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Discriminant Analysis (DA) Technique for Identification Sex and Breed of Rabbits Depending on Morphological Traits

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ABSTRACT

Key words:

Discriminant function, rabbit morphological traits, Wilks' lambda, predicted classification function, breeds and sex.

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Rabbits are a basic source of protein in many areas around the world. Rabbits are characterized by meat of good quality and high protein source. It is of importance to study and predict different rabbit characters. A total of 720 data values of three different breeds of rabbits (NewZeland White, Californian, and Rex) and both sexes were used. Discriminant analysis (DA) was used to classify the three rabbit breeds and sexes based on the morphological characters (body length (BL), chest circumference (CHC), abdominal circumference (ABDC), thigh circumference (THC), ear length (EL) and ear width (EW)). Data were analysed using the procedures of DA on SPSS 23 statistical package. The results were that ear width showed a strong participation (0.65) in discriminating the three breeds and explained most of the variance while body length (-0.61) was next in importance as a predictor followed by abdominal circumference (0.53) and the other variables were less contribution in the first function. In the second function, ear width showed stronger contribution (-0.64) then chest circumference (0.56) in explaining variations followed by body length (0.50). The other variables were low contributors as predictors in classification of the three breeds. Abdominal circumference is the most significant morphological trait as a discriminating variable (0.70) in discrimination between male and female and explained most of the variance followed by ear width (0.56) then the body length (-0.53). It is found that 59.2 % correct classification of the rabbit breeds using the discriminant functions was achieved and 70.8 % correct classification of the rabbit sexes using the discriminant functions was achieved. From This study, it is concluded that rabbit breeds and sexes can be clearly identified based on morphological traits with low percent of wrong classification by using discriminant analysis which considered a suitable tool for classification purposes.

1. INTRODUCTION

Rabbits are an important origin of protein in different areas. Rabbits plays a good role in providing people with meat because of its high production and this meat characterized by high percentage of protein with low fat percent (Schlolaut, 1992; Rajeshwari et al., 2010).

The New Zealand White and Californian rabbit breeds are the most common rabbit breeds around the world and in Egypt. They are widespread for rapid growing and meat producing (Rotimi, 2021).

Qualitative and quantitative characters of the animal body have a great role in producing meat such as breed, sex, age, body conformation and feed management (Sanduo et al., 2012).

Studying morphometric characteristics is important in presenting animal shape and size in relation of sex and breed (Ajayi et al., 2008).

There are many statistical methods used for classification of animal characters and identification process of these characters such as logistic regression, discriminant analysis and classification (Richard et al., 2008).

Discriminant analysis (DA) is a multivariate method used for constructing a descriptive and predictive statistical model. In DA the dependent variable is qualitative and the other independent ones are quantitative.

This technique is mainly used for building of discriminant functions or linear combinations of the independent for discrimination between the categories of the dependent one, checking the difference among the categories, detection independent variables which cause more differences (important variables for the process of classification), classification of cases to one of the categories based on the values of the independent variables, and assessment of the classification accuracy (Johnson and Wichern, 2012; McLachlan, 2004 ; Morrison, 1990).

There are many types of DA technique such as linear discriminant analysis, multiple discriminant analysis, quadratic discriminant analysis, canonical discriminant analysis and Gaussian discriminant analysis (Klecka, 2003).

This study aimed to classify sexes and breeds of rabbits (dependent variables) depending on applying discriminant analysis technique to detect which one of the six morphological traits (independent variables) has a powerful role in characterization process for sex and breed with low percent of misclassification.

2. MATERIAL AND METHODS

2.1 Source of data

Data were obtained from a study belonging to the Department of Animal Wealth Development, Faculty of Veterinary Medicine, Zagazig University, Egypt. This study used data of 120 rabbits (71 males and 49 females) and (40 NewZeland White, 35 Californian, and 45 Rex) different rabbit breeds. A total of 720 data values of different morphological traits of both sexes and three breeds of rabbits were analyzed (Gouda, 2019).

SPSS statistical software version 23 used for calculation of descriptive measures of the different morphological traits and (DA) used to detect the discriminant variables from six morphological variables (Suhardi, et al., 2021).

2.2 Variables under study

Sex and breed of rabbits are dependent (grouping) variables. They analyzed separately to evaluate the variability in the morphological traits.

