Changes in the Migratory Direction of Yellow-faced Honeyeaters *Lichenostomus chrysops* (Meliphagidae) during Autumn Migration

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Yellow-faced Honeyeaters *Lichenostomus chrysops* are well known diurnal migrants in eastern Australia. Each year, large flocks move northward during autumn and early winter. Despite an intensive banding effort (Purchase 1985), neither the exact routes nor the location of the wintering areas have been identified with certainty. Numerous observations, however, allow at least a rough estimate of the course of their migration. Large flocks of Yellow-faced Honeyeaters flying north-east have been observed in the Canberra region (Davey *et al.* 1984) and at various locations along the east coast and adjacent ranges of New South Wales (Hindwood 1948; Hindwood 1956; Liddy 1966).

Only limited records are available from Queensland. In May and June, Robertson (1958) observed Yellow-faced Honeyeaters migrating on a north-westerly course over East Brisbane (27°30'S, 153°E). Members of this species have also been found further north in eastern Queensland between 26°S and 19°S. Blakers *et al.* (1984) suggested that most of them are migrants, as there are no breeding records of the species in that region. A probably isolated breeding population of the Yellow-faced Honeyeater also occurs in the Atherton region (17°S, 145°E) of north Queensland (Gill 1970; Blakers *et al.* 1984). Bravery (1970) reported that numbers increased between May and July in this region, indicating an influx of migrating birds to the local population.

Taken together, these observations suggest that the main stream of migration follows the Great Dividing range and the east coast of Australia, with a change of direction from north-east to north-west taking place around the end of April to early May in the area south of Brisbane (see Fig. 1).

In the present study, the orientation behaviour of captive Yellow-faced Honeyeaters was studied in Armidale, New South Wales. We used Emlen funnel cages to record the birds' directional preferences (Emlen & Emlen 1966; Munro & Wiltschko 1992) in order to see whether the change in direction from north-east to north-west in the course of the season could also be observed in the directional tendencies of captive birds.

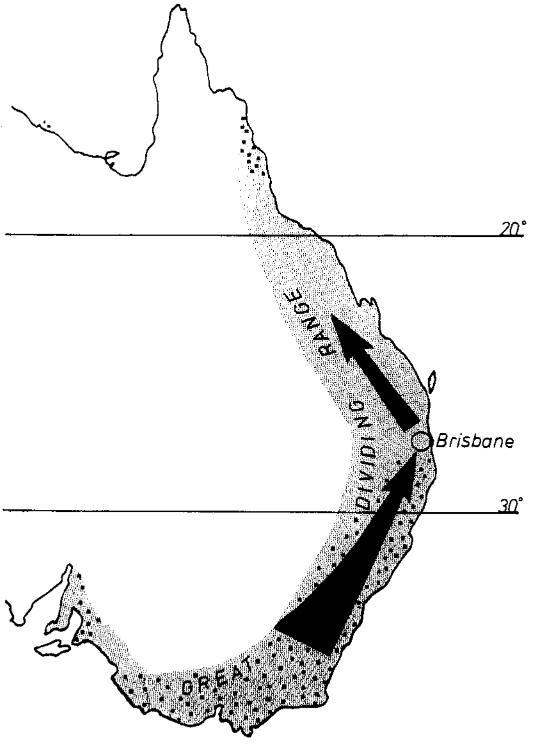

Figure 1 Distribution (stipple) and breeding areas (■) of Yellow-faced Honeyeaters along the south-eastern and eastern coast of Australia. Note gap in breeding records between 19°S and 26°S, birds recorded in this region are probably wintering or passage migrants. The probable migratory route of eastern populations during autumn and early winter is represented by black arrows.

