the Colorado River in the Grand Canyon. *J. Geol.* 89: 269–298.

JOHNSON, P. W. AND R. B. SANDERSON. 1968. Spring flow into the Colorado River, Lees Ferry to Lake Mead, Arizona. Water-Resources Report No. 34, Arizona State Land Department, Phoenix. 25 pp.

JOHNSON, R. R. AND S. W. CAROTHERS. 1987. External threats: The dilemma of resource management on the Colorado River in Grand Canyon National Park, USA. *Environ. Manage.* 11:99–107.

MADDUX, H. R., D. M. KUBLY, J. C. DEVOS, JR., W. R. PERSONS, R. STAEDICKE AND R. L. WRIGHT. 1987. Effects of varied flow regimes on aquatic resources of Glen and Grand canyons. Final Report to the U.S.D.I. Bureau of Reclamation, Upper Colorado Region, Salt Lake City, Utah. 291 pp.

MCCLELLAND, B. R. 1973. Autumn concentrations of Bald Eagles in Glacier National Park. *Condor* 75:121–123.

———, L. S. YOUNG, D. S. SHEA, P. T. MCCLELLAND, H. L. ALLEN AND E. B. SPETTIGUE. 1982. The Bald Eagle concentration in Glacier National Park, Montana: Origin, growth, and variation in numbers. *Living Bird* 21:133–155.

SERVHEEN, C. W. 1975. Ecology of the wintering Bald Eagles on the Skagit River, Washington. M.S. Thesis, University of Washington, Seattle. 96 pp.

SOUTHERN, W. E. 1963. Winter populations, behavior, and seasonal dispersal of Bald Eagles in northwestern Illinois. *Wilson Bull.* 75:42–55.

SPENCER, D. A. (ED.) 1976. Wintering of the migrant Bald Eagle in the lower 48 states. National Agricultural Chemicals Assn., Washington, D.C. 170 pp.

STALMASTER, M. V. 1976. Winter ecology and effects of human activity on Bald Eagles in the Nooksack River Valley, Washington. M. S. Thesis, Western Washington University, Bellingham. 100 pp.

———. 1987. The Bald Eagle. Universe Books, New York. 227 pp.

——— AND J. R. NEWMAN. 1978. Behavioral responses of wintering Bald Eagles to human activity. *J. Wildl Manage.* 43:221–224.

STEENHOF, K. 1978. Management of wintering Bald Eagles. U.S.D.I. Fish and Wildlife Service Publ. FWS/OBS-78/79, Washington, D.C. 59 pp.

TURNER, R. M. AND M. M. KARPISCAK. 1980. Recent vegetation changes along the Colorado River between Glen Canyon Dam and Lake Mead, Arizona. U.S. Geological Survey Professional Paper 1132, U.S. Govt Printing Office, Washington, D.C. 125 pp.

WEBB, R. H., P. T. PRINGLE AND G. R. RINK. 1987 Debris flows from tributaries of the Colorado River in Grand Canyon National Park, Arizona. Open-file Rep. 87–118, U.S. Geol. Survey, Tucson, AZ. 64 pp.

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Received 29 July 1988; accepted 30 June 1989

J Raptor Res. 23(3):113–115

EGG MEASUREMENTS FROM A NORTHERN GOSHAWK (*Accipiter gentilis gentilis*) INCLUDING ONE ABNORMALLY LARGE EGG WITH TWIN EMBRYOS

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Twin embryos are rare in the eggs of wild birds (O'Conner 1984). In captive birds the incidence of twinning has been experimentally increased in the Mallard (*Anas platyrhynchos*) by keeping the eggs at low temp prior to incubation (Batt et al. 1975) and in Domestic Chickens (*Gallus gallus*) by exposing laying females to temps inducing hypothermia (Sturkie 1946). Romanoff and Romanoff (1949) considered that double yolks were not unusual in Domestic Chickens although single yolked eggs with 2 blastoderms were very rare. We can find only 1 published account of twin embryos in the egg of a raptor, namely a Peregrine (*Falco peregrinus*) from Greenland (Pattee et al. 1984).

