Corella, 1992, 16(1): 23-28

REGIONAL, AGE AND SEXUAL DIFFERENTIATION IN THE REGENT HONEYEATER *Xanthomyza phrygia*

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Received 22 February 1991

Assessment by routine morphometric analysis found no geographic variation in the Regent Honeyeater *Xanthomyza phrygia* but distinguished significant sexual dimorphism in size, intensity of plumage colour and extent of warty skin on the face. Seasonal distribution of records indicates that coastal south-eastern Australia forms part of the core breeding range of the species.

INTRODUCTION

Because the Regent Honeyeater *Xanthomyza phrygia* appears to have declined seriously within the last decade (Peters 1979; Franklin *et al.* 1987; Franklin and Menkhorst 1988), a review of its geographical variation has become urgent in order to identify any regionally differentiated forms under imminent threat. The honeyeater is endemic to the eucalypt woodlands and forests of south-eastern mainland Australia, ranging erratically west to the Mt. Lofty-southern Flinders Ranges, and north and north-east along the east and west slopes of the Great Dividing Range to the granite belt and coast of extreme south-eastern Queensland (Franklin *et al.* 1989).

There has been no review of its regional variation since Mathews (1912, 1925, 1931) separated Victorian and South Australian populations as the subspecies *tregellasi* Mathews (type locality: Mulgrave, Victoria) from populations in New South Wales. Both Salomonsen (1967) and Condon (1968) treated the Regent Honeyeater as monotypic, rejecting *tregellasi* without giving reasons for their decisions. To resolve this question and to place geographical differentiation in this species on a firm footing, we present here a conventional morphometric analysis of specimens in Australian museums covering the range of the honeyeater.

MATERIALS AND METHODS

We examined all skins of Regent Honeyeaters in the Australian Museum, Sydney (AM), Australian National Wildlife Collection, Canberra (ANWC), Museum of Victoria, Melbourne (NMV), Queensland Museum, Brisbane (QM), and South Australian Museum, Adelaide (SAMA). Altogether, 126 specimens (114 adults, 12 immatures) with specified localities were assembled, covering the geographic range of the species from southern Victoria to Gulf St. Vincent, South Australia, and to Chinchilla and Brisbane, Queensland; of these specimens, 88 adults and 10 immatures or juveniles were sexed. All were measured for the following characters: wing as flattened chord, tail from base to tip of central rectrices, bill from nostril to tip and as exposed culmen, and tarsus from the notch on the heel to the base of the first split scute on the knuckle. Variation in colour was most marked in the intensity and brightness of yellow chevrons on the mantle and back; it was scored on a graded scale of 1 to 3 reflecting brightness, as follows: 1 — dull, 2 — intermediate, 3 — bright. The extent and wartiness of bare facial skin also varied and was scored on a graded scale of 1 to 4, as follows: 1 — small and smooth, 2 — larger and slightly warted, 3 — moderately large and warted, 4 — very extensive and heavily warted.

For analysis of geographical variation, only sexed adults were used. They were first separated by sex and grouped by State to test Mathews' presumption that South Australian and Victorian populations differed from those in New South Wales. The measurements of the four State samples and sexes were then compared with one another by a two-way analysis of variance of measurement and sex against State. Variation in dorsal scalloping and facial skin was in turn compared individually against sex and State by one way analysis of variance.

To check the results, the specimens were then regrouped in four natural physiographic and biogeographic regions and the measurements and scores of the new groupings reanalysed by the same procedures. The four regions were: the Lofty Range and adjacent plains, (2) the inland scarp of the Great Dividing Range from Victoria north to the Goulburn-Hunter Rivers, New South Wales, (3) the coastal scarp of that range over a parallel tract, and (4) both scarps of that range north of the Hunter-Goulburn Rivers. The basis for the first and last of these divisions is implicit in Condon (1968) and Short *et al.* (1983); that for separating the populations on coastal and inland scarps of the Great Dividing Range is the possibility that the summit ridges of the range isolate them (cf. Franklin *et al.* 1989, Fig. 1).