The predictors were body length (BL), thigh circumference (THC), abdominal circumference (ABDC), chest circumference (CHC), ear length (EL), and ear width (EW) (González Ariza et al., 2021; Marín Navas, et al., 2021).

DA technique has similarities and differences in relation to other common statistical techniques as follows.

	ANOVA	Regression	Discriminant analysis
Similarities			
Number of dependent variables	single	single	single
Number of independent variables	More than one	More than one	More than one
Differences			
Nature of the dependent variable	quantitative	quantitative	qualitative
Nature of the independent variable	qualitative	quantitative	quantitative

These similarities and differences are considered a guide and an important tool in choosing the technique of analysis.

2.3 Mathematical model of discriminant technique

The DA model is a linear combination of

$$\mathbf{D = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + \cdots + b_kx_k}$$

D = discriminant scores.

b = discriminant coefficients.

x = independent variables.

K= the number of independent variables.

This function discriminates for the most classifying variables between the sexes and breeds **(Yakubu, 2011)**.

2.4 Model Assumption

Categorical dependent variable (grouping one). Continuous independent variables, if data are nominal, dummy coded is needed. Normality, linearity, homogeneity of variance, and multivariate normally distributed for predictors.

2.5 Statistical hypothesis

2.5.1 Hypothesis testing in relation to sex

2.5.1.1 Null hypothesis:

There is no difference between males and females depending on morphological traits or morphological traits do not differ in males and females.

2.5.1.2 Alternative hypothesis:

There is a difference between males and females depending on morphological traits or morphological traits differ in males and females.

2.5.2 Hypothesis testing in relation to breed

2.5.2.1 Null hypothesis:

There is no difference among breeds depending on morphological traits or morphological traits do not differ among breeds.

2.5.2.2 Alternative hypothesis:

There is a difference among breeds depending on morphological traits or morphological traits differ among breeds.

2.6 Mahalanobis distance

It is the amount of the distance between a point (case's values on the predictors) away from a distribution (the mean of all cases) **(Mahalanobis, 1936)**. It is applied in different classification methods. It is used to find outliers. The covariance matrix is important to be estimated to classify the point under study as belonging to one of N classes **(McLachlan, 2004)**. A large value of this measure indicates that a case of outliers on one or more of the predictors.

The formula of Mahalanobis distance is $d_t^2\,(x) = (x - m_t)S_p^{-1}(x - m_t)$.

The distance of the value x to the mean of group t.

2.7 Wilks' lambda

It is a measure for detecting the significance of the discriminant function **(Yakubu, 2011)**.

It is an important measure for choosing variables to be a part of the equation depending on of how much these variables decrease Wilks' lambda. At each step, the variable that decreases the overall Wilks' lambda is come in the equation. It equals 1- square of the canonical correlation value (1 - the coefficient of determination).

2.8 Unexplained variance

At each step, the variable that lowers the sum of the unexplained variation between groups is come in the equation.

2.9 Rao's V. (Lawley-Hotelling trace)

It measures the difference between the means of different groups. Any variables increase the value of this measure at each step of analysis is entered in the equation.

The Bartlett`s V transformation of lambda is a chi-square test to calculate the significance of lambda **(Yakubu, 2011)**.

3. RESULTS AND DISCUSSION

3.1 Results of DA for breed

The mean and standard deviations of the different morphological traits of rabbits are calculated as in Table (1).

There are two standardized canonical discriminant function were obtained in this study.

The significance of the discriminant function examined with the minimization of Wilks' lambda (lambda= 0.65) for the first function and (lambda= 0.88) for the second one. Bartlett's test (Chi square= 49.48, 15.06 with P value 0.000**, 0.010** for the first and second function respectively) indicated the fitting for the canonical discriminant analysis as described in Table (2). Also, significance of the discriminant functions indicated that the null hypothesis is rejected and there is a significant difference among breeds depending on different morphological traits.

The eigen values are 0.35 and 0.14 respectively and canonical correlation are 0.51 and 0.35 respectively for function 1 and 2. Eigen value showed the quantity of variance from a function.

Table (3) the standardized canonical discriminant function coefficients is like multiple regression in showing the importance of each independent variable like the standardized regression coefficients (beta’s) in multiple regression. The sign detects the direction of the relationship. The variables with large coefficients were strongly predict the distribution of the different breeds.

