ENERGETICS OF BREEDING DARK-RUMPED PETRELS

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INTRODUCTION

The Dark-rumped Petrel (Pterodroma phaeopygia sandwichensis) is an endangered gadfly petrel that nests in the Hawaiian Islands and ranges throughout the central Pacific. The species was once common in Hawaii with large colonies on all of the main islands, but its numbers have recently been reduced to several small relict populations. Over 85% of the estimated 450 breeding pairs known today nest in and around Haleakala National Park on the island of Maui, the site of a three-year study begun in 1979 (Simons 1983). Like most Procellariiformes, the Dark-rumped Petrel exploits what is generally assumed to be a widely dispersed and unpredictable food resource (Lack, 1967; 1968). This food resource is thought to place important energetic constraints on these birds, and we wanted to examine how those constraints might have shaped the petrel's breeding biology. In addition these birds breed at an elevation of almost 3000 m in one of the highest seabird nesting colonies in the world. We have described the adaptations of the Dark-rumped Petrel's egg to high altitude nesting elsewhere (Whittow et al., 1983). In this paper we shall examine several aspects of the energetics of reproduction. Apart from a study of the much smaller Leach's Storm-Petrel (Oceanodroma leucorhoa)
(Ricklefs et al., 1980a), the energetics of reproduction in these birds has received little attention.

MATERIALS AND METHODS

The metabolic rates of nestling and adult Dark-rumped Petrels were estimated by measuring their rates of oxygen uptake. A portable system using an air-tight chamber and a manometer was used, and most measurements were made at the nest sites. The device consisted of a chamber containing soda lime (to absorb carbon dioxide) a calibrated manometer, and a source of oxygen. Measurements were made on 72 occasions on seven nestlings and five adult birds. A minimum of five measurements were made on each occasion, and these values were averaged to obtain a final estimate. A small chamber of approximately 4 liters in size was used for small nestlings and a larger 10 liter chamber was used for larger nestlings and adults. The system was calibrated in the laboratory by measuring the oxygen uptake of a Rock Dove (Columba livia), and the estimates obtained were within 10% of those reported by other authors (Dawson and Hudson, 1970). It was assumed that the air within the chamber was saturated with water vapor due to the respiration of the bird, and based on this assumption, measurements were converted to standard temperature and pressure dry. Birds were weighed with 500 or 1000 g Pesola scales to the nearest 1.0 g. Nestling heart rates were measured with a small ECG transmitter (E M Telemetry Transmitter #FM-1100-E1). Proventricul ar temperatures of birds were measured with a Wescor model TH-65 digital thermocouple thermometer calibrated against a laboratory mercury thermometer in a water bath. Burrow attendance patterns were monitored using specially designed event recorders at 10 - 12 nests each season (Simons, 1981a; 1981b; 1983). We collected six Dark-rumped Petrel food samples for caloric analysis. All of the samples were obtained from adult birds returning to feed their chicks. The samples were frozen soon after weighing, and at a later date, they were thawed and dried to a constant mass in an oven at 45°C. The water content of the samples was determined by subtracting the dry mass fraction from the initial weight. Dried samples were homogenized by blending with a mortar and pestle, and the caloric content of approximately 10 mg samples was determined using a Phillipson micro-bomb calorimeter with a benzoic acid standard. Duplicates of each sample were assayed. The ash content was determined by burning 6 aliquots of each dried sample in a muffle furnace at 600°C for 6 hours. The caloric content of stomach oil was determined by adding a known amount of oil (approximately 3 mg) to 10 mg pellets of enriched baking flour with a predetermined caloric content (16.73 kJ/g dry, S.D. 0.02). The total caloric content of the stomach oil and flour pellet was measured with the