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DISCRIMINANT ANALYSIS OF MORPHOMETRIC CHARACTERS AS A MEANS OF SEXING MYNAS

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Abstract.—Male and female Common (*Acridotheres tristis*) and White-vented Mynas (*A. javanicus*) are not clearly sexually dimorphic and are thus difficult to identify in the field. Discriminant analysis of nine morphometric characters of adult birds indicates that tail length, gape length, culmen length, toe length, wing length (maximum chord), tarsus length and body mass contributed significantly to sex identification in Common Mynas, while male and female White-vented Mynas could be separated based on culmen length, beak length, wing length, body mass and toe length. In both species, males were on average, larger than females for the discriminating characters. Univariate analysis of variance of the discriminant scores suggests that the linear discriminant function was effective in sex determination for both species. Application of the "jackknife" technique to the same sample of birds showed that the linear discriminant function correctly classified 89% of 57 male and 76% of 33 female Common Mynas, and 81% of 42 male and 59% of 27 female White-vented Mynas. Live birds that were sexed based on the discriminating morphometric characters and randomly paired in separate compartments in outdoor aviaries laid fertile clutches, indicating the viability of using morphometrics as a field technique to sex mynas.

ANÁLISIS DISCRIMINANTE DE CARACTERÍSTICAS MORFOLÓGICAS PARA DETERMINAR EL SEXO EN DOS ESPECIES DE ACRIDOTHERES

Sinopsis.—La hembra y el macho del maina común (*Acridotheres tristis*) y del maina de vientre blanco (*A. javanicus*) no son claramente dimórficos, lo que hace muy difícil su identificación sexual en el campo. Un análisis discriminante aplicado a nueve características morfométricas de los adultos indicó que la longitud de la cola, comisura de las mandíbulas a la punta del pico (comisura), culmen expuesto, dedo central, ala, tarso y el peso contribuyeron significativamente para identificar el sexo en el maina común. La hembra y el macho del maina de vientre blanco fueron separados en base a la longitud del culmen, pico, ala, dedo central y peso. En ambas especies los machos resultaron (en promedio) de mayor tamaño que las hembras. Un análisis univariable de varianza de las anotaciones discriminantes sugiere que la función lineal discriminante fue efectiva para determinar el sexo en ambas especies. La

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aplicación de la técnica "jackknife" a la misma muestra de aves, demostró que la función lineal discriminante puede clasificar correctamente el 89% de los machos (n = 57) y el 76% (n = 33) de las hembras en el maina común, y el 81% de los machos (de 42 individuos) y el 59% (de 27 individuos) de las hembras en el maina de vientre blanco. Individuos cuyo sexo fue identificado basándose en el análisis discriminante de su morfología y luego apareados en jaulas individuales pusieron huevos fértiles. Esto es indicativo de la utilidad y confiabilidad de este método.

The Common Myna (*Acridotheres tristis*) and the White-vented Myna (*A. javanicus*) belong to the family Sturnidae and are abundant in Singapore (1°20'N, 103°50'E), with an estimated population of 300,000 birds (Hails 1985). They are medium-sized birds with the Common Myna weighing 112.2 g on average, and the White-vented Myna 96.7 g. The Common Myna is predominantly brown and can be distinguished from the predominantly grey to black White-vented Myna by the presence of a yellow patch of orbital skin (King et al. 1975), which is absent in the latter species. It is difficult, however, to distinguish males and females of both species visually because of the lack of clear sexual dimorphism. Although male White-vented Mynas may develop a slightly bigger crest than females during the breeding season, the crest feathers are often molted later.

For our other studies of the breeding biology and behavior of these birds in the wild and in captivity, a technique was required that would provide us with a simple means of sexing individually marked birds. Other studies have suggested that discriminant analysis of certain morphometric characters may be one such means (e.g., Brennan et al. 1984, Desrochers 1990, Hanners and Patton 1985). The aim of this study was thus to determine the morphometric characters that could be used in a discriminant analysis to aid in sexing mynas.

