

## The systematic status of the Cape Barren Goose as judged by its photo-responses

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The Cape Barren Goose *Cereopsis novaehollandiae* has a possibly relict distribution, breeding on scattered islands off the southern coast of Australia from the Recherche Archipelago in the west to the Furneaux Group in the east (Frith, 1967). In the past, it perhaps ranged further, but is now confined between longitudes 122°-148°E and latitudes 32°-40°S. Ecologically the bird was probably always restricted to the coast, as suggested by the immense development of its salt-extracting glands, a feature it shares with its relative, the extinct and flightless *Cnemiornis* of New Zealand.

The species is considered by Delacour (1954) to be an aberrant member of the tribe Tadornini of the sub-family Anatinae (ducks) and by Johnsgard (1965) to be of the Anserini (swans and geese). Indeed, when first described it was labelled *Cygnus cendré* (Delacour, 1954). No true geese (*Anser* and *Branta*) occur in the southern hemisphere nor have any been certainly identified as fossils, so it is unlikely that *Cereopsis* is at all closely related to these genera. However, it has a typically goose-like triumph-ceremony which is performed by the mated pair after an enemy has been repulsed (Johnsgard, 1965); and in the reticulated tarsus, absence of a syrinx and in the structure of bones and muscles (including the number of cervical vertebrae), *Cereopsis* resembles the Anserini rather than the Tadornini (Verheyen, 1953; Woolfenden, 1961).

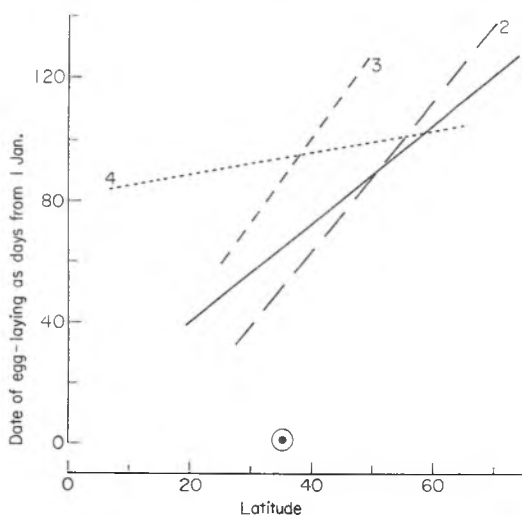
In anserine geese, tadornine sheldgeese, and *Cereopsis* the young are grazers of grass and other low vegetation, so in body proportions, the goslings are rather similar. However, young shelducks and sheldgeese (except the Kelp Goose *Chloëphaga hybrida*) are strongly patterned in black-and-white, while anserine goslings and cygnets tend to be unicoloured, white, grey, yellow or brown. On this basis, the pied *Cereopsis* gosling closely resembles the tadornines. In two other features, *Cereopsis* shows similarities to the sheldgeese rather than to the true geese: opponents are attacked with the 'wrists' of the wings, which have bony carpal knobs; and erect, chest-puffing displays are given as a greeting to the mate (Veselovsky, 1970).

Resemblance of *Cereopsis* to the swans

(genera *Cygnus* and *Coscoroba*) is noted in the fact that the gander undertakes a prime share of nest-building, a task predominantly left to the female in *Anser*, *Branta* and all tadornines (Kear, 1970); and in an incubation period of 35 days, 5 days longer than any anserine goose, but similar to many swans. The species has two other 'primitive' features: goslings are occasionally oiled by their parents (Scott, 1972), as are screamer (Anhimidae) chicks, and copulation occurs on land with no indication that this is a secondary feature.

No taxonomic clues can be obtained from hybrids, simply because *Cereopsis* has never hybridized. To some extent this is not surprising as it breeds in the winter while most of its supposed relatives are in reproductive condition only in spring or summer. But one goose, the Nene *Branta sandvicensis*, also breeds on short days and copulates (secondarily) on land. In 1968, a young hand-reared *Cereopsis* female mated with a Nene gander at the Wildfowl Trust, Slimbridge, England. The pair were encouraged with a spacious pen of their own where they copulated, apparently successfully, and nested during the following 3 years. The eggs were always infertile. This might suggest a degree of genetic incompatibility between the two genera, although further investigation is clearly needed.

Recently we have examined the photo-responses of various wildfowl species by relating the median date of first egg-laying in the Slimbridge collection (and the day length on that date) to the mid-latitude of their natural breeding range (Kear, 1966; Murton & Kear, 1973a,b). The plots of egg-laying date against latitude can be described by regression lines for groups of closely related species and these are summarized in Figure 1. It can be seen that swans emanating from any particular latitude lay earlier in the year, that is, respond to shorter daylengths, than do goose species from the same latitude. But this is only true above latitude 50°N. Further south, true geese must breed later, because at low latitudes they need a longer photoperiod than swans, and it is significant that only *Branta sandvicensis* occurs further south than latitude 40°N as a breeding species. We have argued that closely related species



**Figure 1.** Regression lines relating date of egg-laying (represented as number of days from 1 January = 1) of various wildfowl species at Slimbridge to the mid-latitude of their natural breeding range.

