species with which it competes for nest-sites. It is also the first record of interspecific chick brooding and feeding in alcids. Intraspecific brooding and feeding of chicks has been observed in murres (*Uria* sp.) (Perry, Lundy: Isle of Puffins, Lindsay Drummond, London, England, 1946).

(*Addendum 1982.*—On 8 July 1982, a pair of Horned Puffins arrived at Cooper Island and courted at Black Guillemot nest-sites where later eggs of the latter species were found to have been pushed out of nest depressions. No observations of puffin courtship activities have previously been made at the islands discussed herein.)

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Body temperature and growth of Bonin Petrel chicks.—Body temperature and timing of endothermy in several altricial and semi-altricial species have been related to the length of the nestling period (Dawson and Evans, Physiol. Zool. 30:315–327, 1957), the growth rate constant k (Ricklefs and Hainsworth, Condor 70:121–127, 1968; Dunn, Condor 77:286–291, 1975), feeding history of the chick (Wheelwright and Boersma, Physiol. Zool. 52:231–239, 1979), and the mass of the nestling (Marsh, Physiol. Zool. 52:340–353, 1979). Data for small procellariiforms are meager but they suggest that the semi-altricial chicks are able to maintain adult body temperatures within a few days of hatching (Farner and Serventy, Condor 61:426–433, 1959; Wheelwright and Boersma 1979). Growth among procellariiform chicks is characterized by slow development, a long and flexible fledging period, large deposits of lipid reserves, and achievement of pre-fledging weights well above the adult's body weight, followed by a pre-fledging weight loss. These growth characteristics are considered to be adaptations to meager, distant, or fluctuating food resources (Lack, Ecological Adaptations for Breeding in Birds, Methuen, London, England, 1968). In addition, procellariiform birds have prolonged incubation periods and slow embryonic growth rates which may be related to slow growth of the chick after hatching (Ackerman et al., Physiol. Zool. 53:210–221, 1980; Whittow, Am. Zool. 20:427–437, 1980). A recent visit to Midway Islands in the northwestern Hawaiian Islands presented us with an opportunity to measure the growth and fledging period of Bonin Petrel (*Pterodroma hypoleuca*) chicks, the thermal environment of their nest-burrows, and development of body temperature regulation.

Methods.—Chicks were weighed twice daily at 07:00 and 17:00 with a torsion balance (±0.1 g) up to 2 weeks of age and then with Pesola spring scales (±1 g) until fledging. At 2 weeks of age chicks were banded for subsequent identification and measurement. Growth data from 1980 and 1981 have been pooled and a logistic growth equation fitted to the data (Ricklefs, Ecology 48:978–983, 1967). Data are presented as means ± 1 SD.

The Bonin Petrel nests in a deep burrow (Grant et al., Auk 99:236–242, 1982); a pre-constructed shaft provided access to the nest-chamber. The temperatures of both incubating adults and chicks were obtained by inserting a sheathed thermocouple into the proventriculus. Temperatures were measured with a Kane-May Ltd. Dependatherm. Ambient temperatures of burrows were recorded continuously over several days on a linear recorder, with the thermocouple placed about 10 cm from the incubating petrel.

TABLE 1
GROWTH PARAMETERS OF TWO SPECIES OF TROPICAL PETRELS

Parameter	Bonin Petrel	Dark-rumped Petrel[a]
Asymptote, a	250	400–500
Adult weight, W (g)	182	385
R = a/W	1.37	1.04–1.30
Fledging weight, FW (g)	206	340–360
FW/W (%)	113	88–94
k	0.091	0.061–0.076
ka/4 (g × day^{-1})	5.69	6.10–9.50
kR/4 × 100 (% × day^{-1})	3.12	1.59–2.47
t_{10-90} (4·4/k, days)	48.35	72.13–57.89
Fledging period (days)	82	109–112

[a] Data for two chicks, computed separately, from Harris (1970).