As part of a population study of the Northern Goshawk (*Accipiter gentilis gentilis*) in Great Britain we visited a nest on 5 May 1988 and noted 1 very large egg amongst a clutch of 3 fresh eggs. The largest egg was the dirtiest,

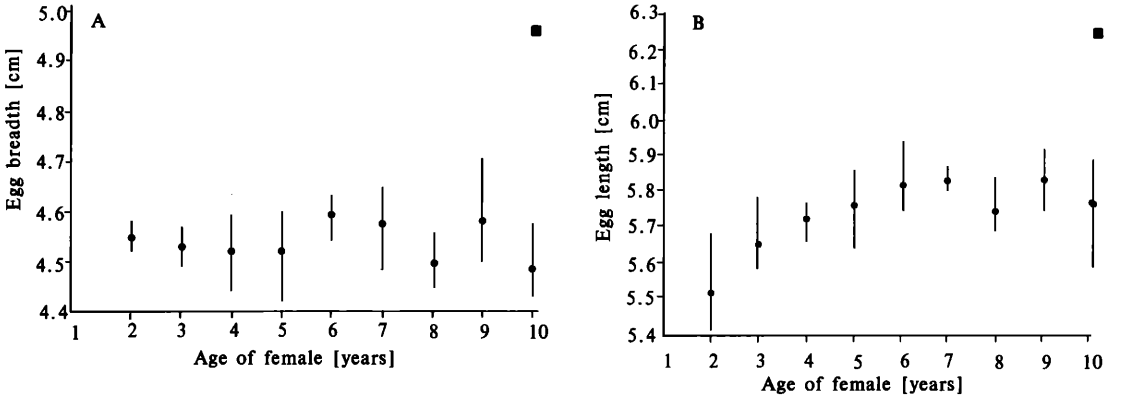

Figure 1. The breadth (A) and length (B) of eggs laid by 1 female Northern Goshawk between the ages of 2 and 10. Circles give the means for each clutch; endpoints of bars show the maximum and minimum within a clutch. The square indicates the abnormal egg.

Table 1. Reproductive history and egg biometrics (cm) of 1 female Northern Goshawk from age 2 to 10. The bird also bred as a yearling in 1979 and reared 2 chicks but eggs were not measured.

				Egg Biometrics		
Year	Female Age	Clutch Size	Brood Size[a]	Length ± S.D. (Range)	Breadth[b] ± 1 S.D. (Range)	Volume Index[c] ± 1 S.D. (Range)
1980	2	3	2	5.52 ± 0.14 (5.41–5.68)	4.55 ± 0.03 (4.52–4.58)	114.26 ± 2.06 (112.00–116.04)
1981	3	4	0	5.65 ± 0.09 (5.58–5.78)	4.53 ± 0.03 (4.49–4.55)	115.63 ± 0.70 (114.82–116.53)
1982	4	4	4	5.72 ± 0.05 (5.66–5.77)	4.52 ± 0.07 (4.44–4.59)	117.02 ± 4.05 (111.58–120.51)
1983	5	3	2	5.76 ± 0.11 (5.64–5.86)	4.52 ± 0.08 (4.42–4.57)	117.58 ± 6.43 (110.19–121.85)
1984	6	3	2	5.82 ± 0.11 (5.75–5.94)	4.59 ± 0.05 (4.54–4.63)	122.52 ± 0.69 (121.88–123.26)
1985	7	4	4	5.83 ± 0.04 (5.80–5.87)	4.57 ± 0.08 (4.48–4.61)	121.51 ± 3.21 (117.81–123.47)
1986	8	3	3	5.75 ± 0.06 (5.69–5.79)	4.49 ± 0.06 (4.45–4.56)	115.8 ± 2.17 (114.46–118.32)
1987	9	4	2	5.83 ± 0.09 (5.75–5.92)	4.57 ± 0.09 (4.49–4.70)	121.96 ± 4.23 (118.52–127.46)
1988	10	4	0	5.77 ± 0.16 (5.59–5.89)	4.48 ± 0.08 (4.43–4.57)	115.95 ± 5.44 (110.70–121.55)
1988 abnormal egg				6.25	4.96	153.76

[a] Number of chicks leaving the nest.
[b] Measured at the widest point.
[c] Volume index = $L \times B^2$, when L = length and B = breadth.

suggesting that it was the first laid. Two days later 1 additional normal-sized egg was present in the nest. We found the nest freshly deserted on 10 June with 2 dead chicks and 2 addled eggs, including the large one. One chick was about 3 d old and the other <1 d old, and the last laid egg was just starting to hatch. Both eggs were removed under licence.

