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White-winged Diuca Finch (*Diuca speculifera*) Nesting on Quelccaya Ice Cap, Perú

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ABSTRACT.—We found evidence of birds nesting directly on glacier ice of the Quelccaya Ice Cap in the Cordillera Vilcanota, Perú at elevations up to 5,300 m. Observations during June and July over several years consisted of numerous nests not *in situ* having obviously fallen from the steep and dynamic, retreating glacier margin. A typical nest was a bulky structure of grass and twigs with a dry mass of 160 g. The inner cup was nicely formed and lined with fine grass, measuring 6–7 cm in diameter and 4–5 cm deep. Feathers and entire wings of White-winged Diuca Finch (*Diuca speculifera*) were observed in association with the nests; this was the passerine species most commonly seen in the area. The evidence indicates the glacier nests were built and used by White-winged Diuca Finch, probably during the Austral autumn when on-site automated measurements indicate the wet season ends and air temperatures have not yet decreased. This is the first well-documented case of high-elevation avian nesting on glacier ice. *Received 30 November 2006. Accepted 26 December 2007.*

Some birds are well adapted to environments which are seasonally dominated by snow or sea ice, but birds are not generally associated with

glaciers. Only the Emperor Penguin (*Aptenodytes forsteri*) is known to routinely nest on ice, typically frozen sea-ice (i.e., fast-ice) but at times in association with ice shelves derived from glaciers (Kooyman 1993). Transient birds have been observed passing over mountain glaciers at high elevations outside the polar regions or discovered after succumbing to harsh environmental conditions (Krajick 2002; L. G. Thompson, pers. comm.). However, glacier surfaces are usually cold, actively changing through accumulation and ablation, and at times wet; conditions that are poorly suited for nesting and raising young birds.

The ornithological literature contains only one detailed account of nesting on a glacier. This was the unusual circumstance where glaciers advancing into Alaska's Prince William Sound overran a Black-legged Kittiwake (*Rissa tridactyla*) colony (Irons 1988). Previously-used nest sites were unavailable and 77 kittiwake nests were constructed on the glacier face. All of these nests failed due to ablation and/or meltwater runoff which either dislodged the nests or caused them to disintegrate (Irons 1988; D. B. Irons, pers. comm.).

The objective of this paper is to present evidence of nesting by White-winged Diuca Finch (*Diuca speculifera*) directly on glacier ice of the Quelccaya Ice Cap in Cuzco De-

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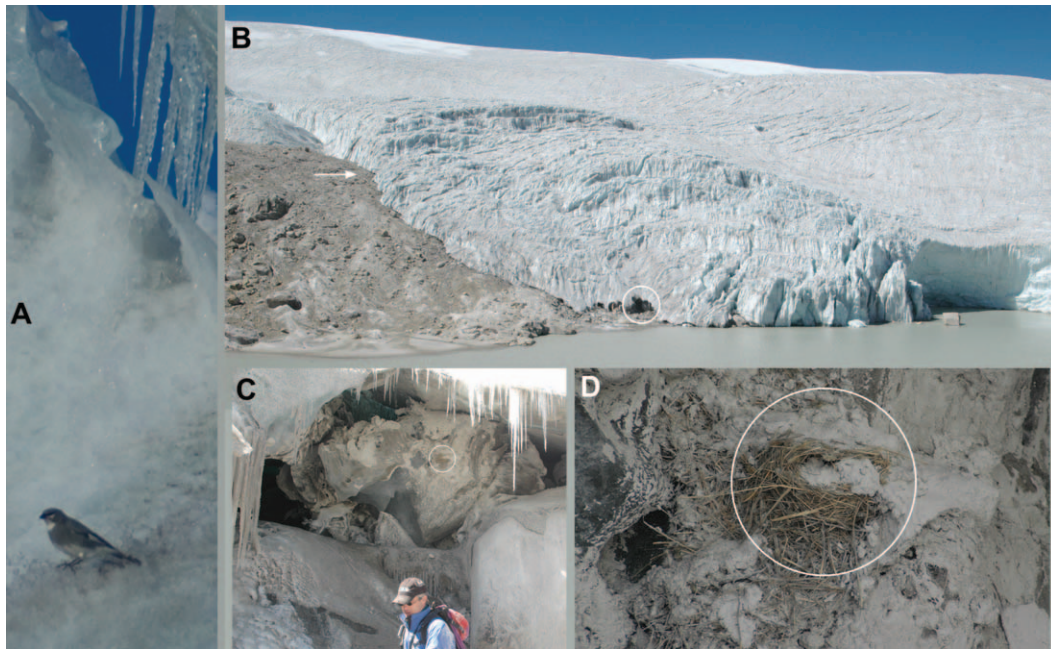


FIG. 1. (A) White-winged Diuca Finch on Quelccaya Ice Cap at $\sim 5,200$ m on 23 June 2007, (B) the same glacier in June 2005 with arrow indicating the approximate location of the first nest observation in 2005 and the nest described in text. Circled area of margin just above the proglacial lake is enlarged in (C) looking under the ice. The circle on (C) encloses a nest which is likely *in situ*, 3 m above rock surface with enlarged view in (D); note silt from meltwater runoff.

partment, Perú (14° S, 71° W). Observations were made over several years during the Austral winter (Jun–Jul) in the course of conducting glacier and climate research on the ice cap. This is the first well-documented case of high-elevation avian nesting on a glacier, corroborating a second-hand report of “ice cave” nesting by White-winged Diuca Finch (Johnson 1967).

