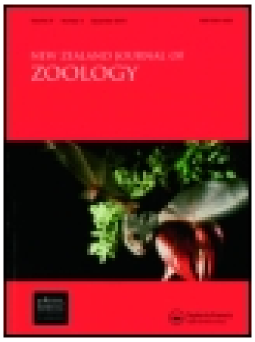

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Melanin pigmentation in the dorsal plumage of New Zealand oystercatchers

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Feather samples gathered from the mantle of breeding birds of the three New Zealand species of oystercatcher were analysed spectrophotometrically to evaluate melanin pigmentation parameters. The only statistically significant difference in these parameters was among individuals, indicating that melanin pigmentation is a conservative character of little systematic value. There is no evidence for geographic variation in melanin pigmentation of black phase *Haematopus unicolor*, and thus there is no justification for considering southern black birds specifically distinct from their northern counterparts on the basis of dorsal plumage colour.

INTRODUCTION

The nomenclature of New Zealand oystercatchers has been subject to considerable change in this century, and they have therefore been referred to as a taxonomically difficult group (Falla *et al.* 1966). The Checklist Committee currently recognises three species: the South Island pied oystercatcher (*Haematopus ostralegus finschi*), the variable oystercatcher (*H. unicolor*), and the Chatham Islands oystercatcher (*H. chathamensis*) (Ornithological Society of N.Z. 1970). Major controversy is centred on the status of the variable oystercatcher, especially the interrelationships of the southern black phase, the northern black phase, and the pied phase. It has been hypothesised that there may be two species of black oystercatcher, one occurring only in southern New Zealand and one occurring as a melanistic phase of the northern variable oystercatcher (Falla 1939, Heather 1966). Two lines of evidence support this contention.

(1) The black phase interbreeds extensively with the pied phase (to produce the intermediate phase) only in northern New Zealand, though it must be noted that factors other than species differences could account for this fact (Baker 1973).

(2) It has been noted by Falla *et al.* (1966) that "the black form of *reischeki* [the northern black phase] is a brown black and lacks the purple gloss of true *unicolor* [the southern black bird], but this needs verification". They also cite evidence questioning this statement: "... black oystercatchers breeding on the northern coast of the North Island can be distinctly glossy; and black oystercatchers seen in flocks on Stewart Island are not noticeable glossy". However, this is probably not a fair comparison. Melanin deposition in the feathers of birds is heavily influenced by the chemical environment in which the precursive melanocytes

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develop (Rawles 1960). Thus seasonal changes in hormonal levels associated with breeding are likely to influence plumage colour, and it is only to be expected that breeding birds would differ in colour from birds gathered in winter flocks. Also, black feathers tend to lose their glossy appearance and become browner as they wear so that the age of the feathers (relative to the annual full moult in February–March) also influences plumage colour.

This study was initiated to investigate geographic variation in the melanin pigmentation of the dorsal plumage of black oystercatchers in New Zealand. For completeness, and for heuristic purposes relevant to systematics, intermediate and pied phase *H. unicolor* were included in the analysis, as were *H. o. finschi* and *H. chathamensis.*

METHODS AND MATERIALS

SAMPLING DETAILS

To minimise variation in melanin pigmentation (and thus plumage colour) arising from feather wear and seasonal hormonal cycles, feather samples were gathered only from breeding birds trapped at the nest. Four feathers were removed from the mantle (medially, between the scapulars) of each bird for spectrophotometric analysis. Details of birds from which feather samples were taken are given in Table 1.

SPECTROPHOTOMETRIC ANALYSIS

The intensity of melanin pigmentation in the distal 5 mm of each feather was analysed with a Beckman DK-2A ratio-recording spectrophotometer, using white standards of 100% reflectance prepared from magnesium sulphate. Such a precision instrument is particularly suited to analysis of differences in melanin pigmentation, as illustrated by Dyck (1966). Curves of percentage diffuse spectral reflectance over the wavelength range 380–770 μm were used to calculate tristimulus values (X, Y, Z) by the weighted-ordinate method (Judd & Wyszecki 1963). This method involves breaking down the reflectance curve into 10-μm intervals and reading off reflectance values ($R\lambda$) on the ordinate at these intervals. Tristimulus values may then be calculated from the equations:

$$X = k \, . \sum_{\lambda=380}^{770} . \, R\lambda.H\lambda.\bar{x}\lambda.\Delta\lambda \quad \text{......} (1)$$

$$Y = k \, . \sum_{\lambda=380}^{770} . \, R\lambda.H\lambda.\bar{y}\lambda.\Delta\lambda \quad \text{......} (2)$$

$$Z = k \, . \sum_{\lambda=380}^{770} . \, R\lambda.H\lambda.\bar{z}\lambda.\Delta\lambda \quad \text{......} (3)$$

where the product $H\lambda.\Delta\lambda$ is the spectral-radiant flux incident on the object being evaluated. In this study, $H\lambda.\bar{x}\lambda$, $H\lambda.\bar{y}\lambda$, and $H\lambda.\bar{z}\lambda$ values were those of Commission Internationale de l'Eclairage (CIE) standard source C, listed in Judd & Wyszecki (1963; table 2.6, pp. 132–3). The wavelength interval $\Delta\lambda$ was set at 10 μm, and for source C, $k = 1$. Thus, by reading $R\lambda$ values into equations (1), (2), and (3), tristimulus values were obtained.

Chromaticity co-ordinates (x, y, z) were computed from the expressions:

$$x = X / (X + Y + Z); \quad y = Y / (X + Y + Z); \quad \text{and } z = 1 - (x + y).$$

TABLE 1—Sample data for breeding New Zealand oystercatchers (*Haematopus* spp.) from which mantle feathers were removed for spectrophotometric analysis of melanin pigmentation parameters

Species	Locality	Latitude (°′S)	Longitude (°′E)	Date	*n*
H. chathamensis	Rangatira Island	44°20′	176°09′W	Nov. 1970	7
H. ostralegus finschi	Ashley River	43°20′	172°20′	Oct. 1970	2
	Rees River, Lake Wakatipu	44°43′	168°13′	Oct. 1970	3
H. unicolor (black phase)	Aupouri Peninsula	34°30′	172°40′	Jan. 1971	5
	Waipu Beach	36°00′	174°28′	Jan. 1970	5
	Patarau, N.W. Nelson	40°41′	172°30′	Dec. 1969	1
	Somes Island, Port Nicholson	41°16′	174°52′	Nov. 1970	2
	Okarito Lagoon	43°12′	170°11′	Dec. 1970	2
	Jackson Bay	43°58′	168°40′	Dec. 1970	2
	Otago Peninsula	45°55′	170°38′	Dec. 1970	4
	Howell's Point, Riverton	46°23′	168°00′	Dec. 1970	4
	Paterson Inlet, Stewart Island	47°04′	168°05′	Dec. 1970	3
H. unicolor (pied phase)	Aupouri Peninsula	34°30′	172°40′	Jan. 1971	3
	Waipu Beach	36°00′	174°28′	Jan. 1970	3
H. unicolor (intermediate phase)	Aupouri Peninsula	34°30′	172°40′	Jan. 1971	2
	Takou	35°06′	173°58′	Jan. 1970	1
	Waipu Beach	36°00′	174°28′	Jan. 1970	3
	Kaikoura Peninsula	42°24′	173°41′	Dec. 1969	2

The x and y co-ordinates were transformed to the illustrative terms dominant wavelength (λd) and excitation purity (σ) respectively (*see* Hardy 1936, table 18). The tristimulus value Y was converted to a brightness term from the equation:

$$Y = 100 y_s$$

where y_s is the trichromatic coefficient of the sample. Dominant wavelength, brightness and excitation purity correspond to the psychological attributes of hue, brilliance, and saturation respectively (Selander & Johnston 1967).

Before commencing colorimetric determinations, several practice runs were made on the same reference sample to check experimental error. Acceptable standards of repeatability ($<1\%$ error) were achieved when the feathers were positioned identically at the sample port before each run.