MATERIALS AND METHODS

The study was conducted between May and November 1985, and mynas were captured as part of a management program for these pest species (Kang et al. 1990). A permit to collect birds was obtained from the Primary Production Department, Ministry of National Development, Singapore. Since 20 Dec. 1991, however, both species of myna have been removed from the protected species listed under the Wild Animals and Birds Act and a permit to capture mynas is no longer required by law.

Mynas were caught using bait in the form of small cubes of bread, approximately 1 cm^3 in volume, that were drugged with a stupefying narcotic (alpha-chloralose) at 1% bait weight. The effects of the drug on mynas have been described elsewhere (Kang 1992). Poisoning was chosen over other methods of capture as it was an effective means of obtaining a sufficient number of birds. Pre-baiting was carried out to accustom the birds to feeding on bread by laying out bread without the drug on several evenings prior to the actual poisoning. Poisoning was carried out after a sufficient number of birds were seen feeding on the bait during the pre-baiting period. Poisoned birds were collected immediately after the baiting, and in some cases on the morning after.

Both species of myna form pre-roost assemblies before joining the communal roost. Three pre-roosting sites on the island of Singapore were selected for baiting: (1) a large open field along Lower Kent Ridge Road, opposite the Faculty of Science, National University of Singapore; (2) an open area of grass and clay at the junction of Clementi Road and Commonwealth Avenue West; and (3) an area of open ground along the Pandan River, at the junction of Toh Guan Road and Jalan Boon Lay. Two days of baiting were carried out at site 1 (19 May 1985 and 19 Jul. 1985) and one day at each of sites 2 (1 Aug. 1985) and 3 (13 Nov. 1985). The captured birds were separated into adults and juveniles based on external morphology; the juveniles having much paler plumage and whitish irides. A total of 100 Common Mynas comprising 90 adults and 10 juveniles, and 123 White-vented Mynas comprising 69 adults and 54 juveniles were caught. They were kept in a deep freezer at −20 C and examined within a month of capture. Dehydration of the carcasses as a result of freezing was not significant as a 2-mo old sample of frozen birds showed little change in body mass before and after storage ($F = 0.002$; df = 1, 58; $P > 0.05$).

The sex of each bird was identified by dissection and examination of the gonads. Nine morphometric characters of each bird were measured and the terminology follows that used in King et al. (1975). They are: (1) body mass, as measured on a Pesola spring balance; (2) beak length, as measured from the anterior end of the nostril to the tip of the beak; (3) culmen length, as measured from the posterior end of the culmen to the tip of the beak; (4) gape length, as measured from the inside angle of the mouth to the tip of the beak; (5) gape width, which is the width of the beak at the angle of the mouth; (6) wing length (maximum chord, i.e., the distance from the carpal joint to the tip of the longest primary feather); (7) tail length, as measured from the base of the two middle rectrices to the tip of the longest rectrix; (8) tarsus length, as measured from the joint between the tibia and the metatarsus to the end of the furthest undivided scute; and (9) toe length, as measured from the end of the last undivided scute to the start of the toe nail on the middle toe.

Discriminant analysis of the morphometric characters was performed using the statistical package SPSS/PC+ (Statistical Package for the Social Sciences), and the accuracy of the linear discriminant function in sexing mynas checked by application of the "jackknife" technique (Norusis 1990).

RESULTS

Morphometric comparisons.—Table 1 shows the means of the nine characters for male and female Common Mynas. A stepwise discriminant analysis (see Norusis 1990) suggests that only seven of the nine characters were important in separating the two sexes (Eigenvalue = 1.20, χ^2 = 66.5; df = 7; $P < 0.01$). Examination of the discriminant function coefficients suggested that they differed most for tail length, followed by gape

TABLE 1. Discriminant analysis of nine morphometric characters as measured for 57 male and 33 female adult Common Mynas. Body mass is measured in g and length in mm. Mean (SE), F-ratios (df = 1, 88) from a univariate analysis of variance (oneway ANOVA) between the two sexes and discriminant function coefficients (DFC) from a Wilks' stepwise discriminant analysis (see Norusis 1990) are shown. NA denotes a character that was excluded by the stepwise discriminant analysis.

