Ecological differentiation of canaries (Fringillidae) in the Western Cape

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Summary

Underhill, L.G., Erni, B. & Mashinini, F.X. 1998. Ecological differentiation of canaries (Fringillidae) in the Western Cape. *Durban Museum Novitates* 23: 56–60. Of 29 passerine families with more than four species in southern Africa, only the Fringillidae have more than 50% of their members occurring in the Fynbos Biome, Western Cape, South Africa. The ecological differentiation between the canaries in this region is attributed mostly to dissimilarities in their geographical distributions; the two species showing the largest overlap in distribution, the Cape *Serinus canicollis* and bully *S. sulphuratus* canaries, are differentiated in body mass and diet. There is no relative staggering of breeding seasonality.

KEYWORDS: *Fringillidae, western Cape, fynbos biome, morphometrics, distribution, diet, breeding.*

Introduction

Most of the 29 passerine families occurring in southern Africa are poorly represented in the Fynbos Biome of the Western Cape. Of the families with more than four species in southern Africa, only the Fringillidae have more than 50% of their members occurring in this region (Table 1). This was first recognised by Winterbottom (1973), who discussed the co-existence of seven members of the genus *Serinus* (including the Cape siskin *Pseudochloroptila totta*, which was then classified as belonging to this genus) in the Fynbos Biome. The high relative diversity of Fringillidae in this biome was also noted by Herremans *et al.* (in prep.). Winterbottom (1973) attributed their co-existence to different preferences in habitat and food; the latter mediated by variation in size. Milewski (1978) showed that the dietary separation between these species was less than Winterbottom had proposed, with several species taking the same food items, but in differing proportions.

In this paper we consider the ecological differentiation between these species, supplementing Milewski's (1978) dietary data with information on geographical distribution, wing-length and body mass, and breeding seasonality.

Materials and Methods

As far as data sources permitted (Table 2), the study area was taken as the Fynbos Biome, as defined by Allan *et al.* (1997). Scientific names of species considered are given in Table 4.

The database of the Southern African Bird Atlas Project (Harrison *et al.* 1997) was used to define the geographical distributions of eight Fringillidae in the Fynbos Biome. For this project, checklist data were collected using a quarter-degree grid; for each grid cell, the data available were the number of checklists for the grid cell, and the number of these checklists recording each species. The proportion of checklists recording a species is known as the reporting rate (Harrison & Underhill 1997).

Mathematical dissimilarities between distributions were calculated using the method of Erni & Underhill (in prep.). The measure of dissimilarity between the distributions of two species is based on a weighted Euclidean distance logarithm and takes into account the overall reporting rates for the two species in the area under consideration, the differences in reporting rate for the two species in each grid cell, and the number of checklists per grid cell. The dissimilarities are scaled between 0 and 1 in such a way that 0 indicates perfect concordance in distribution, and dissimilarity of 1 indicates mutually exclusive distributions. The inter-species dissimilarity matrix was represented by a sequence of dissimilarity plots, in which the dissimilarities relative to each species are plotted.

Milewski (1978) described the diets of seven canary species; the study was based on observations of feeding, and Milewski gave several caveats on the reliability of the data. The diet data were transformed to inter-species dissimilarities by calculating Euclidean distances between the diet of pairs of species. The inter-species dissimilarity matrices, both for diet and for distribution, were represented in two dimensions using non-metric multidimensional scaling (log stress function of Greenacre & Underhill 1982) as implemented in Genstat (Genstat 5 Committee 1993).

Seasonality of breeding was considered by Winterbottom (1973). A larger data set was taken from an unpublished report by R.P. Prŷs-Jones and I. Newton, who analysed the nest record card collection of BirdLife South Africa and assigned observations of breeding activity to the most likely month of clutch-completion. Reference was also made to 'Zone 4' in Dean *et al.* (1997); although this is defined as the area lying south of 31° S and west of 25° E, most of the checklists for this zone were from the Fynbos Biome (Harrison & Underhill 1997). The breeding phenology plots in Dean *et al.* (1997) include the timing of all evidence of breeding, and were not referred back to the most likely month of clutch-completion.

Results

Dissimilarities between geographical distributions in the Fynbos Biome varied between 0.11 and 0.82 (Table 4, Figs 1 and 2). The two species calculated to have the most similar distributions were Cape canary and bully canary (0.11), followed by yellow canary and white-throated canary (0.18). The least similar distributions were between forest canary and protea canary (0.82). The non-metric scaling plot portrays these dissimilarities (Fig. 2).