RESULTS

Mean values and standard errors of the pigmentation parameters of hue, excitation purity, and brightness for New Zealand species of oystercatcher are given in Table 2. To detect possible differences in feather colour due to individual variation, sex, and species, the data in Table 2 were subjected to a three-level, mixed-model, hierarchical analysis of variance (*see* Sokal & Rohlf 1969). Feather replicates were arranged within individuals, sexes, and taxa. The results of this analysis are shown in Table 3. For each parameter, the only significant variance component is among individuals. Neither sexes nor taxa seem to differ in their plumage pigmentation.

TABLE 2—Melanin pigmentation parameters in the mantle feathers of breeding New Zealand oystercatchers (*Haematopus* spp.), based on four feathers per bird sampled

Species/phase	No. of feathers	Mean dominant wavelength ± S.E. (nm)	Mean excitation purity ± S.E. (%)	Mean brightness ± S.E. (%)
H. chathamensis	28	584.0 ± 0.08	63.5 ± 0.07	8.1 ± 0.07
H. ostralegus finschi	20	583.8 ± 0.07	63.8 ± 0.08	8.4 ± 0.18
Black phase *H. unicolor*	112	583.8 ± 0.03	63.4 ± 0.05	8.0 ± 0.05
Pied phase *H. unicolor*	24	583.8 ± 0.04	63.4 ± 0.05	8.1 ± 0.04
Intermediate phase *H. unicolor*	32	584.1 ± 0.05	63.8 ± 0.08	8.0 ± 0.08

TABLE 3—Analysis of variance of melanin pigmentation parameters in mantle feathers of breeding New Zealand oystercatchers (*Haematopus* spp.) (*significant, $P \leqslant 0.001$; other F-ratios not significant)

Source of variation	Degrees of freedom	F-ratios for		
		Dominant wavelength	Excitation purity	Brightness
Among taxa	4;162	2.68	1.31	0.13
Among sexes	5;162	1.47	1.28	0.27
Among individuals	44;162	5.90*	11.49*	18.02*

TABLE 4—Analysis of variance of melanin pigmentation parameters of breeding black phase variable oystercatchers from latitude bands 34–39°S, 39–44°S, and 44–48°S; no F-ratio is significant

Pigmentation parameters	Degrees of freedom	F-ratio
Dominant wavelength	2;108	2.01
Excitation purity	2;108	0.97
Brightness	2;108	1.16

Geographic variation in the pigmentation of the mantle feathers of the black phase variable oystercatcher was investigated by single-classification analysis of variance on the means of feather samples from birds falling into the latitude groupings 34–39°S, 39–44°S, and 44–48°S (Table 4). None of the means are significantly different, indicating that there is no geographic variation (at least on a gross scale) in melanin pigmentation of black phase variable oystercatchers. It is possible, however, that these latitude groupings are too large to detect subtle variations in plumage colour subsumed by Gloger's Rule, which states that, in mammals and birds, races of a species inhabiting warm, humid regions have more melanin pigmentation than those from cooler and drier regions. To investigate this possibility, hue, excitation purity, and brightness values for each bird were subjected to

TABLE 5—Correlation analysis of melanin pigmentation parameters in black phase variable oystercatchers and environmental variables; no correlation is significant

Environmental variable	Pigmentation parameter		
	Dominant wavelength	Excitation purity	Brightness
Rainfall	r = 0.39	r = 0.47	r = 0.41
Relative humidity	r = 0.37	r = 0.29	r = 0.35

correlation analysis with the environmental variables of rainfall and humidity, derived from N.Z. Meteorological Service data (Table 5). The lack of significance of any of the correlation coefficients suggests that melanin pigmentation does not vary in black phase *H. unicolor* in accordance with Gloger's Rule. However, it must be pointed out that geographic variation of melanin deposition may be too finely graded to be detected by spectrophotometric analysis, but even if such limited variation did occur it is clear that it would not account for the gross differences mentioned by Falla *et al.* (1966).

CONCLUSIONS

Dorsal melanin pigmentation appears to have been a conservative character during the evolution of New Zealand oystercatchers, because statistically significant variation occurs only at the level of individuals within species, and not among species. Even within a species (*H. unicolor*) with a relatively widespread range, there is no significant geographic variation such as is predicted by Gloger's Rule. Thus, there is no evidence for separating southern black birds from northern black birds on the basis of plumage colour.

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