OBSERVATIONS

During June 2005, while exploring the retreating Quelccaya Ice Cap margin, we came upon a nest which appeared to have fallen recently from the glacier (within weeks-months). Several other older nests were observed nearby including one in a cave under the ice margin (Fig. 1). More extensive nest searches were conducted in 2006 and 2007 along $\sim 1,500$ m of glacier margin, resulting in location of numerous nests. Most were along two sections with respective lengths of 350 and 530 m, elevation ranges of 50 and 100 m, and upper elevations of 5,200 and

5,300 m. Searches were restricted to this 1,500 m section; the extent to which this is representative of the Quelccaya Ice Cap is unknown. However, nesting on the ice cap has likely not been limited to the last 3 years as L. G. Thompson has occasionally observed nests over the past ~ 30 years (pers. comm.).

Nest remains were most often found on rocks at the base of near-vertical sections of ice margin. At least 14 nests were found in 2006 and at least 16 in 2007. These varied in apparent age from weeks (i.e., previous breeding season) to several years and the 2007 count almost certainly includes some found the previous year. Two of the freshest nests in 2006 were only 3 m apart.

Typically, sections of glacier margin with nest remains were nearly vertical, somewhat grooved or fluted, and ~ 5 – 10 m high. Overhanging icicles and steeply-sloping rock below the margin made access to some nest remains difficult, and nests still attached to the glacier could have been overlooked. One nest was found on the glacier 22 m from the mar-



FIG. 2. (A) Dislodged nest along Quelccaya Ice Cap margin found on 15 July 2006 in inverted position within 1 m of vertical ice wall at 5,190 m. The nest was not present the previous year (26 Jun 2005), although a different residual nest was found ~ 10 m distant. The dark bar on the field book cover is 1.25×9.5 cm. (B) Another dislodged nest in position found, 23 Jun 2007 at 5,230 m; note feathers and 13-cm pen for scale.

gin, below a steep, step-like section of ice (i.e., not *in situ*).

Some nests were entirely intact when found, while others were disintegrating or partially buried by sediment; however, almost all nests were not *in situ* (cf. Fig. 1D). Net retreat of the ice margin is roughly 1 m/year or more along this part of the Quelccaya Ice Cap and nests constructed on the steeply-sloping margin could only be observed *in situ* within a brief interval following construction (i.e., breeding season) prior to falling. Evidence for this interpretation is that several nests were found in inverted position and, in almost every case, a vertical trace of nest material was observed above the nest remains, frozen to the ice.

Remains of varying ages indicate multi-year occupation of favorable sites along the ice margin suggesting that reproductive efforts on the ice cap are successful. In addition, we observed fecal sacs in one of the fresh nests, presumably from nestlings just prior to fledging. No off-glacier nesting evidence was found despite searching areas adjacent to the glacier.

Several nests appeared entirely intact and the following is based upon one of the freshest-appearing nests observed in 2006. Nests were bulky structures of grass and twigs with a deep, well-made inner cup (Fig. 2). It ap-

pears that a rough platform is initially constructed (32×18 cm), which roughly tapers upward and becomes increasingly well-woven towards the top (13 cm outer diameter). Only this better-woven upper portion was found in some cases. The inner cup measured ~ 6.5 cm in diameter and was 4.6 cm deep. Overall dry mass of the nest (Fig. 2A) was 160 g. Nests consisted of woven grass (~ 80 – 90%), particularly the locally abundant *Calamagrostis chrysantha*. The inner cup was lined with finer grass and feathers were observed in or adjacent to some nest remains (Fig. 2B). Analysis by Carla Dove at the Smithsonian Institution revealed feathers of Rufous-bellied Seedsnipe (*Attagis gayi*), Andean Goose (*Chloephaga melanoptera*), and tail feathers of White-winged Diuca Finch. This diverse assemblage suggests that nests are lined with feathers recovered from the surrounding landscape. No evidence of camelid fleece was seen in any nest (cf. Johnson 1967).

DISCUSSION

Although indirect, all evidence indicates that Quelccaya glacier nests were built and used by White-winged Diuca Finch. Little information exists on nesting habits of this species from anywhere in the Andes although Johnson (1967: 368) reported that in the Parinacota area of

Chile, a White-winged Diuca Finch nest was found “on the ground beneath some loose stones on a hillside.” In lieu of breeding-season observations of White-winged Diuca Finches at Quelccaya, our deduction is based upon their local presence, feathers, and the species known association with glaciers.