RESULTS

Age classes

Sequences of change were reconstructed from dated specimens in moult and the proportions of immatures in the series studied. They suggest that juveniles moult gradually from their prevailingly plain dusky-brown, whitish-bellied body plumage into patterned plumage resembling adult dress at about one to three months after fledging, usually in late summer. In this plumage they resemble adult females but are duller. The unmoulted wing (remiges) and tail feathers, in particular, are duller and browner, the central pair of rectrices with almost olive-brown toning barred very faintly darker grey-brown. The area of bare facial skin is small, restricted to the periorbital area and lores, and almost smooth, lacking warts. At the next moult some twelve months later, immatures gain full adult plumage, by which time extensive bare and warted areas of skin have developed on their faces.

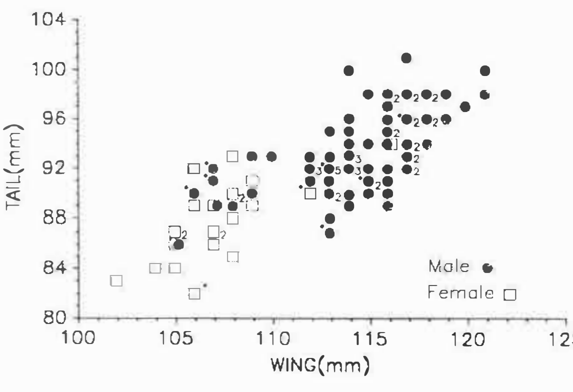

Figure 1. *Distribution of wing and tail measurements of Regent Honeyeaters sexed according to museum label. Integers adjacent to symbols indicate the number of specimens (more than one) sharing that combination of measurements. Small dots indicate immatures.*

Sex classes

Two carefully sexed adults, male and female, collected recently by staff of the ANWC, provided clues for unravelling sexual dimorphism and alerted us to a number of evidently missexed specimens in Australian museums (Appendix 1). Contrary to convention (North 1906–1909; Mathews 1925), adult males and females differ from one another not only in size but also in proportions of bill, intensity of plumage marking, and size and wartiness of facial skin.

In size, adult females are distinctly smaller than males (Tables 1, 2). Thus the wing in adult males ranged from 105 to 121 mm ($n = 68$, $\bar{x} = 114.8$, S.D. = 2.92), and in females from 102 to 116 ($n = 20$, $\bar{x} = 107.0$, S.D. = 2.70) (Fig. 1), with overlap in only a few specimens (11) as shown in Figure 3. Males also had consistently longer, thicker and generally more robust bills than females, despite overlap (Tables 1, 2). In plumage, males are more brightly scalloped with yellow on the mantle as well, allowing for time of year, wear and, to a lesser extent, age (Table 3). Ventrally, the plain black of their throats extends further down on to the breast before it breaks into yellow chevrons, and bare facial skin is more extensive and heavily warted as well (Table 3; Ley 1990). Whereas wartiness is usually limited to a small area below the eye in females, bare skin extends well down over the cheeks in males and is heavily warted with nodules that spread forward over the lores and around the top of the eye.

These differences were established from 98 sexed adult and immature specimens (see Methods). The eleven specimens overlapping in measurements are presumed missexed, because, with the exception of two, they measured close to the mode for the opposite sex and matched the facial and plumage traits of the opposite sex as well (Figs 2, 3; Appendix 1). It is noteworthy that

TABLE 1

Measurements (mm) of sexed adult Regent Honeyeaters grouped by State. N = number of specimens, x̄ = mean, and S.D. = standard deviation.

		Wing		Tail		Culmen-nostril		Exposed culmen		Tarsus	
State	N	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
					MALES						
South Australia	11	116.5	1.51	95.4	1.96	9.1	0.54	17.1	0.70	22.8	0.60
Victoria	10	113.5	4.00	92.2	3.46	9.0	0.67	17.1	1.10	22.3	0.71
New South Wales	43	114.7	2.87	93.8	3.33	9.3	0.56	17.4	0.86	22.5	0.72
Queensland	4	114.7	2.76	92.8	2.22	9.0	0.00	17.0	0.00	22.3	0.50
					FEMALES						
South Australia	5	107.4	1.52	89.6	2.19	8.6	0.55	15.6	0.55	21.8	1.90
Victoria	7	105.9	2.41	86.9	3.44	8.6	0.53	16.3	0.82	21.7	1.03
New South Wales	7	107.9	3.80	88.3	3.20	8.6	0.53	16.3	1.03	21.5	1.38
Queensland	1	107	—	87	—	8.0	—	—	—	21	—

TABLE 2

Measurements (mm) of sexed adult Regent Honeyeaters grouped by natural region. N = number of specimens, x̄ = mean, and S.D. = standard deviation.