The heaviest species, white-throated canary and bully canary, were double the body mass of the lightest species, Cape siskin and forest canary (Table 3). These pairs of species

Table 1. The number of species in each passerine bird family in southern Africa (Maclean 1993), and the number of species occurring in the 'southwestern Cape' bird atlas area, excluding vagrants (Hockey *et al.* 1989).

Family	Southern Africa	Southwestern Cape	Percentage in Southwestern Cape
Eurylaimidae	1	0	0
Pittidae	1	0	0
Alaudidae	25	8	32
Hirundinidae	22	10	45
Campephagidae	3	2	67
Dicruridae	2	1	50
Oriolidae	4	1	25
Corvidae	4	4	100
Paridae	6	1	17
Remizidae	2	1	50
Salpornithidae	1	0	0
Timaliidae	6	0	0
Pycnonotidae	10	3	30
Turdidae	44	13	30
Sylviidae	71	23	32
Muscicapidae	22	9	41
Motacillidae	23	8	35
Laniidae	5	1	20
Malaconotidae	17	4	24
Prionopidae	4	0	0
Sturnidae	14	5	36
Buphagidae	2	0	0
Promeropidae	2	1	50
Nectariniidae	21	6	29
Zosteropidae	2	1	50
Ploceidae	35	7	20
Estrildidae	27	3	11
Viduidae	8	1	13
Fringillidae	20	12	60

also had the longest and shortest wings (Table 3). The ordering of species 'size' on wing-length and body mass was similar, but not identical (Table 4, Fig. 3). The protea canary is plump and short-winged relative to its body-mass, whereas the Cape canary and chaffinch are slender and long-winged relative to their body-masses (Fig. 2).

Based on nest record cards, the month of peak breeding was, for all species, either August or September (Table 5). Inspection of the breeding data for 'Zone 4' in Dean *et al.* (1997) likewise suggests that there is little segregation of breeding seasonality for these species in the Fynbos Biome.

Table 2. Characters used to measure ecological separation in Fringillidae.

Character	Method and/or source
breeding seasonality	BirdLife South Africa nest record cards (R.P. Prys-Jones & I. Newton unpubl. data), atlas data (Dean *et al.* 1997).
distribution	atlas data (Dean *et al.* 1997).
wing-length and body-mass	George D. Underhill ringing records; Richardson & Fraser (1995) for protea canary. Wing-length measured flattened and straightened, using method 3 of Svensson (1992), to 1 mm. Body-mass determined using a 50 g or 100 g Pesola spring balance; readings usually interpolated to 0.1 g.
diet	Tables 4 & 6 of Milewski (1978), with the data for protea canary averaged across months

Milewski's (1968) diets of seven species show considerable inter-species variation (Table 6). This is confirmed by the matrix of dissimilarities (Table 7), where the smallest dissimilarities are between the yellow, streaky-headed and white-throated canaries, represented as a loose cluster of three points in the non-metric scaling plot (Fig. 4). These three species have 'other small seed' as the dominant component of their diets, which may represent diverse diets. Cape and bully canaries were judged to be the most dissimilar in diet, and are farthest apart in Figure 4.

Discussion

These results confirm and extend the conclusions and conjectures of Winterbottom (1973) and Milewski (1978).

All species considered have a similar breeding seasonality (Table 5); within the Fynbos Biome there is probably little opportunity to achieve separation from potential ecological competitors by a relative staggering of the breeding season. A similar conclusion was reached by Winterbottom (1973).

The two species which have the most similar distributions (Figs 1 and 2) in the Fynbos Biome, the Cape and bully canaries, are the most dissimilar in diet (Table 7, Fig. 4). Although their relative differences in average wing-length are small (92%), the average body mass of the Cape canary is 54% that of the bully canary, which is close to the largest

Table 3. Dissimilarities (x 100) between the geographical distributions of eight canaries in the Fynbos Biome.

