dicate that intraseason pair bonding and burrow tenacity are features of behavior of other members of this family, and suggest strongly that these behaviors may occur regularly in successive years.

We thank the following for their support of the project: Norberto Gonzalez C., Raúl Murguía R., José Luis Sierra V., E. V. Mukul, and Edward Kurjack of the Centro Regional Sureste, Instituto Nacional de Antropología e Historia, México; Ignacio Ibarrola B., J. J. Reyes R., and Wilfredo Contreras D. of the Dirección General de la Fauna Silvestre, Secretaría de Agricultura y Recursos Hidráulicos, México; George and Janet Cobb, Joann Andrews, N. G. Lanier-Martin, Lucy Hamilton, Gaye Al-Rashid, Shân Martin, Wayne Martin, and Sarah R. Martin. Partial financial support was provided by The Explorers Club and The Texas Memorial Museum—The University of Texas at Austin (Texas Memorial Museum Publ. No. N. S.-8).

LITERATURE CITED

FORD, N. L. 1983. Variation in mate fidelity in monogamous birds, p. 329–356. *In* R. F. Johnston [ed.], Current ornithology. Vol. 1. Plenum Press, New York.

HAMILTON, G. D., AND R. F. MARTIN. 1985. Investigator perturbation and reproduction of the Cliff Swallow. Auk 102:167–170.

MARTIN, M. W., AND R. F. MARTIN. 1985. Nestling feeding schedules of Turquoise-browed Motmots in Yucatán, Mexico. Wilson Bull. 97:372–374.

OREJUELA, J. E. 1977. Comparative biology of Turquoise-browed and Blue-crowned motmots in the Yucatán Peninsula, Mexico. Living Bird 16:193–208.

OREJUELA, J. E. 1980. Niche relationships between Turquoise-browed and Blue-crowned motmots in the Yucatán Peninsula, Mexico. Wilson Bull. 92: 229–244.

SCOTT, P. E., AND R. F. MARTIN. 1983. Reproduction of the Turquoise-browed Motmot at archaeological ruins in Yucatán. Biotropica 15:8–14.

SCOTT, P. E., AND R. F. MARTIN. 1986. Clutch size and fledging success in the Turquoise-browed Motmot. Auk 103:8–13.

SKUTCH, A. 1945. Life history of the Blue-throated Green Motmot. Auk 62:489–517.

SKUTCH, A. 1947. Life history of the Turquoise-browed Motmot. Auk 64:201–217.

SKUTCH, A. 1964. Life history of the Blue-diademed Motmot *Momotus momota*. Ibis 106:321–332.

SKUTCH, A. 1971. Life history of the Broad-billed Motmot with notes on the Rufous Motmot. Wilson Bull. 83:74–94.

The Condor 91:219–221

OBSERVATIONS ON THE BREEDING OF THE ARCTIC WARBLER IN ALASKA[1]

TREVOR PRICE
Department of Biology C-016, University of California at San Diego, La Jolla, CA 92093

DESIREE BECK
Department of Mathematics C-012, University of California at San Diego, La Jolla, CA 92093

The Arctic Warbler, *Phylloscopus borealis*, breeds commonly along the coastal regions of central and northern Alaska (Gabrielson and Lincoln 1959) and across Eurasia to Northern Sweden (Williamson 1974). Its breeding biology is poorly known (Swanberg 1953; Dement'ev and Gladkov 1968; Kessel, in press). In Alaska only two nests have been described. Both contained chicks near to fledging (Murie 1956). In this note we report observations on 11 nests monitored through the incubation and early nestling stage.

We spent from 29 June to 12 July 1988 camped approximately 15 km from Nome, Alaska (ca. 64°N, 166°W), on the Snake River. The Arctic Warbler breeds commonly in association with willows (*Salix* spp.) along river and stream valleys in the area. All breeding territories appeared to contain at least some *Salix alaxensesis* which grows up to 5 m. However, some nests were found up to 20 m distant from *S. alaxensesis*, beside clumps of *S. pulchra* which typically grows to 1.0–1.5 m. We located seven nests with eggs by flushing incubating females, and four nests with young nestlings by noting the parents' calls when we were in the nest's vicinity.