Characters	Mean (SE)		F-ratio	DFC
	Male	Female		
Body mass	119.6 (1.2)	111.7 (1.6)	15.41***	−0.19743
Beak length	16.0 (0.1)	15.4 (0.1)	14.04***	NA
Culmen length	22.5 (0.2)	21.5 (0.2)	13.23***	0.31887
Gape length	31.0 (0.1)	29.7 (0.2)	37.16***	0.40325
Gape width	15.3 (0.1)	15.1 (0.1)	1.72	NA
Wing length	132.9 (0.6)	126.5 (0.8)	38.12***	0.27785
Tail length	81.2 (0.4)	75.8 (0.8)	42.38***	0.60711
Tarsus length	38.3 (0.2)	36.7 (0.3)	16.59***	0.21502
Toe length	29.1 (0.2)	28.1 (0.3)	9.83**	0.27854

** $P < 0.01$.
*** $P < 0.001$.

length, culmen length, toe length, wing length, tarsus length and body mass, with the characters being larger, on average, in males than females (Table 1).

The linear discriminant function that best discriminates male and female Common Mynas was

$$D = -46.72 + 0.41(\text{gape length}) + 0.25(\text{culmen length}) + 0.21(\text{toe length}) + 0.16(\text{tail length}) + 0.13(\text{tarsus length}) + 0.06(\text{wing length}) - 0.02(\text{body mass}),$$

where D is the discriminant score. Mean discriminant scores for males and females were 0.82 and −1.42, respectively. A univariate analysis of variance (one way ANOVA) of the individual discriminant scores indicates that the linear discriminant function was effective in sex determination ($F = 105.26$; df = 1, 88; $\text{eta}^2 = 0.54$; $P < 0.01$). A further test of the effectiveness of the linear discriminant function in sex determination by application of the "jackknife" technique shows that it correctly classified 89% of 57 males and 76% of 33 females.

The means of the nine morphometric characters for male and female White-vented Mynas are shown in Table 2. Five characters were important in discriminating males and females: culmen length, beak length, wing length, toe length and body mass (Eigenvalue = 0.41; $\chi^2 = 22.4$; df = 5; $P < 0.01$). The discriminant function coefficients suggested that the sexes differed most for culmen length, followed by beak length, wing length, body mass and toe length, with males, on average, being larger than females (Table 2). The linear discriminant function takes the form:

$$D = -27.32 - 0.86(\text{beak length}) + 0.56(\text{culmen length}) + 0.27(\text{toe length}) + 0.13(\text{wing length}) + 0.03(\text{body mass}).$$

TABLE 2. Discriminant analysis of nine morphometric characters as measured for 42 male and 27 female adult White-vented Mynas. Body mass is measured in g and length in mm. Mean (SE), F-ratios (df = 1, 67) from a oneway ANOVA between the two sexes and discriminant function coefficients (DFC) from a Wilks' stepwise discriminant analysis are shown. NA denotes a character that was excluded by the stepwise discriminant analysis.

	Mean (SE)			
Characters	Male	Female	F-ratio	DFC
Body mass	103.4 (1.9)	95.0 (2.2)	7.78**	0.33251
Beak length	15.4 (0.1)	15.2 (0.2)	1.14	−0.63548
Culmen length	24.2 (0.2)	23.4 (0.2)	7.27**	0.67893
Gape length	31.0 (0.2)	30.7 (0.3)	1.74	NA
Gape width	15.3 (0.1)	15.0 (0.1)	2.89	NA
Wing length	124.8 (0.7)	120.2 (1.0)	16.03***	0.61458
Tail length	72.0 (1.0)	69.2 (1.1)	3.64	NA
Tarsus length	37.7 (0.3)	37.1 (0.3)	1.71	NA
Toe length	30.0 (0.2)	29.4 (0.3)	5.12*	0.32143

* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.

