SHORT COMMUNICATIONS

Variability of Egg Size and Composition in the Great White Pelican (*Pelecanus onocrotalus*)

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Eggs vary in size within a species, and it is likely that such variation is associated with differences in the relative proportions of the egg components. Data exist for very few species, however, and for only one, the Starling (*Sturnus vulgaris*), with altricial young (Ricklefs 1977a, Auk 94: 167). This note provides comparative data for another altricial species, though of very different phylogeny, the African Great White Pelican (*Pelecanus onocrotalus*). The data are also of interest when compared with the mean egg statistics available for the Brown Pelican (*P. occidentalis*) (Lawrence and Schreiber 1974, Comp. Biochem. Physiol. 47A: 399) and other species summarized by Ricklefs (1977b, Auk 94: 350).

Fresh, unincubated eggs were collected on 8 August 1971 from a small, recently deserted pelican colony near Sehitwa, Botswana (20°28′S, 22°42′E) on the shore of Lake Ngami. The eggs from the 30 or so abandoned nests had been scattered over some distance by scavengers and were mixed with the many others that continued to be laid singly on the bare ground around the site throughout August; none could therefore be assigned to particular nests or clutches. The majority had probably been laid during the previous 2 weeks.

The eggs were processed the same day as collection. All were measured and the weight and volume obtained by weighing in air and in water. The eggs were then hard-boiled so that the yolk and white could be separated easily. Each component was dried in an air-oven at 100°C for 1–2 days and weighed. Some of the more volatile lipids may have been lost at this temperature, but comparison with the results of other studies (Ricklefs 1977a, b), where lower temperatures were used for drying, suggests that the loss, if any, was very small. Yolk lipids were removed by Soxhlet extraction with chloroform, and the lipid-free dry yolk was reweighed; the lipid weight was obtained by difference. The lipid fraction in dry albumen is negligible (Ricklefs 1977b) and was not extracted. Similarly the carbohydrate in yolk and white is about 1% in each and was not measured. Hard-boiling has no effect on the water fraction of albumen and yolk, and any water loss due to desiccation before collection seems to have been minor, as the water values obtained here were consistent with other studies (Ricklefs 1977b and in litt.). Means and regression coefficients are given ± 1 SE.

The mean egg weight was 181.6 ± 19.1 g (range 152–226 g), and the mean measurements were 92×60 mm ($n = 54$), closely similar to the eggs of Great White Pelicans breeding the same year at Etosha Pan, South West Africa (Berry, Sterk and van Vuuren 1973, Madoqua, Series 1, No. 7: 17). The mean egg volume was 168 ± 17.8 ml.

The wet weight of the yolk, averaging 31.1 ± 3.4 g ($n = 54$), comprised 17.1% of the weight of the fresh egg. This small percentage, the same as in the Starling (17%) but smaller than in the Brown Pelican (26%), seems typical of altricial species. The water fraction of the yolk, $55.4 \pm 0.9\%$, is again similar to that of the Starling (57%) and less than that described for the Brown Pelican, which at 66% is the highest among the range of species summarized by Ricklefs (1977b) and may be erroneous. The lipid content of the dry yolk, $65.5 \pm 1.9\%$, is close to that in the Starling (63.3%) and Brown Pelican (67.6%) and to a wide range of precocial species also (Tables 1 and 2 in Ricklefs 1977b).

The water fraction of the albumen, $88.3 \pm 0.6\%$ ($n = 31$), was remarkably uniform (coefficient of variation 0.67%) and higher than that reported for the Brown Pelican by Lawrence and Schreiber (1974). Their low values were apparently an artifact caused by a faulty processing technique (Lawrence, quoted in Ricklefs 1977b), and it is possible that this may also have contributed to their anomalous yolk result mentioned above. The high albumen water content found in the present study is typical of altricial species.

The wet weight of the yolk was positively correlated with the fresh egg weight ($r = 0.51$, $P < 0.001$), and the correlation between dry yolk weight and egg volume was similar ($r = 0.49$). However, the proportion of yolk in the egg decreased with increasing egg size by $0.046\% \cdot g^{-1}$ ($r = -0.47$, $P < 0.001$). A similar decrease in the proportion of yolk with increasing egg size occurs in both Starlings and domestic poultry. Ricklefs (1977a) compared these two species by multiplying the slopes of the relationships (in $\% \cdot g^{-1}$) by the respective standard deviations of egg weight to give a normalized percentage decrease. The same calculation for the Great White Pelican gives a result of -0.87%, compared with -0.93% for poultry and −0.89% for the Starling. Thus it appears that the relative sizes of the yolks in the three species are similarly conservative with respect to variation in egg size.