Moulted primary feathers were collected annually and used to identify the adults (Opdam and Muskens 1976). We knew the complete reproductive history of this particular female. She first bred as a yearling in 1979 with a 2 yr-old male. She kept the same mate, and the pair used the same nesting territory for each of 10 breeding attempts during 1979–1988. Each year, except for 1979, we measured length and breadth of each egg to the nearest 0 01 cm. Egg breadth showed no trend with age of the female (Fig. 1A), unlike egg length which increased to a plateau at around 3–4 years of age (Fig. 1B). Length and breadth of the abnormally large egg collected in 1988 was well outside the range of all other eggs laid by this female (Fig. 1); volume index of 153.76 cm^3 was 20.6% greater than the next largest egg with an index of 127.46 cm^3 (Table 1), and fresh laid weight was 82.6 g compared to 63.0 ± 3.10 g (mean ± 1 S.D.) for other eggs in the same clutch.

The large egg was opened in October 1988 and 2 embryos of a similar size (about 10–15 d old) in 1 yolk sac were discovered. Incubation period in Northern Goshawks is around 35–38 d (Cramp and Simmons 1980). Embryos were partly decomposed and appeared to have died prior to the nest being deserted because far less development was evident than those in the other eggs.

Pattee et al. (1984) gave no data on normal egg sizes laid by the Peregrine which produced twin embryos but did show that the egg was considerably longer and wider than other Peregrine eggs collected for pesticide analysis from the same area. Our observations show that with the same female Northern Goshawk, the egg with twin embryos was considerably larger than normal. This female was one of the oldest in our study population. She was also one of the most successful, having produced 21 chicks during her lifetime (Table 1). To desert when the chicks were hatching suggests that she may also have been under stress throughout the breeding attempt. We have measured over 400 eggs from other Northern Goshawks during the same period and in the same area, and none were found to be so large. However, giant eggs do occur in other species. In a sample of 200,000 Domestic Chicken eggs, 89 were unusually large (Romanoff and Romanoff 1949). Whatever the cause for twinning, the phenomenum appears to be an extremely rare occurence in the Northern Goshawk.

ACKNOWLEDGMENTS

We thank Drs. L. Kiff, M. Marquiss, I. Newton, O. H. Pattee and P. R. Ratcliffe for helpful comments on an earlier draft; Mrs. D. Chadwick for the typing; and Mr. J. Williams for preparing the figure.

LITERATURE CITED

BATT, B. D., J. A. COOPER AND G. W. CORNWELL. 1975. The occurence of twin waterfowl embryos. *Condor* 77: 214.

CRAMP, S. AND K. E. L. SIMMONS. 1980. The Birds of the Western Palearctic, Volume 2. Oxford University Press, Oxford.

O'CONNOR, R. J. 1984. The growth and development of birds. John Wiley and Sons, Chichester.

OPDAM, P. AND G. MUSKENS. 1976. Use of shed feathers in population studies of *Accipiter* hawks (Aves, Accipitriformes, Accipitridae). *Beaufortia* 24:55–62.

PATTEE, O. H., W. G. MATTOX AND W. S. SEEGAR. 1984. Twin embryos in a Peregrine Falcon egg. *Condor* 86: 252–253.

ROMANOFF, A. L. AND A. J. ROMANOFF. 1949. The avian egg. John Wiley, New York.

STURKIE, P. D. 1946. The production of twins in *Gallus domesticus*. *J. Exp. Zool.* 101:51–63.

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Received 15 March 1989; accepted 31 July 1989