Mean discriminant scores for males and females were 0.51 and −0.79, respectively. The linear discriminant function was effective in separating the two sexes (one way ANOVA: F = 27.8; df = 1, 67; eta^2 = 0.29; $P < 0.01$), and correctly classified 81% of 42 male and 59% of 27 female White-vented Mynas.

Application of technique.—As an application of the above results, nine captive Common and 13 White-vented Mynas were measured by KN and WLK for the morphometric characters that best discriminated the sexes for each species (see Tables 1 and 2). We thus determined that we had in captivity four male and five female Common Mynas and seven male and six female White-vented Mynas. Three and five pairs of Common and White-vented Mynas, respectively, were randomly chosen for release into two outdoor aviaries, each measuring 9 × 3 × 3 m and subdivided into four smaller compartments. Each pair of birds was kept separately in these individual compartments and nest boxes were provided for breeding.

We found that two pairs of Common Mynas and four pairs of White-vented Mynas laid fertile clutches over a period of 12 mo, suggesting that these birds, at least, were correctly sexed using the technique of morphometric measurements based on the discriminant analysis described in this paper. Additional support was provided by observations of copulating birds in which the behavior of the two members of the pair conformed to their expected male and female roles.

DISCUSSION

The morphometric measurements obtained for Common Mynas were generally consistent with those taken for the same species in New Zealand

(Baker and Moeed 1979, Counsilman 1974). Common Mynas in Singapore, however, appear to be smaller than those in New Zealand. For instance, a collection of New Zealand male Common Mynas weighed 130.5 g, on average (Counsilman 1974) compared to 119.6 g in our sample. In comparison with measurements made of both species in Malaysia, wing, tail and tarsus length measurements appeared to be consistent (Medway and Wells 1976).

The technique described in this paper presents a simple way to sex mynas when sexual dimorphism is not pronounced. Some caution is needed, however, in applying the linear discriminant function to identifying female White-vented mynas as its level of accuracy (59%) is marginally better than that due to chance alone (50%). Although males of both species tend to be larger than females, such a comparison is only possible when both members of a pair are present at the same time, which is not always the case. Thus birds can be caught, sexed, tagged for individual identification and then released either into the wild or into an aviary for further study of their behavior where knowledge of the sex of the birds may be important, e.g., the role of the two sexes in parental care. Similar applications of the results of discriminant analyses have been made in the studies of other species by Brennan et al. (1984), Desrochers (1990) and Hanners and Patton (1985).

One disadvantage of the technique is that fairly large numbers of specimens must be collected initially to cater for individual variation in the morphometric characters for a valid discriminant analysis. In this study, mynas were killed and sexed by dissection, as culling was part of the management program of mynas in Singapore. Laparoscopy as a technique for sexing the birds was not used as we did not have access to the facilities. Another precaution is in the selection of suitable morphometric characters for measurement. It is likely that measurements of "hard" body parts, e.g., beak, tarsus, culmen, would be preferable to other characters such as body mass or tail length, which may vary significantly with other factors such as food availability or time of year and should perhaps not be used as sole characters in a discriminant analysis.

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1994 JOINT ANNUAL MEETINGS OF THE ASSOCIATION OF FIELD ORNITHOLOGISTS AND THE FEDERATION OF NEW YORK STATE BIRD CLUBS

The Association of Field Ornithologists and the Federation of New York State Bird Clubs will hold joint annual meetings on 14–16 Oct. 1994 at the Frost Valley Conference Center in the southern Catskills. A symposium on owls is planned. Julio de la Torre will give the keynote address, live owls will be displayed by the Hudson Valley Raptor Center and there will be nocturnal owling excursions. Eagles, ravens, loons and waterfowl are likely on local field trips. Workshops, demonstrations and poster papers are planned. Accommodations will be available for every pocketbook. The paper session will be chaired by Dr. Valerie Freer, Science Department, Sullivan County Community College, Loch Sheldrake, New York 12759 USA. Join the "Fall alternative" in ornithological meetings at the height of foliage season in a beautiful lakeside setting. Circulars will be mailed in early spring to AFO and Federation members.