	Cape canary	forest canary	bully canary	yellow canary	white-throated canary	protea canary	streaky-headed canary	Cape siskin
Cape canary		44	11	31	45	59	30	35
forest canary	44		33	73	75	82	27	61
bully canary	11	33		43	57	63	25	43
yellow canary	31	73	43		18	66	52	48
white-throated canary	45	75	57	18		67	43	53
protea canary	59	82	63	66	67		77	38
streaky-headed canary	30	27	25	52	43	77		58
Cape siskin	35	61	43	48	53	38	58	

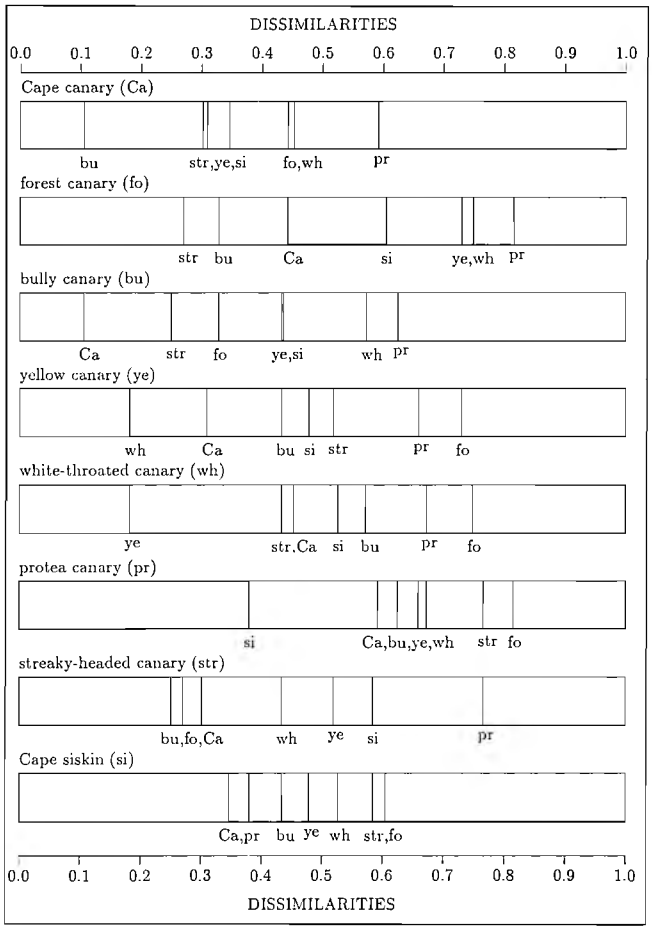

Fig. 1. Dissimilarity plots for canary species in the Fynbos Biome. The bar for each species shows those species most similar in geographical distribution at the left-hand end of the bar, and those least similar at the right-hand end. Species abbreviations are given in the bar for the species.

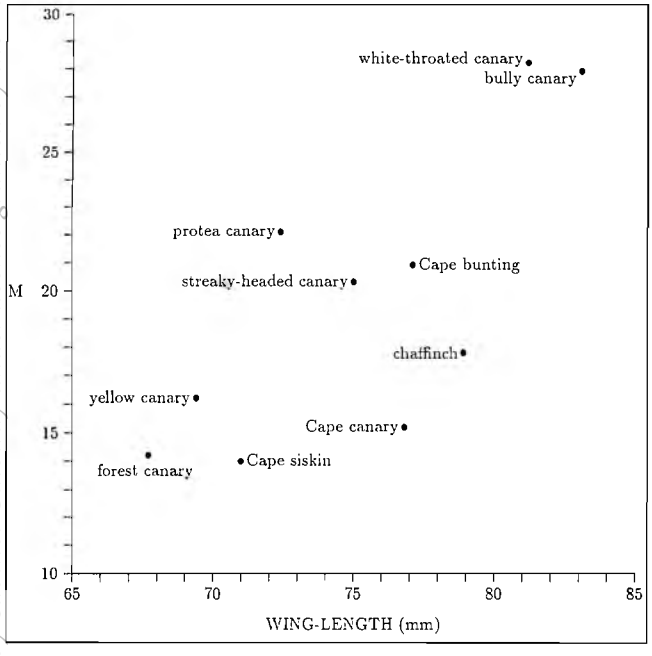

Fig. 3. Scatter diagram of mean wing-length and mean body mass for species of Fringillidae in the Fynbos Biome.

