Preliminary Statistical Analysis of Captive Breeding Programs

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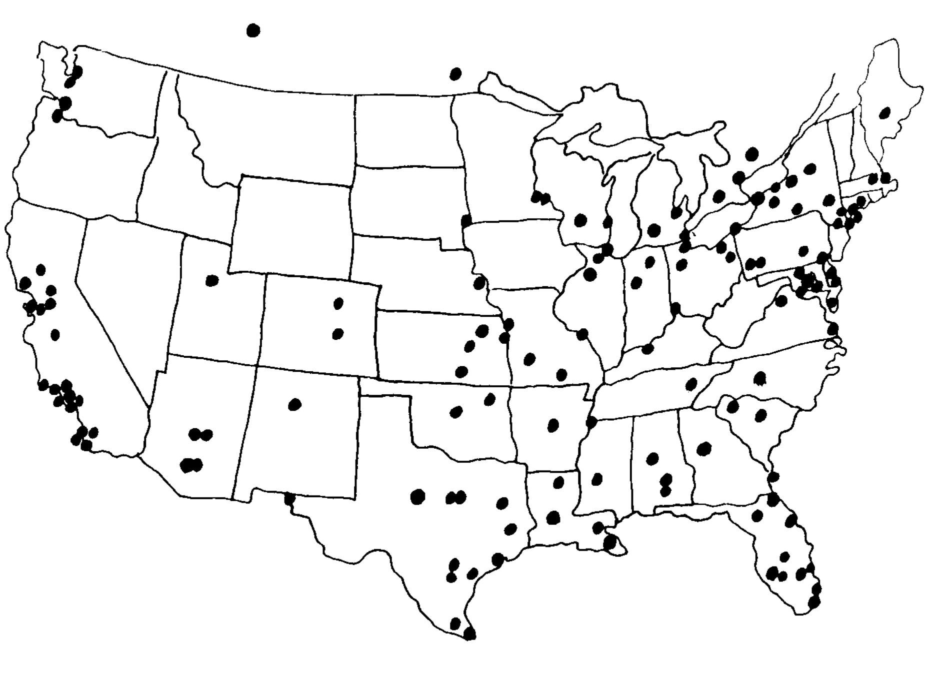
The purpose of this paper is to examine patterns that have emerged over the past two years in captive breeding programs in the United States of avian species that are generally more difficult to propagate. The data has been collected and compiled by the San Diego Zoo under the direction of Kerry Muller, Assistant Curator of Ornithology. The data surveys were funded by the International Foundation for the Conservation of Birds (IFCB) in Los Angeles, California. All major zoological institutions and several large private collections are represented in the survey as the purpose of the survey is to assist in the management of bird collections through the matching of species sexually and in locating pairs of species with programs intent upon their propagation. The analysis of the data collected to date is viewed by the authors as a beginning in what could prove to be a valuable tool in the management and propagation of avian species in North America.

Although this survey covers many collections and species not covered by other surveys, there is still a dearth of data so far as statistical analysis is concerned. Such a lack of data is probably due more to the unavailability of many species and difficulty in breeding the ones available than to a lack of survey participation. At least partially due to this lack of data we have limited the present analysis to the three largest groups represented in the survey — Anseres, Phasianidae, and Psittacidae.

In the present study the data was obtained from nearly 125 participants in the United States with geographical locations of the participants as follows:



Location of participants in Canada and the U.S.

A sample was considered as a survey participant possessing at least a pair of a particular species in a breeding situation. For the species included in this paper the participants had a combined total of more than 1300 samples, i.e., pairs in breeding situations. The data were collected in two surveys covering the two periods 1980 and 1981.

Correlations were sought between the number of survivors and rainfall, altitude, longitude, latitude. The data were analyzed using a computer program for statistical analysis called SPSS and the computer programming necessary for this analysis was done by Mr. Wilbon Davis. The measure of breeding program performance was the ratio of surviving offspring to total breeding stock and only those results which had a less than 1 in 20 chance of being due to luck are included.