		Wing		Tail		Culmen-nostril		Exposed culmen		Tarsus	
Region	N	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.	x̄	S.D.
					MALES						
Mt. Lofty Range	11	116.5	1.51	94.4	1.96	9.1	0.54	17.1	0.70	22.8	0.60
Coast Dividing Range	37	114.4	3.35	93.9	3.68	9.2	0.58	17.3	1.00	22.4	0.86
Inland Dividing Range	13	114.2	1.90	92.4	2.14	9.2	0.55	17.1	0.64	22.5	0.52
North of Hunter River	7	115.7	3.25	93.3	2.63	9.5	0.55	17.4	0.55	22.4	0.53
					FEMALES						
Mt. Lofty Range	5	107.4	1.51	89.6	2.20	8.6	0.55	15.6	0.55	21.8	1.10
Coast Dividing Range	9	107.1	3.82	88.1	3.37	8.7	0.50	16.7	0.76	21.6	0.98
Inland Dividing Range	3	107.0	2.65	86.7	3.78	8.7	0.58	16.0	1.00	22.3	0.58
North of Hunter River	3	106.0	1.00	86.7	2.52	8.0	0.00	15.5	0.71	20.7	1.53

nine of the eleven are females identified as males (Figs 2, 3), suggesting that the well-known error of mistaking adrenal glands for testes was the cause. Five of the eleven are immature, and ten of them were collected between April and August, in months when breeding activity is minimal (Franklin *et al.* 1989) and gonads are reduced. By the above criteria, the 28 unsexed specimens in eastern Australian mainland museums can now be sexed with some confidence (Figs 2, 3; Appendix 1).

Geographical variation

Basing statistical analyses only on adults sexed according to museum label, we found no significant morphological differentiation among the samples from both sets of four regions compared. In body measurements, two-way analysis of variance gave significant separation between sexes across States and regions ($P<0.001$) but found no significant difference among States and regions themselves ($P>0.05$), (Tables 1, 2). For

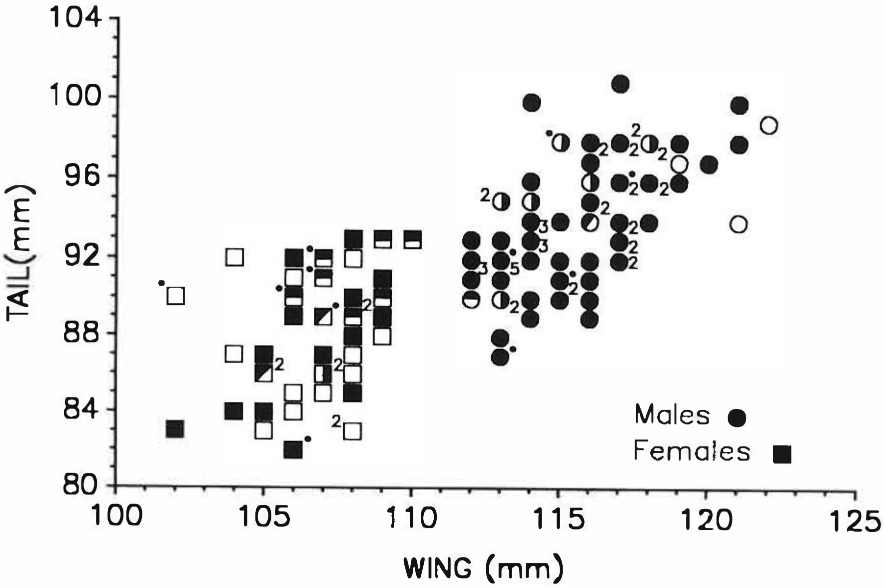

Figure 2. *Distribution of wing and tail measurements of all specimens of Regent Honeyeaters examined, with unsexed and presumed missexed specimens reassigned according to our sexual criteria (see Results). ● = correctly sexed male, ■ = correctly sexed female, ○ = unsexed male, □ = unsexed female, ◑ = unsexed (left) and accurately sexed (right) male sharing that combination of measurements, ◨ = unsexed (left) and accurately sexed (right) female sharing that combination of measurements, ⊖ = missexed male, ⊟ = missexed female, ◐ = correctly sexed male (left) and missexed male (right) sharing that combination of measurements, ◩ = correctly sexed female (left) and missexed female (right) sharing that combination of measurements. Integers adjacent to symbols indicate the numbers of specimens sharing that combination of measurements. Small dots indicate immatures.*

TABLE 3

Geographical variation in facial wartiness and intensity of dorsal scalloping in sexed adult Regent Honeyeaters grouped by both State and natural region. See text for scoring of area and wartiness of facial skin and for brightness of dorsal scalloping. Integers denote the number of specimens scored for each scale category.