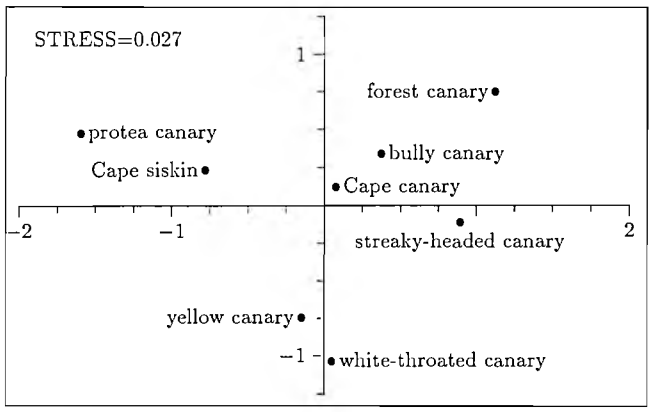

Fig. 2. Non-metric multidimensional scaling of the data of Table 3, dissimilarities in geographical distribution between canary species in the Fynbos Biome.

relative difference of 50% of any pair of species in Table 4. These two species are therefore differentiated both in body mass and in diet. In comparison with the bully canary, the Cape canary is a slender bird (Fig. 3).

The yellow and white-throated canaries also have similar distributions in the Fynbos Biome (Figs 1 and 2). Within the context of Table 7, the difference in diet is relatively small; the white-throated canary diet includes 'large seed' which is rarely taken by yellow canaries (Table 6). The average body-mass of the yellow canary is 57% that of the white-throated canary (Table 4). These two species are therefore differentiated mainly in size and to a lesser extent in diet.

The largest inter-species dissimilarity between distributions, 0.82, was between the forest and protea canaries (Table 3, Figs 1 and 2). Both are described as occurring in 'evergreen forest' in, for example, Maclean (1993). However, inspection of the distribution maps in Dean *et al.* (1997) show that the ranges of these two species in the Fynbos Biome are the most nearly mutually exclusive of any pair of species considered here.

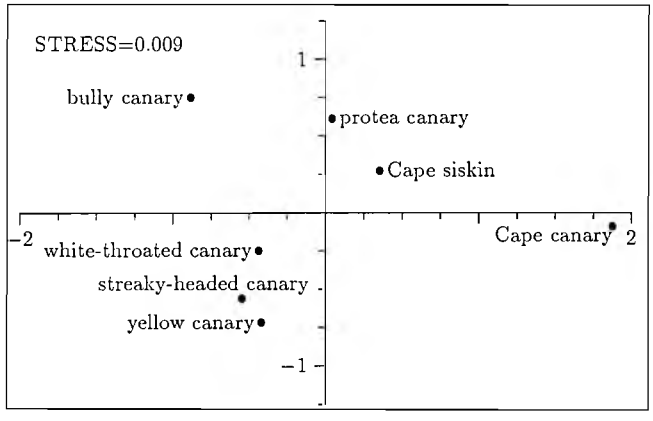

Fig. 4. Non-metric multidimensional scaling of the data of Table 7, dissimilarities in diet between canary species in the Fynbos Biome.

Table 4. Summary statistics of wing-length and body-mass of Fringillidae in the Fynbos Biome.

	Wing-length (mm)					Body-mass (g)				
Species	mean	*s*	range	IQR	*n*	mean	*s*	range	IQR	*n*
chaffinch *Fringilla coelebs*	78.9	6.1	65-85	76-84	9	17.8	1.9	15.5-21.7	16.6-19.3	10
Cape canary *Serinus canicollis*	76.8	3.2	65-86	75-80	213	15.2	1.3	10.0-19.7	14.0-16.0	207
forest canary *S. scotops*	67.7	1.6	65-70	66-69	31	14.2	0.9	13.0-16.4	13.7-15.0	31
bully canary *S. sulphuratus*	83.1	2.6	75-80	81-85	352	27.9	2.1	20.3-35.3	26.5-29.2	335
yellow canary *S. flaviventris*	69.4	2.6	62-80	67-71	230	16.2	1.4	10.3-19.5	15.4-17.0	229
white-throated canary *S. albogularis*	81.2	3.0	75-89	79-84	48	28.2	2.6	22.9-33.0	26.5-33.0	50
protea canary *S. leucopterus*	72.4	2.1	70-74	-	11	22.1	1.4	18.8-24.8	-	11
streaky-headed canary *S. gularis*	75.0	2.0	73-77	-	3	20.3	0.6	19.5-20.7	-	3
Cape siskin *Pseudochloroptila totta*	71.0	1.7	68-75	69-72	64	14.0	1.0	11.1-16.5	13.3-15.0	60
Cape bunting *Emberiza capensis*	77.1	4.1	68-85	74-80	70	20.9	1.6	17.5-26.0	19.8-22.3	72

Table 5. Estimated months of clutch completion in the Fynbos Biome calculated from Nest Record Cards (R.P. Prys-Jones & I. Newton unpubl. report).