NEST CHARACTERISTICS

All nests were located within 1 m of willows on a moss or grass substrate. Two were placed outside the periphery of the willow stands, seven just inside the pe-

[1] Received 10 August 1988. Final acceptance 14 November 1988.

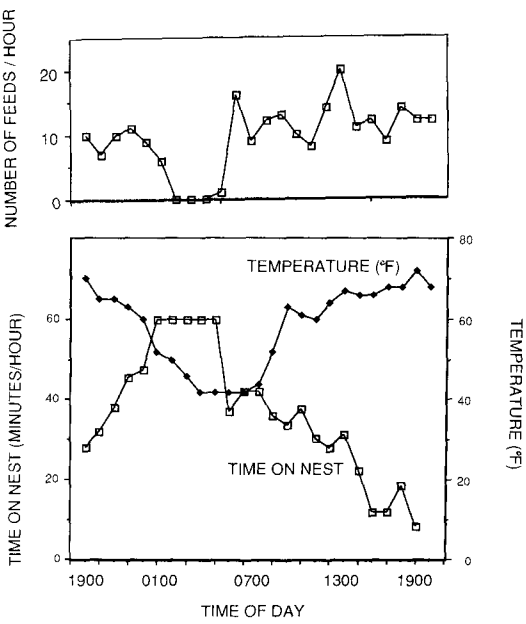

FIGURE 1. Results from a 24-hr nest watch on a nest containing 3-day-old chicks. Above: The number of feeding trips per hour. Below: Shade temperature, taken on the hour, and number of minutes the female spent on the nest each hour. Time of day refers to Alaskan Summer Time, 3 hr later than standard for that time zone.

riphery, and two among open areas of scattered willows. Two were built into a bank, and nine were placed on level ground. Two were built adjacent to the base of a small (250 cm) willow sapling. Nests were domed and predominantly constructed of grass. The roofs were always covered with varying amounts of moss. Three nests were collected: their fresh weights were 14.5 g, 20 g, and 33.5 g and they were lined with thin grass and moose hair. None of the 11 nests were lined with feathers. Similar features were reported for two nests studied in McKinley National Park, Alaska (Murie 1956), and for nests in Scandinavia (Swanberg 1953) and in the Soviet Union (Dement'ev and Gladkov 1968).

EGGS

Of the seven nests found during incubation five contained six eggs, and two contained five eggs. Including the nests with young chicks, eight had clutch sizes of six and three had clutch sizes of five ($\bar{x}$ = 5.7 ± 0.5 SD). The eggs were generally white with pink spots at the large end. In one six-egg clutch five of the eggs were unspotted. Dimensions of seven eggs (from three nests) were 15.7 ± 0.73 SD × 12.8 ± 0.46 SD mm. Characteristics of the clutch and eggs are similar to other subspecies breeding in the Soviet Union (Dement'ev and Gladkov 1968). The median hatch date was 8 July. Hatching began on 7 July, and only one nest had not hatched by 12 July. Breeding thus appears to be highly synchronous among pairs.