The different coefficients and their values which reflected the discriminating power of the independent variables were arranged as follows:

In the first function, it is found that ear width showed a strong participation (0.65) in discriminating the three breeds and explained most of the variance while body length (-0.61) was next in importance as a predictor followed by abdominal circumference (0.53). The other variables showed less contribution.

In the second function, ear width showed stronger contribution (-0.64) then chest circumference (0.56) in explaining variations followed by body length (0.50). The other variables were low contributors as predictors.

The structure matrix table as in Table (4) considered another way in reflecting the importance of the predictors. It showed the correlations of each variable with each discriminant function.

The structure coefficients are Pearson coefficients or discriminant loadings. Abdominal circumference was highly loaded on the first function (r = 0.67) than the second function (r = 0.51), and ear width was highly correlated with the first function (r = 0.61) than the second function (r = -0.37). Chest circumference was highly loaded on the second function (r = 0.68) than the first function (r = 0.57). The predictors with high coefficients were contributed more in discrimination process.

Table (1): Descriptive statistics of the morphological traits of different rabbit breeds.

Breed		Mean	Std. Deviation	N
NewZeland White	Body length	21.81	2.64	40
	Chest circumference	22.34	2.08	40
	abdominal circumference	25.10	2.92	40
	Thigh circumference	14.16	2.04	40
	Ear length	10.63	0.82	40
	Ear width	5.89	0.53	40
Californian	Body length	22.96	2.34	35
	Chest circumference	23.67	2.00	35
	abdominal circumference	26.33	1.92	35
	Thigh circumference	14.69	1.71	35
	Ear length	10.44	1.00	35
	Ear width	5.73	0.40	35
Rex	Body length	21.77	2.79	45
	Chest circumference	24.33	2.03	45
	abdominal circumference	27.67	2.43	45
	Thigh circumference	14.98	1.72	45
	Ear length	10.57	0.74	45
	Ear width	6.16	0.43	45

Table (2): Canonical discriminant functions.

Function	Eigen value	% of Variance	Cumulative %	Canonical Correlation	Test of Function (s)	Wilks' Lambda	Chi-square	df	Sig.
1	0.351[a]	71.4	71.4	0.51	1 through 2	**0.65**	**49.48**	12	**0.000****
2	0.141[a]	28.6	100.0	0.35	2	**0.88**	**15.06**	5	**0.010****
a. First 2 canonical discriminant functions were used in the analysis.									

Table (3): Standardized canonical discriminant function weights.

	Function	
	1	2
Body length	**-0.61**	**0.50**
Chest circumference	0.26	**0.56**
Abdominal circumference	**0.53**	0.35
Thigh circumference	0.02	-0.26
Ear length	-0.34	-0.20
Ear width	**0.65**	**-0.64**

Table (4): Pooled within-groups correlations between discriminating variables and canonical discriminant functions.

	Structure Matrix	
	Function	
	1	2
Abdominal circumference	**0.67**	**0.51**
Ear width	**0.61**	-0.37
Chest circumference	**0.57**	**0.68**
Body length	-0.17	0.47
Thigh circumference	0.26	0.30
Ear length	0.02	-0.23

Table (5): Canonical discriminant function coefficients (unstandardized coefficients).

	Function	
	1	2
Body length	-0.23	0.19
Chest circumference	0.13	0.27
Abdominal circumference	0.21	0.14
Thigh circumference	0.008	-0.14
Ear length	-0.40	-0.24
Ear width	1.42	-1.40
(Constant)	**-7.78**	**-1.52**

Table (5) showed the unstandardized canonical discriminant function which was used to classify individual birds. Body length (BL), chest circumference (CHC), abdominal circumference (ABDC), thigh circumference (THC), ear length (EL) and ear width (EW)) were the predictors included in the discriminant (D) equation.

The discriminant function was written depending on unstandardized coefficients as follows:

The first function is:

D = -7.77 + (– 0.23 BL) + (0.13 CHC) + (0.21 ABDC) + (0.008 THC) + (– 0.40 EL) + (1.42 EW).

The second function is:

D = -1.52 + (0.19 BL) + (0.27 CHC) + (0.14 ABDC) + (– 0.14 THC) + (– 0.24 EL) + (-1.40 EW).