		Extent and wartiness of facial skin				Brightness of dorsal scalloping		
Sex	Region	1	2	3	4	1	2	3
M	South Australia	2	1	6	3	0	1	11
M	Victoria	1	3	6	2	2	7	3
M	New South Wales	1	1	11	11	0	4	20
M	Queensland	1	1	1	1	0	2	2
F	South Australia	1	3	1	0	0	4	1
F	Victoria	5	2	0	0	2	5	0
F	New South Wales	1	4	1	0	3	2	1
F	Queensland	1	0	0	0	0	1	0
M	Mt. Lofty Range	2	1	6	3	0	1	11
M	coast Dividing Range	2	2	8	9	1	4	15
M	inland Dividing Range	0	2	8	2	1	7	5
M	north of Hunter River	1	1	2	3	—	2	5
F	Mt. Lofty Range	1	3	1	0	0	4	1
F	coast Dividing Range	4	4	0	0	2	6	0
F	inland Dividing Range	2	1	0	0	2	1	0
F	north of Hunter River	1	1	1	0	1	1	1

dorsal brightness and facial wartiness, there were again significant differences between sexes ($P<0.001$) but not between States and regions ($P>0.05$), except between States alone in dorsal brightness in males ($P<0.001$). Nevertheless, even though the yellow dorsal chevrons were generally broadest and brightest in the numerically large South Australian and New South Wales samples, and narrowest and dullest in Victorian material, the difference was not great, with much overlap among individuals locally. The supposedly blacker back claimed by Mathews (1912, 1925) to be shared by Victoria and South Australian populations was not apparent.

DISCUSSION

The Regent Honeyeater is evidently monotypic, without any regional differentiation in morphology. The brighter yellow dorsal chevrons in South Australian samples, in particular, are probably seasonal. Most specimens in that series (20 out of 22 adults) were collected between March and August, immediately after the late summer-early autumn annual moult when plumage is fresh.

Lack of differentiation is not only consistent with evidence that Regent Honeyeaters are nomadic, but the seasonal distribution of specimen records also reinforces the pattern of movements reported by Franklin *et al.* (1989). On inland slopes of the Great Dividing Range, there is a seasonal spread of specimens, with 11 from the breeding period between August and February and five from the non-breeding period between March and July. On the coastal scarps of the range, the proportion of specimens from the breeding months is much higher: 41 out of 50 dated skins. When considered with the South Australian sample and sight and specimen records summarized by Franklin and Menkhorst (1988) and Franklin *et al.* (1989, Fig. 2), these data suggest that Regent Honeyeaters undertake a regular seasonal dispersal. In the non-breeding period (autumn-winter), they spread along inland scarps of the Great Dividing Range and to the Mt. Lofty Range region and south-eastern Queensland. During the breeding season, there is a consistent contraction to south-east Australian coastal regions and adjacent inland scarps of the Great Dividing Range (Franklin *et al.* 1989; *pace* Blakers *et al.* 1984). The spine of the Great Dividing Range thus forms no barrier between inland and coastal populations.

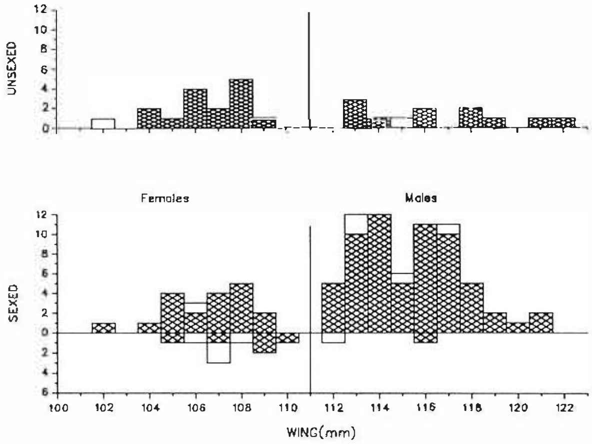

Figure 3. *Histogram of wing measurements of all sexed and unsexed adult specimens of Regent Honeyeaters assigned to sex. Integers on vertical axes are the number of specimens with a given length of wing. Presumed missexed specimens are included below the abscissa for the sexed series. Unhatched blocks represent immatures.*