Two variables are said to be positively correlated if one increases when the other increases and are said to be negatively correlated if one decreases when the other decreases. For example, if breeding success of a particular species is positively correlated with altitude this would mean that greater breeding success was achieved at higher elevations. On the other hand if there is a negative correlation with altitude for a particular species, then there was greater breeding success at lower elevations. It should be noted that for a correlation to exist between breeding success and, say, elevation, there must be breeding attempts at numerous elevations.

The number r^2 is a measure of the degree of influence a change in one variable has on the other. If $r^2 = 1$, the relationship is perfect, e.g., if breeding success of one species were correlated with rainfall and r^2 were 1, then breeding success of that species would be 100% predictable from rainfall. On the other hand, if $r^2 = 0$, there is no linear relationship between the variables, i.e., there is no way to predict to any degree of accuracy the breeding success of the species based on rainfall.

In most of our cases, r^2 ranged from .10 to .30. A good interpretation of this is that 10% to 30% of the variance of breeding success is attributable to the indicated variable for the particular species. For example, if breeding success and altitude are correlated positively and $r^2 = .3$, then 30% of the explanation for breeding success is due to altitude. A correlation is dependent upon percent increase in the total captive population and *not* dependent

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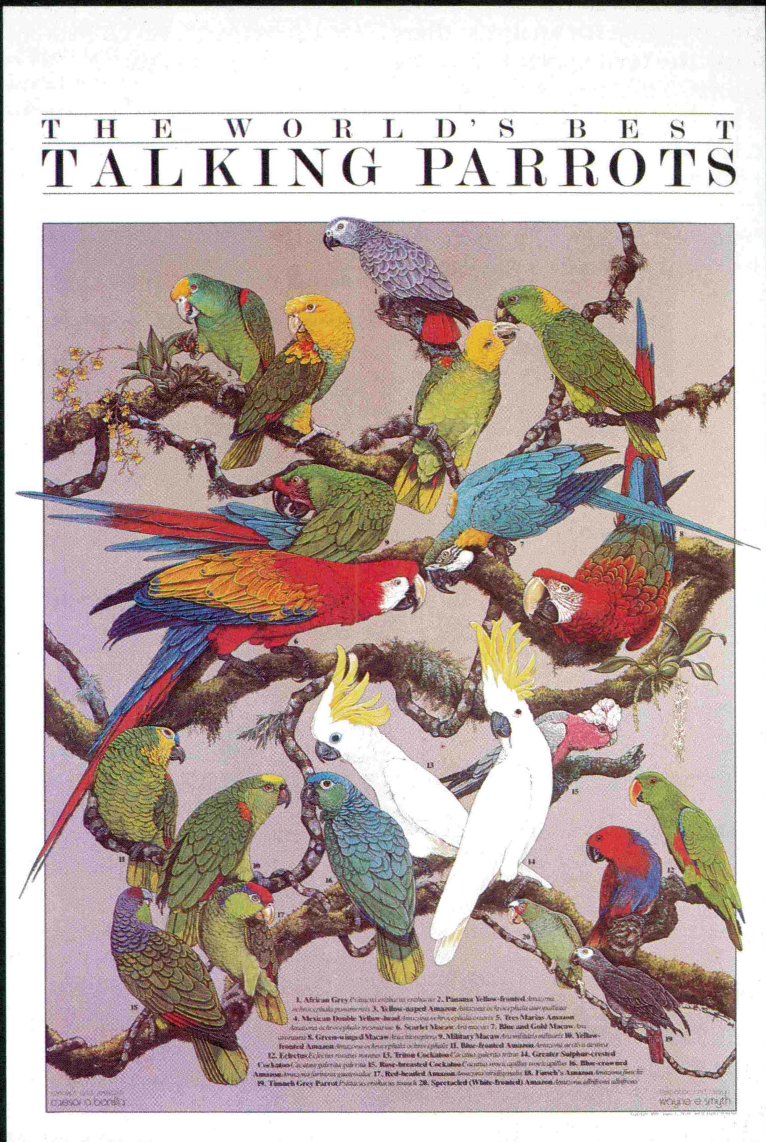

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Anseres

Due to the large diversity of the species of waterfowl no correlation for waterfowl to altitude, longitude or latitude was expected and none was found. However, a correlation between waterfowl breeding success and rainfall was expected, but none was found.