The wet weight of the albumen was highly correlated with fresh egg weight ($r = 0.92$, $P < 0.001$), and the correlation between the albumen dry weight and egg volume was similar ($r = 0.93$); the proportion of albumen in the egg was positively correlated with increasing egg weight, but not significantly ($r = 0.347$, $P = 0.06$). Variation in egg size in the Great White Pelican therefore appears to depend mainly on the amount of albumen laid down, as is also the case in the Starling (Ricklefs 1977a) and Herring Gull (*Larus argentatus*) (Parsons 1976, Condor 78: 481).

As in the Starling, variation in the lipid fraction of the yolk (between 61.5% and 69.5%) was not correlated with either yolk size or egg size, nor with the relative size of the yolk. Nevertheless, because of the positive relationship between yolk size and egg size, larger eggs contained greater absolute amounts of lipid, although in relative terms, as a result of the negative correlation between egg size and proportionate yolk size, larger eggs contained proportionately less lipid overall ($r = -0.42$, $P < 0.01$).

In order to facilitate comparison with future studies, these relationships may be expressed more conveniently as the regression coefficients of the log values of the various egg components on log fresh egg weight (Ricklefs in litt.). Thus the slope of the regression of log wet weight of yolk on log fresh egg weight was 0.53 ± 0.12; log wet weight of albumen on log fresh egg weight was 1.17 ± 0.10; and log yolk lipid weight on log fresh egg weight was 0.55 ± 0.14.

Energy per gram of fresh egg (including shell) seems commonly to be above 1.6 $kcal \cdot g^{-1}$ in precocial species and around 1.1 $kcal \cdot g^{-1}$ in altricial ones, whereas the eggs of the Brown Pelican were intermediate at 1.37 $kcal \cdot g^{-1}$ (Lawrence and Schreiber 1974, Ricklefs 1977b). The same calculation for the Great White Pelican, using constants of 9.5 $kcal \cdot g^{-1}$ for lipid and 5.65 $kcal \cdot g^{-1}$ for nonlipid dry weight, gives a value of 1.06 $kcal \cdot g^{-1}$, typical of altricial species. The difference between the two pelican species evidently derives from the proportionately greater amount of dry matter in the egg of the Brown Pelican. Whereas the egg of the Great White Pelican is twice as heavy as that of the Brown Pelican, the dry weight of the yolk is greater in the ratio of only 1.7:1 and the dry weight of the albumen is proportionately even less, in the ratio of only 1.2:1 (Lawrence and Schreiber 1974). These differences remain unexplained.

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The Relationship Between Prey Species Ecology and Dive Success in Ospreys

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Lambert (1943) first reported on dive success of Ospreys (*Pandion haliaetus*). Since then, several studies have analyzed various physical parameters affecting Osprey foraging, including tides (Ueoka 1974) and weather variables (Grubb 1977a). The relative success of dives from hovers and interhovers (Grubb 1977b) and the dive success of adult and juvenile Ospreys in the same area (Szaro 1978) have also been investigated. The relationship between prey species and foraging success has received little attention, although Nesbitt (1974) found substantial differences in dive success in two areas with different prey.

Here I synthesize studies reporting Osprey dive success and prey species captured under natural conditions in 13 areas, as reported in the literature. Dive success (the proportion of observed dives that were successful) is used as the measure of Osprey foraging success, as it measures the relative ease of capture. It would be less influenced by prey availability than other foraging parameters, such as foraging time required per fish caught. Also, dive success is less influenced by weather conditions than other foraging parameters (Grubb 1977a).

The studies compared here were conducted in a variety of habitats, including coastal, estuarine, river, and eutrophic, mesotrophic, and oligotrophic lake environments. Water depth and clarity, prey availability and abundance, and weather conditions varied. Because all of these variables could not be monitored, and may not have been equally important, only dive success and prey species ecology were considered here.

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