Species	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.
chaffinch	-	-	2	1	2	-	-	-	-	-	-	-
Cape canary	4	46	68	55	31	7	1	-	-	-	-	-
bully canary	2	11	5	6	1	-	-	-	-	-	-	-
yellow canary	25	127	140	47	9	1	-	1	1	-	1	-
white-throated canary	8	43	57	33	4	-	-	-	-	-	-	-
protea canary	-	-	-	3	2	-	-	-	-	-	-	-
streaky-headed canary	-	4	5	2	-	-	-	-	-	-	-	-
Cape siskin	-	6	4	4	4	1	-	-	-	-	-	-
Cape bunting	-	20	62	46	9	4	1	-	-	-	-	-

Table 6. Diets of seven canary species in the Fynbos Biome (Milewski 1978).

Species	Graminoid seed	Achenes	Other small seed	Large seed	Seed kernels in fleshy fruits	Fruit pulp	Foliage buds	Nectar	Animal matter	Fresh floral parts	Succulent leaf pulp	Other soft plant parts	Other plant matter
Cape canary	+	91	9	+	0	+	0	0	+	0	0	0	0
bully canary	+	6	5	14	46	14	+	3	7	2	0	3	0
yellow canary	1	19	61	+	0	0	1	11	3	1	0	0	3
white-throated canary	+	11	44	19	8	2	0	2	4	6	4	0	0
protea canary	15	16	5	36	6	5	5	7	3	2	0	0	0
streaky-headed canary	+	9	54	+	7	15	+	3	6	3	3	0	0
Cape siskin	35	22	9	3	0	0	7	5	1	1	0	0	1

Table 7. Dissimilarities between diets of canaries in the Fynbos Biome, calculated as the Euclidean distances between the rows of Table 6.

	Cape canary	bully canary	yellow canary	white-throated canary	protea canary	streaky-headed canary	Cape siskin
Cape canary		99	90	90	86	95	80
bully canary	99		77	57	51	64	66
yellow canary	90	77		30	69	23	64
white-throated canary	90	57	30		46	25	57
protea canary	86	51	69	46		64	44
streaky-headed canary	95	64	23	25	64		64
Cape siskin	80	66	64	57	44	64	

If the calculated dissimilarity between the geographical distributions of two species exceeds 20%, the visual difference between the distributions is generally striking (Erni & Underhill in prep.). Our results suggest that differences in distribution is the main differentiation factor for the canaries in the Fynbos Biome. In the two cases where pairs of species do overlap markedly in range, one member of the pair is almost double the size of the other.

Allometric considerations would suggest that body-mass is proportional to wing-length to the power of three (e.g. Summers 1988). The smallest wing-length, for forest canary, is 81% of the longest wing-length (Table 4). However, raising this proportion to the power of three yields 0.54 (i.e. 0.81 3=0.54), which is close to the ratio of the smallest to the largest body-mass in Table 4. Thus the observed wing-length variation is comparable to the range in body-mass. The extent of scatter in Fig. 3 is considerable, and demonstrates a variety of body-shapes, varying from slender to plump. This represents another characteristic upon which ecological differentiation can be based. It is likely that slender birds such as the chaffinch and the Cape canary are able to fly faster and longer distances, which facilitates both regular migration and nomadism, and in turn the rate at which new habitat can be colonized. The chaffinch is a partial migrant in its natural habitat in Europe, and a Cape canary has been recovered 80 km from its place of ringing, having moved from the Cape of Good Hope Nature Reserve to Caledon (Dean *et al.* 1997). The plumpest bird considered, the protea canary, has not colonized suitable Mountain Fynbos habitat on the Cape Peninsula, separated from the nearest extant populations by the 40 km barrier of the Cape Flats (Dean *et al.*1997).

Acknowledgements

LGU acknowledges support from the Foundation for Research Development (FRD), Pretoria, and the University of Cape Town Research Committee. BE received an FRD postgraduate bursary. FXM participated while on vacation training supported by the Tutu Trust. Unpublished ringing records of G.D. Underhill were used. J.A. Harrison and M. Herremans commented on early drafts.

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