As an aid to further analysis, the waterfowl were subdivided into seventeen broad subgroups generally according to genus. In these still rather broad groupings only a few correlations were determined. The comb ducks had a negative correlation (r^2 = .51) to latitude and positive correlation (r^2 = .54) to longitude. The pintails, shovelers, etc. had a negative correlation (r^2 = .07) with latitude. This means that there was a definite positive correlation between breeding success and latitude, i.e., breeding success increased from North to South across the United States. However, since r^2 = .07, the consequence of latitude is small since only 7% of the explanation for breeding success would be considered as due to latitude. The crested ducks (*Anas, s. specularoides, A.S. alticolo*) exhibited a definite positive correlation (r^2 = .47) with altitude which coincides with their native habitat.

Of 31 species of waterfowl with sufficient data available for analysis, there were some thirteen species showing correlations. This means that for the species having no correlations, that altitude, latitude, longitude, and rainfall had no linearly discernable patterns and, therefore, no recognizable effect on breeding success.

The following table lists the various correlations found:

	Altitude	Latitude	Longitude	Rainfall
Trumpeter	(+)r^2 = .22			
NeNe				(−)r^2 = .16
Andean Geese	(−)r^2 = .29	(−)r^2 = .24		
European Shelduck	(+)r^2 = .33			(−)r^2 = .22
South African Shelduck		(+)r^2 = .32	(−)r^2 = .28	
Paradise Shelduck		(−)r^2 = .29		
Ringed Teal		(−)r^2 = .11		
Marbled Teal	(+)r^2 = .54	(+)r^2 = .13		(−)r^2 = .23
Chiloe Widgeon		(+)r^2 = .27		
Hawaiian Duck		(−)r^2 = .36		
Patagonian Crested Duck	(+)r^2 = .46			
Eider (American)			(+)r^2 = .27	
Argentine Ruddy Duck		(−)r^2 = .50		

Note: (+) or (−) indicates positive or negative correlation

Some correlations were not unexpected. It is not surprising that trumpeters had a higher breeding success at higher altitudes and nenes did better in areas of lower rainfall. One would have expected trumpeters to do better in areas of higher rainfall and nenes to have better success closer to the equator, but neither proved true. A very unexpected result was that no species showed any positive correlation with rainfall. In fact, three species showed a negative correlation with rainfall. It still would seem that rainfall should be an important environmental factor in breeding success for waterfowl. A possible explanation of the lack of correlation to rainfall is that timing (season) of the rainfall is important while total annual rainfall is not.

The two most important factors in breeding success for waterfowl appear to be latitude and altitude.

Phasianidae

Phasianidae had a negative correlation (r^2 = .12) with latitude and a negative correlation (r^2 = .10) with longitude. No correlation was found between breeding success and rainfall. The phasianidae were further subdivided into ten subgroups, again generally according to genus. In these ten subgroups, seven had correlations of interest as indicated:

	Latitude	Longitude
Partridge	(−)r^2 = .19	(−)r^2 = .12
Francolin	(−)r^2 = .42	(+)r^2 = .17
Pheasant	(−)r^2 = .12	(−)r^2 = .15
Tragopans	(−)r^2 = .16	
Peacock pheasant	(−)r^2 = .24	(−)r^2 = .28
Eared pheasant	(−)r^2 = .59	(−)r^2 = .52

Note: (+) or (−) indicates positive or negative correlation

As expected, nearly all showed negative correlation to latitude with the high values of r^2 indicating a significant influence on breeding success but no correlation between rainfall and breeding success was found. It should be noted that while the values of r^2 are not strictly additive, they do have a combined effect. For example, for the peacock pheasants, r^2 = .04, .24, and .28 for altitude, latitude, and longitude, respectively. Hence, the effect that location has upon breeding success is nearly overwhelming for peacock pheasants. A surprising result is that both Eared pheasants and tragopans had a negative correlation between breeding success and latitude, i.e., the nearer the equator (within the United States at least) the higher the breeding success.