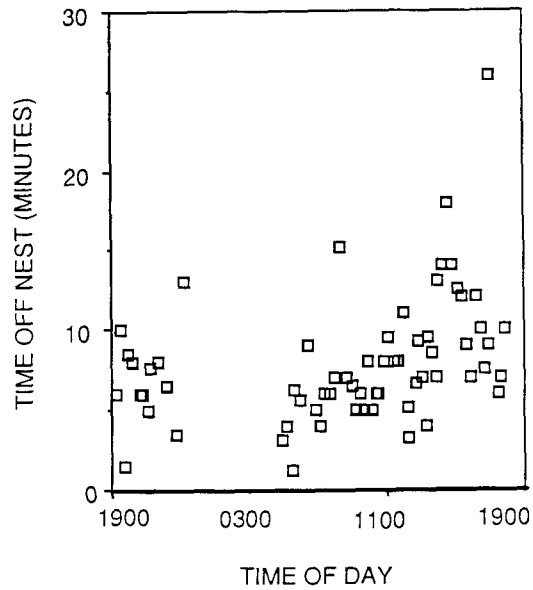

FIGURE 2. Time the female spent off the nest between incubation periods during a 24-hr nest watch.

NESTING SUCCESS

When summed across all nests, the number of days the nests were monitored was 43 days during incubation and 20 days for small hatchlings. There was no predation on eggs or chicks. In both a Finnish population of *P. trochilus* (Tiainen 1983a), and an Indian population of *P. inornatus* (Price and Jamdar, unpubl. observ.) approximately one predation event was observed for a similar time period. Although significance cannot be attached to this result there was an absence of the main Eurasian nest predators (corvids and snakes) from the study area, and predation may be low in Alaska.

In seven nests checked when the young were several days old only one egg (out of 40) had failed to hatch. Hatching does appear to be somewhat asynchronous within broods, since six of the nests we checked contained some eggs and some nestlings on one visit.

EARLY NESTLING STAGE

On 10 July the sun set at 01:40 and rose at 04:45, but it did not get very dark, and it seemed likely that birds could still forage. We conducted a 24-hr watch from 19:00 on 9 July to 19:00 on 10 July, on a nest with five 3-day-old chicks. The weather was fine. Results show a strong diurnal rhythm, with no feeding of the chicks for 4.5 hr and continual incubation by the female of the nestlings for 6 hr (11:30–05:30) (Fig. 1). Throughout the rest of the day the female incubated for an average of 30.8 ± 11.5 SD min each hour. Although we could not always individually identify the parents most of the feeding was done by the male. The female sometimes fed before she went on to the nest, and sometimes did not; on other occasions we were unable to tell whether she fed or not. Thus the number of feeding trips may be underestimated, but by a max-

imum of two per hour. There was an average of 11.5 ± 3.0 SD feeding trips per hour, and at least 9.3 ± 2.6 SD of these were by the male. If the female was off the nest the male often sat above the nest after feeding the young, and waited for her return. If brooding, the female often left the nest as the male arrived.

Periods off the nest are shown in Figure 2. Time spent on or off the nest by the female did not seem to be associated with any difficulty in foraging for the female, as has been suggested to be the case for Arctic waders incubating eggs (Cartar and Montgomerie 1987), but rather with ambient temperature and the need for the female to maintain the temperature of the young (Haftorn 1978). When it was particularly warm the female sat quietly outside the nest for several minutes. Swanberg (1953) conducted a 24-hr nest watch on a nest of *P. borealis* containing 8- to 9-day-old chicks in Swedish Lapland. The sun was set for 2 hr 40 min but the female brooded continuously for almost 6 hr overnight, and intermittently for less than 60 min during the rest of the day. There was a total of 385 feeding visits (compared with ca. 225 in our watch). The female made more than twice the number of feeding visits than the male, but the male appeared to bring larger loads (Swanberg 1953). The differences between Swanberg's observations (less brooding, more feeding trips, and more trips by the female than the male) and ours probably largely reflect the different age of the nestlings. Tiainen (1983b) conducted extensive observations on nest attendance by *P. trochilus* in Finland, and obtained similar results to ours or to Swanberg's depending on the age of the chicks.