Table (6) showed that 57.5% of the original observations from the NewZeland White rabbit breed were correctly classified, with the remaining 27.5% and 15 % were wrongly classified into the Rex and Californian rabbit breeds respectively. Also 65.7% of the Californian rabbit breeds were correctly classified into their respective group, the other two breeds representing 17.1% were misclassified. The functions obtained were able to separate the Rex rabbit breed form the other breeds with 55.6% correct classification of the Rex breed into their desired group with the remaining 24.4 % and 20 % were wrongly classified into the NewZeland White and Californian rabbit breeds. In all, approximately 59.2 % correct classification of the rabbit breeds using the linear discriminant functions was achieved. Also, the correct classification rate for the cross validated results was 51.7 **(**Mahmood and Naeem, 2011).

Table (6): Classification results for cases selected for use in the analysis.

Classification Results[a,c]						
		Breed	**Predicted Group Membership**			**Total**
			NewZeland White	**Californian**	**Rex**	
Original	**Number**	**NewZeland White**	23	6	11	40
		Californian	6	23	6	35
		Rex	11	9	25	45
	%	**NewZeland White**	**57.5**	15.0	**27.5**	100.0
		Californian	17.1	**65.7**	17.1	100.0
		Rex	24.4	20.0	**55.6**	100.0
Cross-validated[b]	**Number**	**NewZeland White**	21	7	12	40
		Californian	10	18	7	35
		Rex	13	9	23	45
	%	**NewZeland White**	**52.5**	17.5	30.0	100.0
		Californian	28.6	**51.4**	20.0	100.0
		Rex	28.9	20.0	**51.1**	100.0

a.59.2% of original grouped cases correctly classified.

b. Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c.51.7% of cross-validated grouped cases correctly classified.

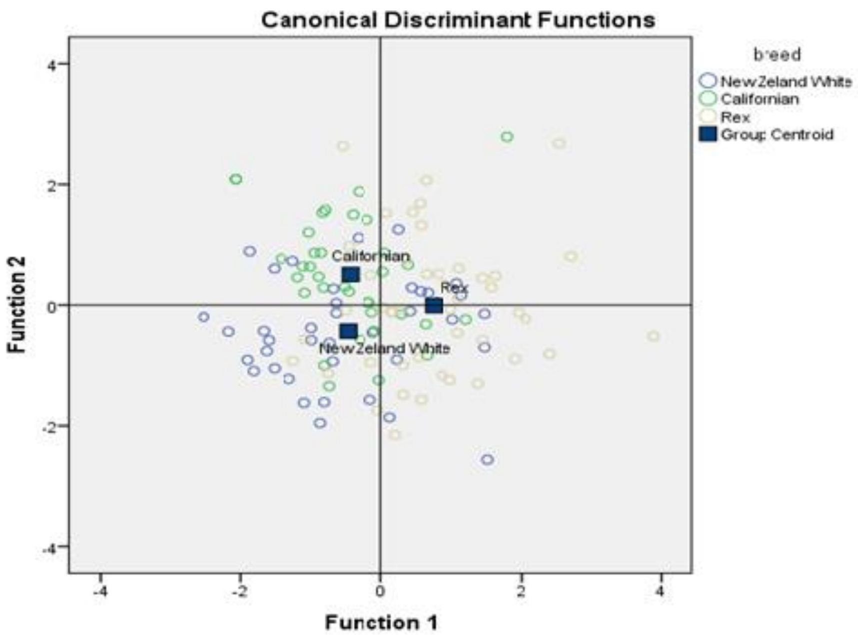

Figure (1): The Canonical discriminant plot of the morphometric traits for classifying different rabbit breeds.

In this plot, the three breeds lie beside each other at the center without overlapping. This is distribution indicated a successful classification.
The chart also showed that the Californian is the most homogenous breed. The other breeds less in homogeneity. NewZeland White and Rex breed was more like each other (Suhardi et al., 2021).

3.2 Results of DA for sex

The mean and standard deviations of the different morphological traits of rabbits are calculated as in Table (7).

DA is applied in relation to sex and the results were that, there is one standardized canonical discriminant function was obtained for sex.
The significance of the discriminant function examined with the minimization of Wilks' lambda (lambda= 0.79). Bartlett's test (Chi square= 27.59 with P value 0.000**) indicated the fitting for the canonical discriminant analysis as described in Table (8). Significance of the discriminant function indicated that the null hypothesis is rejected and there is a significant difference between both sexes depending on different morphological traits (Rotimi and Ati, 2020).

Table (7): Descriptive statistics of the morphological traits of rabbit breeds.