As far as species are concerned, there were only eleven having sufficient data for analysis. Of these, five had correlations of interest as indicated in the following table:

	Latitude	Longitude
Crested Green Wood Partridge	(−)r^2 = .23	(−)r^2 = .15
Edwards	(−)r^2 = .89	(−)r^2 = .89
Impeyan	(−)r^2 = .89	(−)r^2 = .77
Grey Peacock Pheasant	(−)r^2 = .80	(−)r^2 = .70
Malay Great Argus	(−)r^2 = .40	(−)r^2 = .45

It is interesting here to note the extremely high correlation that most of these species have between breeding success and latitude with the higher success being attained closer to the equator. Oddly, there also is a very strong correlation of breeding success to longitude, and no correlation to rainfall or altitude. Again, as in the waterfowl, a possible explanation is that total rainfall may be comparable from East to West, but the rainfall in the East is apparently more conducive to breeding success.

Psittacidae

There was no apparent correlation between breeding success with Psittacines in general and altitude, latitude, longitude, and rainfall. A positive correlation with breeding success and rainfall was expected but did not appear.

Psittacines were subdivided into eleven subgroups, generally according to family. Of these eleven groups, ten had sufficient data for analysis and five had at least one correlation between breeding success and altitude, latitude, or rainfall as follows:

	Altitude	Latitude	Rainfall
Lory			$(-)r^2 = .13$
Lorikeet		$(-)r^2 = .17$	
Parrots			$(+)r^2 = .14$
Conure			$(+)r^2 = .09$
Lovebirds	$(+)r^2 = .15$		

Note: (+) or (–) indicates positive or negative correlation

The only correlation that seems surprising was the greater breeding success in areas of lower rainfall for lories.

When Psittacines were considered by species there were fifteen with sufficient data for analysis and of these only four showed correlations of any sort and all four showed a correlation between breeding success and rainfall. Leadbeater cockatoos showed a negative correlation ($r^2 = .38$) to rainfall while Grand Eclectus, Scarlet Macaws, and Jandaya conures all showed positive correlation ($r^2 = .22$, $r^2 = .10$, $r^2 = .23$, respectively) to rainfall. Leadbeaters were the surprise with a definite preference for lower rainfall. As with the waterfowl, annual rainfall was not the factor it was expected to be. Again, however, there may very well be a correlation between rainfall and breeding success if the timing of the rainfall is considered. This is likely to be discernable if we divide the United States into regions and compare breeding success between regions using climographs. A climograph covering the area of a species' most successful breeding in the wild compared to a climograph of the same species' most successful breeding in captivity might tell us which species should have sprinklers turned on at what times.

The reader is invited to send suggestions for possible further analysis of data to either of the authors:

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Dr. Arthur Risser, Curator/Ornithology, San Diego Zoo, P.O. Box 551, San Diego, California 92112. ●

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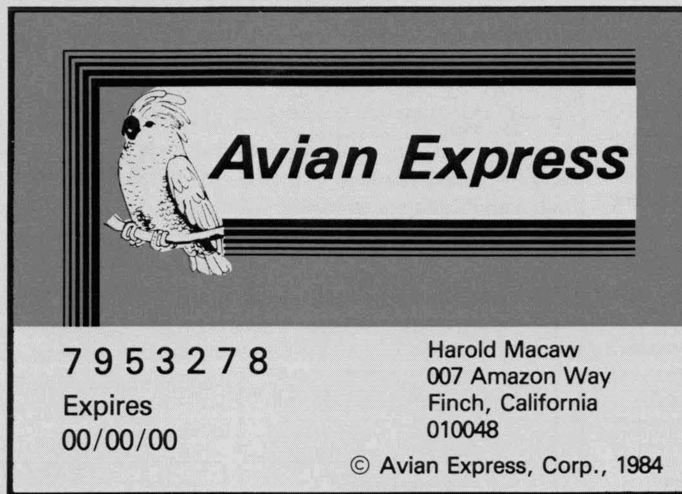

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