Results.—After an external pipping-(shell fracture)-to-hatch interval of 5–6 days, during which "peeping" may be heard for about 3 days, the chick emerges after having cracked the shell near the blunt pole of the egg (Pettit et al., Physiol. Zool. 55:162–170, 1982). After drying, the hatchling is light grey dorsally, becoming lighter ventrally to whitish on the abdomen, resembling chicks of many petrel species. The eyes open within 48 h and the tarsi gradually darken from pale grey with flesh-colored webbing on the feet, to a darker grey overall, after

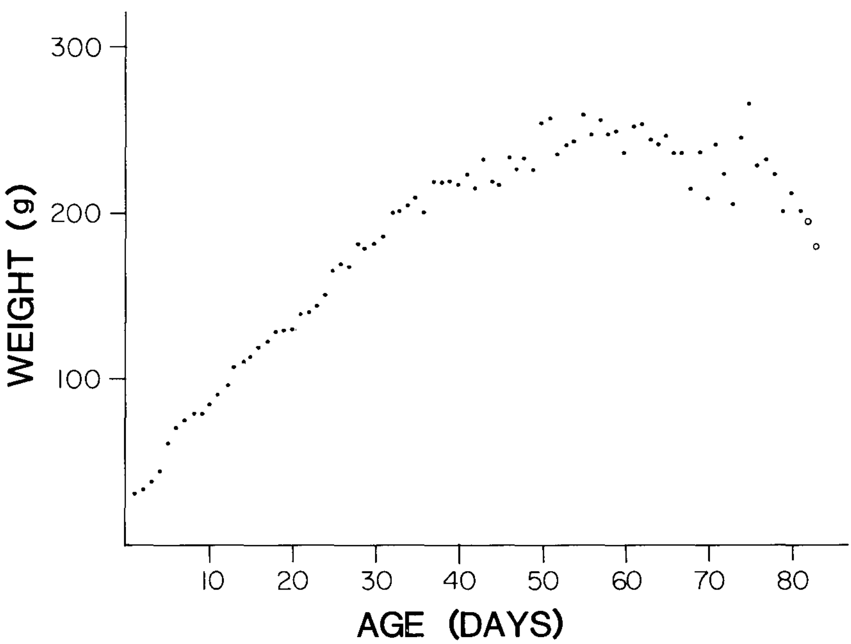

FIG. 1. Mean daily weights (g) of Bonin Petrels on Midway Atoll in 1980 and 1981. Open circle is value for a single chick.

TABLE 2

MEAN WEIGHT GAIN (G) OVER 24 H AND MEAN BODY TEMPERATURE (°C) OF BONIN PETREL CHICKS

	24 h weight gain			Body temperature		
Age (days)	$\bar{x}$	±SD	N	$\bar{x}$	±SD	N
1	7.7	3.7	8	37.2	0.8	11
2	9.5	3.3	9	38.3	0.5	7
3	11.1	5.6	10	38.2	0.4	5
4	8.4	6.6	8	38.2	0.2	4
5	12.3	10.1	9	37.7	0.3	2
6	18.9	9.3	7	37.8	0.2	3
7	10.4	6.7	6	38.1	0.2	3
8	9.9	4.9	5	38.3	0.4	4
9	19.8	15.5	8	—	—	—
10	17.5	14.8	9	38.0	0.8	3
11	19.9	14.0	6	38.2	0.4	3
12	17.4	16.7	6	38.3	0.6	3
13	13.0	9.7	7	38.5	—	1
14	19.4	12.9	6	38.5	0.4	3
15–60	—	—	—	38.2	0.4	26

3–4 weeks. This developmental sequence is similar to that of other *Pterodroma* spp. (Warham, Emu 67:1–22, 1967; Warham et al., Auk 94:1–17, 1977). The white egg-tooth disappeared from the characteristically thick bill at a mean age of 9.9 ± 2.0 days (N = 14). Adults brood chicks for only 1–2 days post-hatching, but may return to spend an additional day in the nest-chamber during the first week of feeding. Chicks are initially fed regurgitated proventricular oil and later small pieces of squid and fish. Chicks may regurgitate oil upon handling but do so infrequently.

Mean daily weights of Bonin Petrel chicks (N = 12–19) are presented in Fig. 1. The logistic growth equation fitted to the data is $W_t = 250/1 + e^{-0.091(t-19.3)}$, $r = 0.985$ where W_t = weight (g) of chick at age t (days); e is base of natural logarithms, 2.72; and r is the correlation coefficient. Table 1 presents growth parameters based upon the logistic equation. Fledging occurred at a mean age of 82.2 ± 2.8 days (N = 5) and a mean weight of 206.0 ± 23.9 g (N = 5). The mean maximal recorded weight was 282.5 ± 35.5 g (N = 14), and occurred at a mean age of 56.8 ± 7.1 days (N = 14). The absolute maximum weight was 341 g (187% of adult weight) in one chick 51 days old.