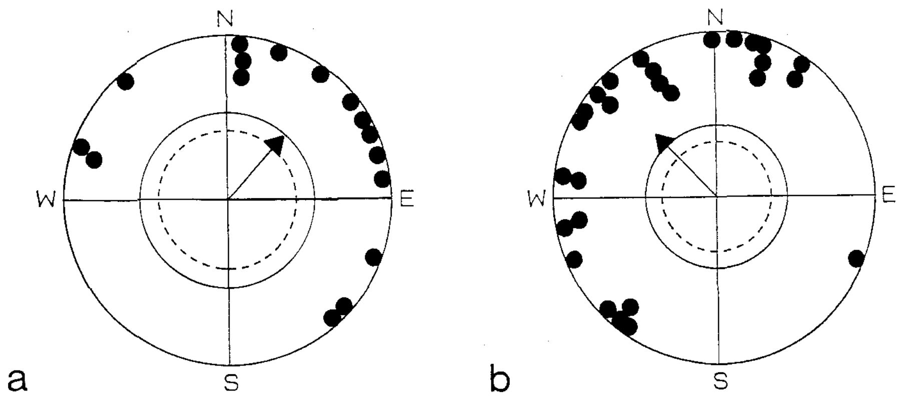

Figure 2 Orientation behaviour of Yellow-faced Honeyeaters. Directional preferences in (a) March–April 1990 and (b) May–July 1990. The headings of the birds in each individual test are represented by solid dots at the periphery of a unit circle. The mean vector with the direction α_m and the length r_m is symbolised by an arrow. The inner circle (broken line) represents the 5% and the outer circle (unbroken line) the 1% significance level of the Rayleigh test.

Material and methods

Test birds

The 24 test birds were caught in the Armidale region, north-eastern New South Wales (30°30′S, 151°40′E), in autumn 1989 and 1990, and in spring 1989. They were kept under natural conditions in outdoor aviaries. At the end of the experiments the birds were banded and released. The experiments were approved by the NSW National Parks and Wildlife Service (Licence No. B671) and the Animal Care and Ethics Committee of the University of New England (Licence No. AWC 900115).

Orientation tests

The experiments were conducted outdoors between 6 March and 31 July 1990. The recording time was in the morning between 0600 and 1200 h, i.e. during the time of day when honeyeaters show their highest level of activity (Munro unpubl. data) and flocks of migrating Yellow-faced Honeyeaters are observed in the wild (Liddy 1966; Robertson & Woodall 1983). Emlen cages were used for recording the birds' directional preferences (Emlen & Emlen 1966). The cage was conical and 15.5 cm high with an upper diameter of 35 cm and an lower diameter of 10 cm. On the inside this cage was lined with typewriter correction paper (TippEx, Germany). In an attempt to escape, the birds left scratch marks on the correction paper, indicating their direction of movement. Orientation tests lasted for an hour. One bird per cage was tested at a time. The cage was covered with clear plexiglass. A shield extending 10 cm beyond the upper edge of the cage prevented the bird from seeing landmarks and restricted its view to the sky. Further details of the orientation cage are given in Munro & Wiltschko (1992).

Data analysis and statistics

Standard methods of circular statistics were used to analyse the data. Directional preferences were tested by the Rayleigh test (Batschelet 1981). Differences in the distribution between samples were tested with the Mardia Watson Wheeler test (Batschelet 1981), the Wilcoxon Signed Rank test (Woolf 1968) and the Mann-Whitney test (Zar 1974).

Results

In the tests, Yellow-faced Honeyeaters showed mainly northerly tendencies reflecting the generally northward movements of this species during autumn migration (Munro & Wiltschko 1992). We found that during early migration (March and April) the birds preferred a north-easterly course (Fig. 2a), while in the latter stage of autumn migration (May to July) a north-westerly mean direction was recorded (Fig. 2b; and Table 1). The two mean directions were significantly different ($P < 0.01$, Mardia Watson Wheeler test). To avoid the non-independence of repeat observations on a bird, we calculated a single mean direction for all birds tested more than once in a period. The directional preferences were still observed in each time period (March–April: $n = 11$, $\alpha_m = 45°$, $r_m = 0.64$, $P < 0.01$; May–July: $n = 19$, $\alpha_m = 319°$, $r_m = 0.61$, $P < 0.001$, Rayleigh test) and these directions still differed significantly ($P < 0.01$, Mardia Watson Wheeler test). The Mann-Whitney test showed no orientational differences within both periods when the directional tendences of birds tested only once were compared with means of those tested more frequently.