These seasonal shifts demonstrate that the south-east coastal regions are at least as much part of the core breeding grounds of the Regent Honeyeater as the inland slopes of the Great Dividing Range, notwithstanding that the honeyeater may breed locally anywhere over its range (Franklin and Menkhorst 1988; Franklin *et al.* 1989). This bears on the conservation of the species. So far, reasons for its decline have been attributed primarily to loss of Red Ironbark *Eucalyptus sideroxylon* — Yellow Box *E. melliodora* and *E. leucoxylon* woodland and open forest, habitats limited mainly to the inland slopes of the Great Dividing Range (Franklin *et al.* 1987, 1989). But whereas Regent Honeyeaters are still recorded regularly in these forests and woodlands, they seem to have all but disappeared from the coastal slopes of the Range. If the coastal slopes and valleys are (or were) as important for breeding and recruitment as the above records suggest, then causes for decline should also be looked for there, where, as pointed out by Franklin *et al.* (1989), even the most basic information on preferred habitat is lacking. Moreover, the wealth of records from the Mt. Lofty Range in non-breeding months in the first half of this century indicate that the region then supported a large proportion of the wintering populations.

Now extensively cleared, the range and the pathways to it through the South Australian mallee today deny wintering cover of any significance to the Regent Honeyeater (Franklin and Menkhorst 1988).

The extent of sexual dimorphism in the Regent Honeyeater described here now makes it possible to identify both sexes with reasonable reliability, particularly when handling and banding birds. There is probably little or no overlap in length of wing, that recorded in the text above apparently reflecting missexing. In sexing living birds, however, it is necessary to bear in mind that first-year males will resemble females in both plumage and facial skin, and that fresh measurements will be slightly greater, sex for sex, than those given here from dried specimens.

ACKNOWLEDGMENTS

We are grateful to the collection managers of the following five national and State collections for the prompt loan of material for study: Mr. W. E. Boles, Australian Museum, Sydney, Ms. B. Gillies, Museum of Victoria, Dr. Philippa Horton, South Australian Museum, Mr. N. W. Longmore, Queensland Museum, and Mr J. C. Wombey, Australian National Wildlife Collection, Canberra. We are also grateful to Walter Boles and Dr. P. Moors, Royal Australasian Ornithologists Union, Melbourne, for valued criticism of the manuscript.

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APPENDIX 1

Specimens of unsexed and presumed missexed specimens of Regent Honeyeaters in eastern Australian mainland museums here assigned to the correct sex by our criteria (see Results). Asterisks indicate immatures.

Unsexed = males	
AM:	0.1248 (Oct 1887), 0.8845* (— 1896), 0.8910 (—), 0.11842 (30 June 1949), 0.13258 (Sept. 1903), 0.16349 (Sept. 1909), 0.16350 (Sept. 1909), 0.16882 (Oct. 1911), 0.22304 (—).
ANWC:	56302 (—).
NMV:	R13419 (Nov. 1931).
SAMA:	SA White Coll. (—).
Unsexed = females	
AM:	0.8844 (—), 0.8935 (—), 0.9519 (—), 0.10621 (—), 0.11803* (—), 0.11805 (—), 0.11844 (11 Oct. 1911), 0.11845 (Sept. 1900), 0.16883 (14 Oct. 1911), 0.16884 (—).
ANWC:	56299 (—), 56300 (—), 56301 (—).
NMV:	B5742 (10 June 1921), B5741 (22 June 1895).
SAMA:	B22994 (27 Aug. 1942).
Missexed females = males	
AM:	0.27600 (June 1917).
NMV:	B16342* (30 June 1949).
Missexed males = females	
AM:	0.29077 (12 Aug. 1912), 0.29084 (Aug. 1920), 0.29094 (Aug. 1920).
ANWC:	15681* (4 April 1971).
NMV:	B15559 (c. 1909), B5743* (21 April 1903), B5776 (20 May 1954).
SAMA:	B23160* (21 June 1919), B23159* (6 July 1918).