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Airspeed and Heading of Autumnal Migrants over Hawaii

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From 27 August to 28 October 1979 we made simultaneous radar observations and visual ground counts of migrants on the islands of Oahu and Maui, Hawaii. These observations revealed migrations approaching the islands from the north at the end of August and again during October (Kloeckner et al. 1982). The ground counts indicated that the early migrants were shorebirds, primarily Lesser Golden-Plover (*Pluvialis dominica*) and Ruddy Turnstone (*Arenaria interpres*), and the later migrants were ducks, primarily Northern Shoveler (*Anas clypeata*) with a smaller number of Northern Pintail (*A. acuta*). We report the flight behavior of the birds observed at Hawaii and contrast this behavior with that of birds moving over the island of Antigua in the Caribbean, recently reported by Williams (1985).

We used the FAA-National Guard long-range surveillance radar at the summit of Mt. Kaala, Oahu (elevation 1,200 m, wavelength L band 23 cm, peak power 8 MW, 5 rpm). On Maui we used the ASR-7 air traffic control radar at Kahului airport (elevation 6 m, wavelength S band 10 cm, peak power 425 kW, 15 rpm). The Maui radar (at 3-20-km range where birds were detected) was sensitive to birds flying at altitudes ranging from sea level to 1,500 m (see Gauthreaux 1980). The radar at Mt. Kaala, because of its elevation, was insensitive to even small aircraft flying below 1,200 m. The differential sensitivity of the two radars was used to estimate the altitude of migrants.

Velocity of winds aloft was available from radiosonde launches twice daily at Lihue, 360 km northwest of Maui, and at Hilo, 201 km southeast of Maui. Surface charts and upper-air charts were used to interpolate between these stations to obtain winds aloft at Oahu and Maui. The relatively undisturbed flow of trade winds near the Hawaiian Islands makes such interpolation more reliable than over continental areas. Wind data for the Mt. Kaala radar were averaged for altitudes between 1,200 and 3,000 m. Wind velocities for Maui were averaged from sea level to 1,500 m.

Echoes of birds were recorded from the Plan Position Indicator (PPI) displays of the radars on Ektachrome 160 film using super 8-mm time-lapse cameras. The paths of individual echoes were scored for direction and speed of movement as described in Kloeckner et al. (1982).

Track and ground speed refer to the velocity of a bird relative to the ground. Heading and airspeed refer to the velocity of the bird relative to the air mass and are calculated from track and ground speed by vector addition of the negative velocity of the wind at the altitude of the bird.

In simultaneous observations with the Mt. Kaala and Maui radars, birds approaching the Hawaiian Islands from the north only were detected at low elevation (i.e. at Maui). Birds departing southward from Maui (low altitude) were not detected more than 5 km from shore, while birds departing southward from Oahu (high altitude) were not detected at less than 30 km from shore, suggesting an increase in flight altitude as birds departed the islands southward. The density of migrants detected by radar was much less than at continental sites (Kloeckner et al. 1982). We concluded that migrant birds landed at Hawaii rather than flying over or past the islands. Radar observations in the western North Atlantic revealed a very different pattern. Richardson (1976) and Williams et al. (1977) reported birds moving over the islands of Bermuda and the Caribbean at altitudes of up to 6,000 m; only at Tobago, close to the South American coast, was the pattern of low-altitude flight recorded.

The dispersion of tracks of birds approaching Maui from the north, shown in Fig. 1, was less than that of the calculated headings shown in the figure. The vector mean direction for tracks at Maui was 158°, r = 0.98, and the mean heading was 144°, r = 0.95 (r is a measure of dispersion around the mean; Batschelet 1981). A Watson-Williams test for the concentration parameter indicated the two values of r are different at $P < 0.01$ ($F = 2.24$). (The vector mean direction for winds used in these calculations was 242°, r = 0.54, and the mean wind speed was 19 km/h, SD = 2.8.) Richardson (1976) and Williams (1985) reported that tracks of migrants over the Caribbean were more widely dispersed than headings, suggesting drift by variable winds from a constant compass heading (data from the island of Antigua are included in Fig. 1 for comparison). This does not appear to be the case for birds approaching Hawaii; birds approaching the islands for a landing appear to be compensating for wind drift to maintain a final course. On Maui, most birds appeared to direct their final approach toward one of two large ponds on the island (see Kloeckner et al. 1982). A similar analysis cannot be made for birds departing Hawaii to the south because we obtained only 11 complete tracks, 9 of which were under the same wind conditions. (Mean track for these 9 was 180°, mean ground speed 63 km/h, mean heading 158°, mean airspeed 74 km.)

Mean ground speed for the 92 birds detected approaching Maui was 42.6 km/h (SD = 8). Mean airspeed was 42.5 km/h (SD = 14). Regressing daily mean airspeed (A) on the following wind component (W) resulted in the regression equation: $A = 44 - 1.05\ W$. The r^2 value of 0.91 was highly significant ($P < 0.001$). Regressing daily mean ground speed (G)

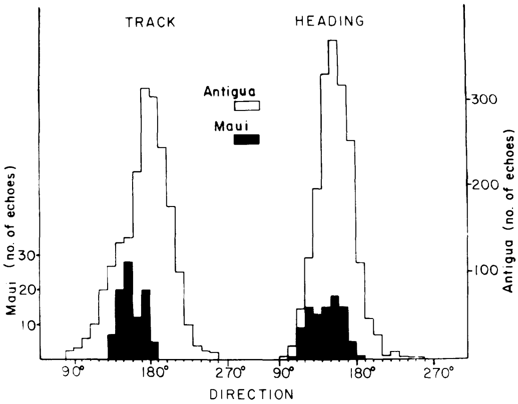

Fig. 1. Distribution of track and heading of birds detected by radar at Maui, Hawaii and Antigua, West Indies. The data from the two sites are not plotted on the same scale. All data for Maui are shown, but only southbound birds are shown for Antigua.

on W gave G = 43 − 0.027 W. The r^2 of 0.07 was not significant ($P > 0.05$). The greater variance in the airspeeds and the close relationship to the magnitude of the following wind component indicate that the birds were compensating for wind conditions so as to maintain a constant ground speed. This phenomenon is well documented for waterfowl flights over land, most recently by Wege and Raveling (1984), and has been reported for birds moving over the Atlantic (Larkin 1980). The mean airspeeds recorded in Hawaii are low for waterfowl and shorebirds and probably reflect reduced flight speeds as the birds prepare for landing.

All data obtained at Hawaii are consistent with the hypothesis that birds that arrive from the north are preparing to land on the islands rather than to continue flight over the islands, as is observed in the Caribbean. Birds that migrate further south in the Pacific presumably depart from the islands after feeding. The flight behavior of birds arriving at Maui shows compensation for wind effects in maintaining ground speed and track, while birds arriving over the Caribbean appear to maintain airspeed and heading (Richardson 1980, Williams 1985).

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Calcarius lapponicus coloratus **in the Aleutian Islands, Alaska**

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Recent observations of *Calcarius lapponicus coloratus* Ridgway, 1898, on Attu Island suggest that this Commander Islands form of the Lapland Longspur, which has not been reported previously from Alaska, may occur with some regularity in the westernmost Aleutian Islands, where it apparently interbreeds with *C. l. alascensis* Ridgway, 1898.

On 23 May 1983 I identified a male longspur on territory at Alexai Point (52°48′N, 173°18′E) as *C. l. coloratus.* It was readily distinguishable from the