Small groups of White-winged Diuca Finches of unknown age class were frequently observed among rocky moraine surfaces and bogs in the area. This species is known to not typically retreat northward or to lower elevations during winter (Johnson 1967, 1972). On one occasion in June 2007, while we were investigating an apparent roosting site within a crack of the glacier, a flock of ~20 White-winged Diuca Finches began gathering late in the afternoon at the glacier margin, both on and off the glacier (Fig. 1). The birds acted disturbed by our presence in contrast to their behavior during diurnal feeding.

Several feathers observed in proximity to the nests were White-winged Diuca Finch wing or tail feathers. In addition, two nearly-entire wings (chord = 105 mm) of White-winged Diuca Finch were found on the ice at a 2007 nest site. No feathers were found from other passerine species (e.g., ground tyrants [*Muscisaxiola spp.*]) observed in close proximity to the glacier.

White-winged Diuca Finch is the only species to be repeatedly associated in the ornithological literature with Western Hemisphere glaciers. Niethammer (1953) observed an estimated 100 White-winged Diuca Finches gathering for the night inside a glacier crevasse at Chacaltaya (5,200 m) Bolivia in mid-summer. He also collected one male specimen on 20 December in breeding condition with enlarged testes (6×4 mm vs. ~3 mm for another specimen collected in late August). A second association between White-winged Diuca Finch and glaciers was in the mid-1960s when P. R. Parker of the Chacaltaya Astrophysical Observatory found a nest “in an ice cave” at 5,300 m, leading Johnson (1967:368) to postulate the species “quite possibly nests at a higher altitude than any other passerine form.” Subsequently, several sources mention that White-winged Diuca Finch has been recorded roosting in glacier fissures (Meyer de Schauensee 1970), glacier

crevasses (Ridgely and Tudor 1989) or glacier cracks (Fjelds  and Krabbe 1990).

Relatively little is known about the timing of White-winged Diuca Finch nesting in Per  or elsewhere. Johnson (1967) suggested this species nested after the summer rains in the Parinacota region (Chile–Bolivia) where White-winged Diuca Finches were present all year. Immature White-winged Diuca Finches in Bolivia were noted by Fjelds  and Krabbe (1990) during July and August (La Paz), and August (Cochabamba). These findings are consistent with the Quelccaya situation, where climatic conditions present multiple difficulties for breeding birds, especially snow and low temperature (cf. Hendricks and Norment 1992, Martin and Wiebe 2004).

We began operating an automated weather station (AWS) in 2003 at the ice cap summit, ~3 km east of the nest sites and ~500 m higher in elevation. These data permit a close approximation of the climate in which nest building, incubation, and rearing of nestlings occurs on the glacier.

Pronounced seasonality of precipitation at Quelccaya typically features considerable and frequent snowfall from late September to early-mid April. During this wet season, 2 m or more of snow accumulates at the ice cap summit but, at the slightly lower elevation margin, ablation predominates; meltwater flows off during the day and freezes at night. Some precipitation at these nest sites (5,150–5,300 m) may be in the form of rain, as they are close to a rising atmospheric freezing level (Thompson et al. 1993, Bradley et al. 2006). This would impact the bird’s exposure to moisture, thermal regulation, food availability, and other factors, and the viability of glacier nesting in the area.

Diurnal fluctuations in air temperature at Quelccaya are greater than the annual variation. By assuming a constant environmental lapse rate, summit AWS measurements can be adjusted to the elevation of nesting site, revealing average daily minima of -3.1° and -6.3° C during the wet and dry seasons, respectively. Thus, air temperature is low during the night throughout the year with extreme radiational cooling whenever cloud cover is low (especially in the dry season). Maxima for the same periods reach 2.9° and 0.9° C at the nesting sites.

Successful nesting in this dynamic environment and extreme climate requires not only

thermal and mechanical adaptations to the ice substrate, but also careful timing within the seasonal cycle of climate. The AWS data suggest that Quelccaya glacier nesting by White-winged Diuca Finch most likely occurs as the wet season concludes in April when nesting sites become exposed and drier, as the transient snow line elevation rises. Daily mean temperatures decrease after March as decreasing cloud cover results in colder nights, but the decrease in daily maximum is considerably more gradual until June (DRH, unpubl. data). Young finches had apparently fledged in each of the past 3 years by this date.

Note Added in Proof.—Quelccaya fieldwork during June 2008 provided additional observations. The first nests clearly *in situ* were observed on the glacier, in locations and orientation as hypothesized. One contained two abandoned eggs consistent in size and color for White-winged Diuca Finch (Johnson 1967). Also, a single off-glacier nest, similar to that described above, was found *in situ* under boulders ~500 m from the glacier. A late-afternoon gathering of 20–30 White-winged Diuca Finch was again observed, 30–60 min prior to sundown, at the same section of fractured glacier margin where this behavior was observed in 2007. Several roosts were located nearby, all entirely within (vs. beneath) the glacier. One expedition member observed and photographed White-winged Diuca Finch roosting at the site prior to sunrise (J. A. Castañeda Gil, pers. comm.). Supplemental material on glacier-nesting White-winged Diuca Finch at Quelccaya Ice Cap is available at <http://www.geo.umass.edu/climate/quelccaya/diuca.html>.

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