In 36 of 140 (26%) measurements of body weight during the first 2 weeks post-hatching there was a net loss of weight over 24 h ranging from 1.1–36.3 g, the result of little or no feeding. Chicks are generally fed during the night and only 4 of 120 measurements of weights showed a net increase during a 10-h daytime period. Table 2 presents the mean weight gains over a 24-h period during the first 2 weeks post-hatching. On the second day after hatching a chick was fed 14.5 g or 52% of its body weight. The largest relative amount of nocturnal feeding was recorded in a 10-day-old chick which was fed 53.5 g or 61% its body weight. Maximum overnight weight gain was 79 g in a 24-day-old chick.

Mean body temperature of 11 incubating adults measured during the day was 37.0 ± 0.1°C. The mean ambient burrow air temperature (N = 3) recorded between 31 January and

3 March 1980 was 17.1 ± 0.3°C. During mid-March, burrow air temperatures increased to 20–22°C (mean 20.8 ± 0.7°C, N = 11).

On the first day post-hatching, 9 of 11 chicks were brooded and had mean body temperatures of 37.2 ± 0.8°C as compared with a body temperature of 35.8°C in an unbrooded, 1-day-old chick. By age 2–3 days post-hatching (Table 2) chicks attained mean adult body temperature (38.2 ± 0.6°C; Udvardy, Auk 80:181–194, 1963). With no feeding for 2 days, the body temperature of a single chick, aged 5 days, was 24.0°C at an ambient burrow temperature of 20.5°C. After feeding by the parent of about 30 g of regurgitated food, the body temperature rose to 38.2°C the next day.

Discussion.—Attainment of adult body temperatures by petrel chicks at a relatively early age (2–3 days) may free parents from brooding, allowing foraging at sea soon after hatching. The early metabolic and thermoregulatory independence of Bonin Petrel chicks is partially due to the relatively stable micro-environment of the nest-chamber, which is typical of other burrow-nesting procellariiforms (Farner and Serventy 1959; Howell and Bartholomew, Condor 63:185–197, 1961; Wheelwright and Boersma 1979). In addition, it is not unusual for brooded or freshly hatched procellariiform chicks to have body temperatures higher than the brooding adult (Farner and Serventy 1959; Howell and Bartholomew 1961; Pettit and Whittow, unpubl.).

Diurnal body temperatures of incubating Bonin Petrels averaged 37.0°C in this study, which is significantly lower ($P < 0.05$, Student's t-test) than the mean incubation temperature of 38.5°C reported by Howell and Bartholomew (1961). Udvardy (Auk 8:191–194, 1963) reported a mean body (rectal) temperature of 38.2°C in non-incubating Bonin Petrels resting on the ground at night on Laysan Island. Our value (37.0°C) is at the lower extreme of those reported for 31 species of Procellariiformes (Warham, Condor 73:214–219, 1971). Our petrel body temperatures were recorded by simply pulling the bird out through the preconstructed shaft and rapidly inserting the thermocouple. Howell and Bartholomew (1961) dug out their birds to take their body temperatures. Perhaps this digging was stressful enough to elevate the body temperature of the petrels measured by these authors.

The growth parameters of two Dark-rumped Petrel (*Pterodroma phaeopygia*) chicks from the Galapagos Islands (Harris, Condor 72:76–84, 1970) are presented for comparison with the Bonin Petrel (Table 1). The logistic growth rate constant, k, is 0.091 in the Bonin Petrel and 0.061 and 0.076 for the two Dark-rumped Petrel chicks, indicating a slower rate of growth for the larger dark-rumped chicks. Other growth parameters such as t_{10-90}, i.e., the amount of time (days) required to grow from 10–90% of the asymptotic weight, also indicate slower growth in Dark-rumped Petrels. Growth data for other tropical members of this genus have not been published.

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Prolonged incubation behavior in Common Loons.—Prolonged incubation has been documented for many bird species (Skutch, Parent Birds and Their Young, Univ. Texas Press, Austin, Texas, 1976) but has not previously been reported for the family Gaviidae.