to the nearest 0.2 g on a 100 g Pesola balance. Student's *t*-tests were used to test the significance of intersexual size differences.

We estimated metabolic rates (MR) from oxygen (O_2) consumption measured in translucent, airtight chambers (volume 5 liter) using an open flow-through system. Air from outside the laboratory was pumped through a regulating flowmeter into the chamber, over the bird, and out through the following equipment: a silica gel drying tube, a Rotameter flowmeter, and a silica gel/Carbosorb/silica gel tube leading to a Taylor Servomex OA570 paramagnetic oxygen analyzer (after Adams and Brown 1984). Incurrent air was used to set the oxygen analyzer at a standard 20.94 $\%O_2$ every hour during experiments. The Rotameter flowmeter was calibrated against a Hastings Mass Flowmeter (Model ECPR-1A).

Esophageal temperature (assumed to approximate core body temperature, T_b) was measured within 1 hr of capture using a thermocouple inserted at least 15 mm down the esophagus. We then placed test birds into a chamber and allowed them to become accustomed to their surroundings for 1 hr before taking readings of flow rate, $\%O_2$, and chamber temperature. Readings were taken at 30-min intervals for 22 hr, after which time we again recorded esophageal tempera-

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TABLE 1. Morphometrics of male and female Inaccessible Island Rails.

Dimension (mm/g)	Males ($n = 6$)		Females ($n = 7$)		Significance	
	$\bar{x} \pm$ SD	Range	$\bar{x} \pm$ SD	Range	t_{11}	$P <$
Culmen length	21.4 0.4	20.7–22.0	19.8 0.2	19.5–20.1	9.01	0.001
Bill depth (at base)	7.5 0.2	7.4–7.8	6.9 0.4	6.2–7.5	3.06	0.05
Bill width (at base)	5.3 0.2	5.1–5.5	4.9 0.2	4.6–5.2	3.58	0.01
Tarsus	22.9 0.9	22.0–24.5	22.5 1.0	22.0–24.5	0.77	ns*
Wing	54.3 0.5	54.0–55.0	52.1 0.7	51.0–53.0	6.41	0.001
Mass†	41.8 3.8	38.0–49.0	36.9 2.8	34.0–42.0	2.58	0.05

* ns = not significant.
† $n = 12$, one sick female (mass 26.2 g) omitted.

tures, and birds were reweighed and released. During the experimental period, birds were subjected to ambient photoperiods and temperatures (12–24°C chamber temperatures).

O_2 consumption (at STPD) was calculated (Hill 1972) and converted to an energy equivalent assuming that 1 liter O_2 = 20.083 kJ. An estimate of standard metabolic rate (SMR) was calculated as the mean of the four lowest measures of energy consumption during the 22-hr test period.

RESULTS AND DISCUSSION

MORPHOMETRICS

We captured 13 adult Inaccessible Island Rails. Mean mass of six males and six females was 39.36 ± 4.09 g (excludes one sick female, mass 26.2 g). Males were significantly larger than females in all measures except tarsus length (Table 1). Elliott (1957) suggested that males were slightly larger than females, but gave no supporting data. Our morphometric data are less variable than previously published measurements (Hagen 1952) possibly because all birds sampled were at least 1 year old and all were measured by one person. Our culmen measurements are slightly longer than previous measurements probably as a consequence of using different measuring techniques.

METABOLIC RATE AND BODY TEMPERATURE

We measured metabolic rates and body temperatures for eight birds (five males and three females). Metabolic rates generally were greatest immediately after capture, suggesting that capture and subsequent handling is stressful. All periods used to estimate SMR (when O_2 consumption was lowest) were during the night, in accordance with the Inaccessible Island Rail being largely diurnal (Hagen 1952, Collar and Stuart 1985, pers. observ.). However, experimental birds were active at times throughout the night, and free-living birds were heard calling up until 22:00 and after 04:00.

Estimates of SMR from two individuals (19.8 and 30.3 $\text{kJ} \cdot \text{day}^{-1}$) were excluded from the analysis because the birds remained active and did not attain a stable, low MR. Mass-specific O_2 consumption for the other six birds was 1.03 ± 0.35 $\text{ml} \cdot \text{g}^{-1} \cdot \text{h}^{-1}$ (range = 0.66–1.70) giving an estimated SMR of 19.5 ± 5.4 $\text{kJ} \cdot \text{day}^{-1}$ (range = 12.5–25.5). This is only 60–68% of the basal metabolic rate (BMR) predicted for a 39.4 g bird from allometric equations for resting nonpasserine birds (28.8 $\text{kJ} \cdot \text{day}^{-1}$; Aschoff and Pohl 1970; 32.5 $\text{kJ} \cdot \text{day}^{-1}$; Kendeigh et al. 1977), a reduction in MR typical of groups considered to have relatively low BMRs (e.g., Caprimulgiformes and Coliiformes; Bartholomew and Trost 1970, Lasiewski et al. 1970).

Mean mass loss (±SD) during the approximately 24-hr period of enforced starvation was 5.7 ± 1.7 g (11–19% body mass), largely due to defecation and water loss. This fairly substantial mass loss may have contributed to the low estimate of MR (cf. Prinzinger et al. 1981, Weathers et al. 1983). However, starvation and dehydration is unlikely to have been a major factor reducing MR because all periods of lowest O_2 consumption occurred at night, irrespective of when experiments were started (three each in the morning and afternoon). Even the MRs of very small birds (<20 g) only fall below the initial postabsorptive level after fasts of 12 hr (Weathers et al. 1983).

Inaccessible Island Rail mean T_b immediately after capture (39.9 ± 0.7°C, range = 39.3–41.1) was higher than T_b after the experiment and enforced fast (38.5 ± 0.5°C, range = 37.8–39.2). This probably is due partly to exertion during capture and partly to starvation causing a reduction in T_b (Prinzinger et al. 1981, Shapiro and Weathers 1981). However, both measures of T_b are considerably lower than that predicted from an allometric relationship for all birds (42.5°C; McNab 1966). The fasting T_b is typical of food-restricted (but still active) individuals of the Coliiformes (Bartholomew and Trost 1970, Prinzinger et al. 1981). Like this order, the low T_b of the Inaccessible Island Rail may result from a low MR. However, the thermal conductance (and possible selective advantage) of the soft, hair-like plumage of the Inaccessible Island Rail warrants investigating.

Flying Rallidae do not have particularly low BMRs (mean BMR 102.7% of allometric predictions, $n = 5$, range = 83–118%; calculated from Kendeigh et al. 1977, Brent et al. 1984), suggesting a relationship between a low MR and flightlessness. Calder and Dawson (1978) reported low MRs from flightless ratites, but could not assess whether this was a consequence of flightlessness or taxonomic differences. Flightless birds typically do not have a lower metabolic capacity than do flying birds (Brackenbury 1984), and thus it is likely that the Inaccessible Island Rail's island lifestyle has resulted in its low BMR. Within its very limited spatial range, the Inaccessible Island Rail occurs at large population densities, and the limited information available on demography (delayed maturity, relatively small clutch size), suggests that, in the absence of major predators or competitors (Collar and Stuart 1985), the species has reached carrying capacity at Inaccessible Island. Such conditions probably favor energy conservative features, such as low BMR, small body size, and the evolution of flightlessness (Faaborg 1977). It would be interesting to determine whether the Inaccessible Island Rail also uses hypothermia to conserve energy (cf. Reinertsen 1983). Further research on this intriguing species is required to address these questions.

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