Sex		**Mean**	**Std. Deviation**	**N**
Male	Body length	22.26	2.56	71
	Chest circumference	22.94	2.18	71
	abdominal circumference	25.63	2.62	71
	Thigh circumference	14.36	1.92	71
	Ear length	10.56	0.92	71
	Ear width	5.83	0.48	71
Female	Body length	21.97	2.80	49
	Chest circumference	24.24	1.98	49
	abdominal circumference	27.56	2.37	49
	Thigh circumference	15.00	1.68	49
	Ear length	10.53	0.74	49
	Ear width	6.11	0.44	49

Table (8): Canonical discriminant functions.

Function	**Eigen value**	**% of Variance**	**Cumulative %**	**Canonical Correlation**	**Test of Function (s)**	**Wilks' Lambda**	**Chi-square**	**df**	**Sig.**
1	0.27	100.0	100.0	0.46	1	**0.79**	**27.59**	6	**0.000****

Table (9): Standardized canonical discriminant function weights.

	Function
	1
Body length	**-0.53**
Chest circumference	0.12
Abdominal circumference	**0.70**
Thigh circumference	0.09
Ear length	-0.44
Ear width	**0.56**

The discriminating power of the independent variables were arranged as in Table (9). In this function, abdominal circumference showed a strong participation (0.70) in discrimination between male and female and explained most of the variance followed by ear width (0.56) and the body length (-0.53). The other variables showed less contribution.

The structure matrix table as in Table (10) showed that abdominal circumference was highly loaded on the function (r = 0.73), and chest circumference was highly loaded also where (r = 0.59). Ear width was highly loaded with the function (r = 0.58).

From Table (11) the discriminant function is

D = - 6.61 + (- 0.20 BL) + (0.06 CHC) + (0.28 ABDC) + (0.05 THC) + (- 0.51 EL) + (1.20 EW).

Table (10): Pooled within-groups correlations between discriminatingvariables and canonical discriminant functions.

Structure Matrix	
	Function
	1
Abdominal circumference	**0.73**
Chest circumference	**0.59**
Ear width	**0.58**
Thigh circumference	0.33
Body length	-0.10
Ear length	**-0.04**

Table (11): Canonical discriminant function coefficients (unstandardized coefficients).

	Function
	1
Body length	- 0.20
Chest circumference	0.06
Abdominal circumference	0.28
Thigh circumference	0.05
Ear length	-0.51
Ear width	1.20
(Constant)	-6.61

Table (12): Classification results for cases selected for use in the analysis.

Classification Results[a,c]					
		sex	Predicted Group Membership		Total
			Male	Female	
original	count	Male	50	21	71
		Female	14	35	49
	%	Male	**70.4**	29.6	100.0
		Female	28.6	**71.4**	100.0
Cross-validated[b]	count	Male	48	23	71
		Female	17	32	49
	%	Male	67.6	32.4	100.0
		Female	34.7	65.3	100.0

a.70.8% of original grouped cases correctly classified.

b.Cross validation is done only for those cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.

c.66.7% of cross-validated grouped cases correctly classified.

This function had the ability to differentiate the two sexes directly, where positive D value for male and negative value for female (Yakubu, 2011).

It is found that 70.4 % of the original observations from male rabbit group were correctly classified, with the remaining 29.6% being wrongly classified into the rabbit female group. Also 71.4% of values of the female rabbit were right classified into their respective group, and 28.6 % being wrongly classified into the male group as shown in Table (12). In all, approximately 70.8 % right classification of the rabbit sexes using the linear discriminant functions was done while 29.2% of the male and the female rabbits were misclassified. Also, the correct classification rate for the cross validated results was 66.7 % (Rotimi and Ati, 2020).

4. CONCLUSION

Generally, discriminant analysis (DA) is important for detecting the suitable variables in classification of different groups, then classify cases inside the groups. In this study discriminating function applied for classifying the three rabbit breeds (NewZeland White, Californian and Rex) and rabbit sexes. This canonical discriminant functions gave maximum classification among the three breeds with an overall discrimination rate of 59.2 % and 70.8% maximum classification of the function between both sexes. From this study we can conclude that, the rabbit breeds can be clearly classified based on morphological traits with low percent of wrong classification without studying any on genetic traits. This study proved that a discriminant analysis is a successful tool in separating different sexes and breeds of rabbits depending on their morphological traits. Future genetic studies can be used for suitable handling of these traits.

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