Many aspects of *P. borealis* breeding biology, such as the incubation and nestling periods, remain unknown. Our observations suggest that its behavior is typical of members of the genus *Phylloscopus*. All species build domed nests, although some are unlike *P. borealis* since they line with feathers, and some build in trees (Ticehurst 1938; Tiainen et al. 1983; Price and Jamdar, in press). The average clutch size of *P. borealis* is larger than that of *Phylloscopus* species breeding in the Himalayas (Price and Jamdar, in press), but slightly smaller than that of species breeding in Europe (Tiainen 1983a, Tiainen et al. 1983). It is smaller than that of *P. borealis* breeding in Scandinavia, where the average clutch size of 15 nests was 6.4 ± 0.51 SD (Swanberg 1953).

Predation does not appear likely to have led to a reduced clutch size in Alaska (cf. Lima 1987) because predators seem to be rare. Alternatively food supply may affect clutch size. The explanation for variation in clutch size among species in different localities cannot lie completely in longer days enabling more foraging time, because day lengths are comparable in Alaska and Europe but clutch sizes are on average 0.7 eggs smaller in Alaska. During our observations on a nest with very young chicks, the parents appeared to have no trouble bringing food: the male brought most of the food and he spent much time resting. It is possible that as the young grow older the parents might have difficulty finding food and this could set the upper limit on clutch size. We found three species of New World warbler breeding commonly in our study area (the Orange-crowned Warbler, *Vermivora celata,* Yellow Warbler, *Dendroica petechia,* and Wilson's Warbler, *Wilsonia pusilla*), and most pairs of these species had fledged young 2 to 3 weeks earlier than *P. borealis.* Because of *P. borealis'* long migration (from the Philippines) it may breed later than is optimal, and food supplies may be declining by the time young have maximum food requirements.

We thank Brina Kessel and Richard Harris for advice on Arctic Warbler localities, and Brina Kessel and Juha Tiainen for comments on the manuscript.

LITERATURE CITED

CARTAR, R. V., AND R. D. MONTGOMERIE. 1987. Day-to-day variation in nest attentiveness of White-rumped Sandpipers. Condor 89:252–260.

DEMENT'EV, G. P., AND N. A. GLADKOV [EDS.]. 1968. Birds of the Soviet Union. Vol. 6. English ed. Israel Program for Scientific Translations, Jerusalem.

GABRIELSON, I. N., AND F. C. LINCOLN. 1959. The birds of Alaska. Stackpole, Harrisburg, PA.

HAFTORN, S. 1978. Egg laying and regulation of egg temperature during incubation in the Goldcrest *Regulus regulus.* Ornis Scand. 9:2–21.

KESSEL, B. In press. Birds of the Seward Peninsula, Alaska: their biogeography, seasonality and natural history. Univ. of Alaska, Fairbanks.

LIMA, S. L. 1987. Clutch size in birds: a predation perspective. Ecology 68:1062–1070.

MURIE, A. 1956. Nesting records of the Arctic Willow Warbler in Mount McKinley National Park, Alaska. Condor 58:292–293.

PRICE, T., AND N. JAMDAR. In press. Breeding of eight sympatric species of *Phylloscopus* warblers in Kashmir. J. Bombay Nat. Hist. Soc.

SWANBERG, P. O. 1953. Om nordsångaren (*Phylloscopus borealis* Blas.). Vår Fågelvärld 12:49–78.

TIAINEN, J. 1983a. Dynamics of a local population of the Willow Warbler *Phylloscopus trochilus* in Southern Finland. Ornis Scand. 14:1–15.

TIAINEN, J. 1983b. Ecological energetics of nestling growth in the Willow Warbler *Phylloscopus trochilus.* Ann. Zool. Fenn. 20:13–24.

TIAINEN, J., I. K. HANSKI, AND J. MEHTALA. 1983. Insulation of nests and the northern limits of three *Phylloscopus* species in Finland. Ornis Scand. 14: 149–153.

TICEHURST, C. B. 1938. A systematic review of the genus *Phylloscopus.* British Museum, London.

WILLIAMSON, K. 1974. Identification for ringers. 2. The genus *Phylloscopus.* British Trust for Ornithology, Tring, United Kingdom.