However, it revealed a significantly different direction between the two periods ($P < 0.05$). Furthermore, individual birds tested in both periods showed a significant change in direction according to the Wilcoxon Signed Rank test ($P = 0.05$).

Discussion

The directional tendencies of our captive birds recorded in Armidale, New South Wales, reflect the migration route of the species along the Australian east coast and the Great Dividing Range. The north-easterly mean direction found in March and April agrees well with the directions of migratory flocks of Yellow-faced Honeyeaters reported from the Canberra region and various locations in New South Wales (Hindwood 1948; Liddy 1966; Davey *et al.* 1984). Also, the north-westerly direction of the second part of autumn migration is in agreement with the observation of Robertson (1958) in Brisbane and the direction that birds should take to spread along the coast and Dividing Range in Queensland (Fig. 1). This means that data from the funnel cages not only give a general tendency of migration, but also mirror changes in direction that birds show along their route.

The seasonal shift in directional preference was not caused by birds that consistently oriented differently being used in the two time periods. Individuals tested during both phases of migration showed the same directional shift seen by the sample. Furthermore, the data analysis revealed that the directional tendencies of birds tested only once were not different from those tested more frequently. These findings correspond to a study on the orientation behaviour of the European Robin *Erithacus rubecula* where such an independence was described for a much larger sample (Wiltschko 1968).

The phenomenon of birds changing direction in the course of their migratory flights has also been reported from other parts of the world. Many European migrants wintering in Africa avoid crossing the Alps and the centre of the Mediterranean Sea, by passing to the south-west or south-east and then shifting to more southerly courses (Zink 1977). Among these birds are the central European populations of the Garden Warbler *Sylvia borin* and the Pied Flycatcher *Ficedula hypoleuca*; they migrate first south-west to Iberia and then take southerly and south-easterly courses to reach their winter quarters south of the Sahara. The eastern European population of the Blackcap *Sylvia atricapilla* shows the reverse tendency, first flying on a south-easterly course down the Balkan Peninsula. When tested in orientation cages, birds of these species showed the corresponding change in direction at the time of season when their free-flying conspecifics do so in the wild (Gwinner & Wiltschko 1978 for Garden Warblers; Beck & Wiltschko 1988 for Pied Flycatchers; Helbig *et al.* 1989 for Blackcaps). These tests took place in Germany under environmental conditions that were very different from those that the birds would have experienced if they had migrated to Iberia or the Eastern Mediterranean. This led to the conclusion that the change in direction was based on an endogeneous component, being controlled by an innate migratory time program which also determines the amount and duration of migratory activity (*cf.* Berthold 1988).

All species tested to date, however, migrate at night. For such birds, landscape features such as mountain ranges and coastlines might be generally only of minor importance. Yellow-faced Honeyeaters, in contrast, are day migrants. For these birds, landscape features are much more prominent. Therefore, one might have assumed that the shift from north-east to north-west of the east Australian coastline and the mountains at the border of New South Wales and Queensland plays an important role in guiding their migration. Interestingly the birds shifted their directional tendencies also in captivity in Armidale, when such landscape cues were not available to them. This strongly suggests that the change in migratory direction is, at least in part, also controlled by an endogenous program in day migrants.

Table 1 Orientation results of Yellow-faced Honeyeaters tested in March–April and May–July 1990 in the presence of the natural geomagnetic field and celestial cues. r_m = length of mean vector, α_m = direction of mean vector, P = significance level of Rayleigh test (Batschelet 1981).

Test period	Number of birds	Number of tests	Mean vector α_m	Mean vector r_m	Significance
March–April	11	16	42°	0.52	$P < 0.025$
May–July	19	27	316°	0.52	$P < 0.001$

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