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Information Derived from Captive Raptors: A Selected Review

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Potential uses of captive raptors for research are discussed. A selection of papers on incubation, clutch size, fertility, photoperiod, eggshell thinning and DDT, taxonomy, general biology, development of young, visual acuity, veterinary aspects, plumage changes and metabolism is reviewed.

Introduction

Numbers of diurnal raptors are in captivity in Australia but little research has been produced from them. Data obtained from captive raptors, including those permanently injured, can be used to indicate profitable areas for research, clarify and amplify field research and provide information difficult or impossible to obtain in the wild. Captive breeding allows the researcher to control some of the variables encountered in the wild and places him in a more convenient position to monitor trends.

A selection of papers containing information derived from captive raptors is summarized and discussed below in the hope that ideas will be generated for related work in Australia on birds already held in captivity. Although we have limited this selection to studies of diurnal raptors, the techniques discussed in these papers are applicable to and have been used with other captive birds eg. Frith (1977) and Disney (1978).

Breeding Research

Incubation and Clutch Size

Little is known about incubation in raptors, especially in Australian species. Incubation times can be difficult to determine in wild birds, especially those nesting in hollows, as adults may squat or stand over eggs giving an observer the impression that incubation has commenced. Nice (1954) has pointed out that 'too short (incubation) periods are usually attributed to birds of prey' (p. 191). This has been confirmed, for instance, by Nelson (1972a, 1977) who found incubation periods in both captive and wild Peregrine Falcons *Falco peregrinus*, to be 32 to 38 days (usually 32-34). These periods are quite variable and it is clear that the 28 to 30 day interval for peregrines and other large falcons sometimes mentioned in the literature is in error.

Very little is known about temperature and rotation of eggs during incubation. Schwartz *et al.* (1977) used transmitters implanted in dummy falcon eggs to study incubation in one captive pair of Prairie Falcons *F. mexicanus*, and one captive pair of Peregrine Falcons. They compared egg movement during dark periods and light periods. Egg temperatures found were lower than had previously been suspected.

Control of clutch size is also poorly understood in most raptors. Porter (1975) experimentally altered the clutch size of captive American Kestrels *F. sparverius* to ascertain whether they were determinate or indeterminate layers, as defined by Davis (1955). When eggs were systematically removed from laying females, an unusually large number of eggs were laid. This suggested they were indeterminate layers. However, when eggs were added and the clutch thus prematurely completed, birds continued to lay normal sized clutches (determinate layers). The addition of eggs did not advance the onset of incubation to before the laying of the next to last egg (third or fourth).

Duration of Fertility

Duration of fertility is often related to photoperiod and air temperature in raptors but may also reflect food supply and rainfall patterns (Brown and Amadon, 1968). Often studies are undertaken where large samples of animals are available for the determination of gonad size or condition and hence sexual cycles, e.g. Frith *et al.* (1976). However, it is often difficult to obtain large samples of raptors. Bird and Lague (1976) used an alternative method to define reproductive cycles. Semen was collected by massage from 18 randomly selected captive male American Kestrels over two years. Each time it was analysed for colour, volume, concentration of spermatozoa, sperm count, motility of spermatozoa and percentage contamination.

Bird and Buckland (1976) determined the onset and duration of fertility of captive American Kestrels by artificially inseminating eight females once each, then removing their eggs one by one and checking for fertility.

Photoperiod

Kestrels in experiments conducted by Willoughby and Cade (1964) responded to photoperiod manipulation by producing fertile eggs approximately three months ahead of natural schedule despite the cold temperatures existing in New York at that time. Olsen and Olsen (1980) reported similar findings in the Australian Kestrel *F. cenchroides*.

Nelson (1972(b)) discussed the failure of Peregrine Falcons *F.p. tundrius* of northern origin to breed in captivity. A model was developed based on information about these falcons that approximated the photoperiodic changes they would theoretically receive during their annual trans-equatorial migration. Nelson and Campbell (1973,1974) describe the implementation of this programme and discuss the successful breeding of arctic peregrines with notes on behaviour, ontogeny, etc. These peregrines were also bred using southern Alberta photoperiod.

Eggshell Thinning and DDT

Causality between pesticides in an ecosystem and population declines of raptors has always been difficult to establish because of the number of variables implicated. Captive breeding programmes have shed some light on this area. Wiemeyer and Porter (1970) showed experimentally that DDE (a metabolite of DDT) caused thinning of eggshells in captive American Kestrels. Lincer (1975) went further in this work. Firstly he established a dose-response relationship between dietary DDE and eggshell thinning in captive American Kestrels. Secondly he induced wild kestrels to use nest boxes in a study area and, by using Ratcliffe's Index (Ratcliffe (1970) and analysing egg contents he was able to show that the eggshell thinning was correlated significantly with the amount of DDE present in the egg for the same species in both the laboratory and the field.

DDT-induced breakage of eggshells in raptors has been the subject of much contention in the past (Hickey 1969). Ivins and Halliwell (1974) measured eggs of Prairie Falcons to quantify relationships between embryo viability and shell thickness. They compared captive laid eggs (all placed in an artificial incubator) to those of wild falcons and found that eggs of the wild falcons required stronger shells to 'withstand successfully the trauma of natural incubation' (p. 66).

Nelson (1976) examined aspects of egg breakage in wild and captive Peregrine Falcons that may have resulted from aberrant behaviours (e.g. egg eating) often said to be induced by DDE. Normal incubation behaviour adequately accounted for accidental breakage of thinner than normal eggshells.