(1) *Anser* and *Branta* geese (25 species)

$$y = 6.9 + 1.6x; r_{23} = 0.871, P < 0.001$$

(2) Swans (8 species)

$$y = -35.4 + 2.47x; r_6 = 0.882, P < 0.01$$

(3) Shelducks (6 species)

$$y = -12.3 + 2.8x; r_1 = 0.941, P < 0.01$$

(4) Sheldgeese (5 species)

$$y = 81.6 + 0.4x; r_3 = 0.786, \text{not significant.}$$

The isolated point with co-ordinates  $y = 1$ ;  $x = 36$  represents *Cereopsis* and its relationship to the regression lines depicted is examined statistically in the text.

share common regression lines because the physiological mechanisms controlling their photo-responses and breeding behaviour have not evolved significant divergences from the ancestral pattern (Murton & Kear, 1973a). On this basis, we can enquire whether the breeding of the Cape Barren Goose at Slimbridge shows any resemblance to the response patterns of the groups featured in Figure 1.

The median date for first eggs of *Cereopsis* at Slimbridge over 23 years has been 1 January, designated day 1, and the mid-latitude of its natural breeding range is 36°S. The regression lines in Figure 1 relate to eight swan, *Cygnus* and *Coscoroba*, species, twenty-five *Anser* and *Branta* species, six shelducks *Tadorna* species and five sheldgeese *Neochen* and *Chloephaga*. Regression equations, correlation coefficients together with their significance levels are given in the caption to the figure. Statistically we wish to determine to which of the regression lines in Figure 1 the isolated point  $y_0, x_0$  is closest and whether it might be regarded as belonging to one of the four groups whose taxonomic relationships are reasonably certain.

If  $y_0$  can be defined by the regression

equation which describes the swan data we predict that:

$$\begin{aligned} \hat{y}_{01} &= a_1 + b_1 x_0 \\ &= -35.44 + 2.47(36) \\ &= 53.48 \end{aligned}$$

and the divergence from expectation is given by

$$d_1 = y_0 - y_{01} = 1 - 53.48 = -52.48$$

The standard deviation of the predicted value  $y_{01}$  is:

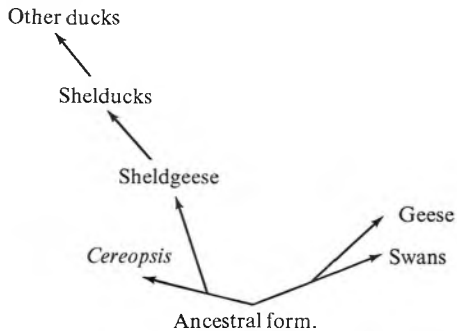
$$\begin{aligned} s'_1 &= s_1 \sqrt{\left[1 + \frac{1}{n_1} + \frac{(x_0 - \bar{x}_1)^2}{n_1 (\text{var } x_1)}\right]} \\ &= 12.68 \sqrt{\left[1 + \frac{1}{8} + \frac{(36 - 51.5)^2}{8(160.78)}\right]} \\ &= 12.68 \sqrt{1.312} = 14.524 \end{aligned}$$

We calculate  $t_1 = d_1/s'_1 = -52.48/14.524 = 3.613$  with  $n_1 - 2 = 6$  degrees of freedom. The two-tailed probability that this differs from zero is between  $P = 0.02 - 0.01$ . Similarly, if  $y_0$  can be defined by the regression line for true geese we obtain a  $t_2$  value  $= d_2/s'_2 = -63.5/13.145 = 4.831$  with 23 degrees of freedom (d.f.). This is very significantly different from a value of zero

( $P \ll 0.001$ ). Considering the shelduck regression in the same way we obtain  $t_3 = 39.954$  which with 4 d.f. gives  $P \ll 0.001$ .

Perusal of Figure 1 shows that the regression line (correlation coefficient not significantly different from zero) describing the photoresponse of the South American sheldgeese cannot be nearer to the *Cereopsis* point than the regression line for the shelducks just considered.

Thus the statistical analysis confirms the visual impression from Figure 1 that the photo-response of *Cereopsis* is totally unrelated to the pattern shown by the true geese or sheldgeese, rather different from the shelducks and that it is closer to the swan group than to any of the above. This suggests that *Cereopsis* might be close to the ancestral stock which led on the one hand to the shelducks and on the other to a line that has terminated with *Cereopsis*. We propose an evolutionary tree in which the swans and *Cereopsis* are closer to each other than to any living goose or sheldgoose species and perhaps closer to the ancestral stock from which the Anatidae arose. These relationships might be illustrated as follows:



### Summary

The median date of egg-laying of various wildfowl species in the Wildfowl Trust's collection at

Slimbridge, England, is plotted against the mid-latitude of their natural breeding range. The result for the Cape Barren Goose *Cereopsis novaehollandiae* is closer to the pattern for the swans than to that of the true geese or the sheldgeese. An evolutionary tree placing *Cereopsis* closer to the swans than to any living goose or sheldgoose species and perhaps closer to the ancestral Anatidae stock is proposed.

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