Taxonomy

Information obtained from the captive breeding of raptors such as incubation times, behaviour, plumage changes, ontogeny, etc., can amplify taxonomic relationships. Several other aspects of captive breeding in raptors have been employed for taxonomic purposes. Willoughby (1966) collected remiges and retrices of captive breeding American Kestrels for determination of moult chronology to illuminate taxonomic work done previously by Stresemann (1958), Stresemann and Stresemann (1960) and Mebs (1960).

● *Captive female Brown Goshawk defending her young.* Photo: P. Olsen

Cade and Weaver (1976) discussed the scientific importance of captive hybridization of species such as Gyrfalcons *F. rusticolus* and peregrines. They compared physical aspects of the two species and their hybrids, and discussed implications for obtaining information on phylogeny of species in the genus *Falco* and family Falconidae from future hybridization. They suggest using hybridization to investigate how genetic factors influence such complex behaviour as courtship display, species specific vocalization and hunting behaviour.

General Biology

Willoughby and Cade (1964) studied the breeding biology of captive American Kestrels *F. sparverius*. Several environmental factors influencing reproduction were investigated. For example, this species was found to have a well defined breeding season and though normally hostile to members of the same species became sociable in spring. The absence of a nest hole prevented ovulation in females and inhibited full sexual behaviour in males. Pair combinations were manipulated to determine dominance patterns in relation to sexual dimorphism using the small Florida race, *F.s. paulus* and the larger northern race, *F.s. sparverius*.

Others have done similar work in general biology. Porter and Wiemeyer (1972) reported on the chronology of egg laying, duration of nestling periods and nestling sex ratios in captive American Kestrels. They also removed eggs from laying females to examine relaying patterns. Olsen and Olsen (1980) compared the nesting chronology of three captive and two wild pairs of Australian Kestrels, and the development of nine captive bred and five wild bred nestlings. Data from egg collections and the Australian Bird-banding Scheme were examined in relation to the findings and similar data on other species of kestrel was used for comparison. Ageing and sexing techniques were tested. Wild and captive broods showed no differences in those measurements taken. Olsen, Olsen and Mooney (in prep) did a similar comparative study on captive and wild Brown Goshawks *Accipiter fasciatus*.

Campbell and Nelson (1974, 1975) discussed captive breeding of North American Merlins *F. columbarius*, emphasizing ethological observations. They discuss length of incubation and fledging periods, vocalizations, photoperiod, breeding in the first year, imprinting to man and to nest site types, and autumn territoriality.

Nelson (1972(a), 1972(b), 1973, 1976) has produced important research on the Peregrine Falcon particularly on behavioural aspects, by combining data from carefully placed hides, long distance observation and captive breeding.

Non-breeding Research

Much research into aspects of reproduction has been done with single unmated birds, for example, Porter's (1975) experiments with clutch size alteration and Bird and Lague's (1976) semen production experiment.

Considerable work has been done with single birds on subjects other than breeding. Examples include Kemp's (1975) and Schmutz and Schmutz' (1975) studies of the development of a hand raised Lanner Falcon (*F. biarmacus*) and two American Kestrels respectively. Olendorff (1974) compared growth rates in three species of hand raised *Buteos*. Mooney (1976) explored a number of behavioural aspects in captive Brown Falcons *F. berigora*. Fox *et al.* (1976) compared grating acuity, the ability to resolve high contrast square wave grating, in an American Kestrel and humans. Reymond (pers. comm.) conducted a similar investigation into the eyesight of a Wedge-tailed Eagle *Aquila audax* using a captive bird taught to fly to a perch in front of a grid. Cooper (1978) has done extensive work on the veterinary aspects of wild and captive raptors; these could be important limiting factors in the wild.

Morris (1976) followed plumage changes in the Brown Goshawk. We have monitored plumage changes and moult chronology in nine species of captive Australian raptors and are presently studying museum skins of these species in light of the data collected from captives. From another study, based on food trials with captive birds, we will be able to estimate how much a wild raptor has eaten.

Green and Mooney (unpublished data) calculated sodium and water turnover in two captive Masked Owls *Tyto novaehollandiae,* a Marsh Harrier *Circus aeruginosus* and a Brown Falcon by injecting radioactive sodium salt and tritium and taking a subsequent blood count. Intake of food, castings and excrement were carefully monitored. Calorimetric analysis allowed energy value calculations so that the accuracy of the calculated sodium and water turnovers could be checked. Mosher (1976) has reviewed the existing literature on raptor energetics, pointing out existing gaps and suggesting research to close these gaps. He suggests research in the following areas: "(1) energy cost for productive work, especially moult, incubation, growth and flight, (2) metabolic response to wind and humidity, (3) seasonal metabolic acclimatization, (4) energetic efficiencies—metabolized energy/gross energy intake and efficiency of prey capture, i.e., energy value of captured prey/energy cost of hunting and, (5) sexual differences unrelated to body weight, in metabolic responses" (p 100).

Conclusion

It must be emphasized that data collected from captive raptors is often inconclusive on its own and is best used to amplify other forms of research or generate ideas for studies in the field. Very few research situations warrant removal from the wild of healthy raptors, however, the large numbers of injured, diurnal raptors available to zoos, wildlife authorities, tertiary institutions and those private individuals holding permits could be a valuable source of information on raptors in Australia.

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