14. MEGAPODES IN NORTHERN AUSTRALIA: A SUMMARY OF RECENT RESEARCH ON THE ORANGE-FOOTED SCRUBFOWL AND AUSTRALIAN BRUSH TURKEY

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Abstract

Malleefowl are unquestionably the aberrant megapode: all of the other 21 species live in subtropical and tropical regions, mainly in dense rainforests where the construction of incubation mounds is relatively straighforward. Malleefowl are of particular interest because they have somehow managed to adapt what would have been a life in the jungle to millennia of relentless drying. Coping with extreme climate change is possible but requires sophisticated adaptations. Comparisons with the two more northern megapodes that occur in Australia – the Australian Brush-turkey and the Orange-footed Scrubfowl - provides an assessment of the extent of this adaptation in Malleefowl as well as an opportunity to learn how the other species are faring. Although many megapodes remain seriously threatened, these two Australian species have learned how to live successfully among people, in some locations such as Brisbane, Darwin and Cairns, becoming nuisances in urban areas. Despite its abundance, however, the scrubfowl remains poorly studied. On the other hand, continuing work on the brush-turkey has greatly enhanced our understanding of the species and of many aspects that are common to the family as a whole. Of particular importance is the recent discovery of a specialised form of temperature sex determination in brush-turkeys in which different levels of mound heat result in highly skewed sex ratios. This presentation will review some of these recent findings, highlighting issues of particular relevance to Malleefowl conservation and ecology.

Introduction

Malleefowl *Leipoa ocellata* are unquestionably the aberrant megapode: all of the other 21 species live in subtropical or tropical regions, mainly in dense moist rainforests where the construction and maintenance of incubation mounds is relatively straightforward (Jones *et al*. 1995). Malleefowl are of particular interest because they are survivors of the Pre-Pleistocene era when much of Australia was covered in moist non-sclerophyllous forests. Like the extinct giant megapode *Progura gallinacea*, the ancestors of present-day Malleefowl would presumably have constructed large mounds in similar fashion to most of the extant mound-building megapode species. It is a measure of its resilience and adaptability that this bird has been able to maintain the typical megapode incubation process in the face of continental drying that transformed almost every element of mound construction and operation to be able to continue undeterred into the present day.

The primary focus of the 2007 Malleefowl Forum was on the current desperate conservation status of the Malleefowl in most parts of its range and on the task of recovery and securing the species' survival. The status of the other two Australian megapodes is, thankfully, quite different: both the Orange-footed Scrubfowl *Megapodius reinwardt* and the Australian Brush-turkey *Alectura lathami* are classified as of Least Concern, and both occur in most of their historical range (Dekker *et al*. 2000). Both are common and even abundant and increasing in many locations, especially in populations that have recently started to exploit urban environments (see below). There is, however, considerable contrast between the species in terms of the amount and type of research conducted on each. The Malleefowl, while only one of numerous megapode species that is critically threatened (Dekker *et al*. 2000), has been the subject of by the far the largest number of conservation biology studies. On the other hand, the Australian Brush-turkey, being the only abundant species to live in and near two of Australian largest cities (Sydney and Briisbane), is the best studied of all megapodes (Jones 1999). Despite occurring in Australia, the only developed country to support megapodes, the largely tropical and remote distribution of the Orange-footed Scrubfowl, as well as its secure conservation status, has resulted in relatively little research attention. The aim of this paper is to provide a concise summary of some recent studies on both of the two megapodes occurring to the north of the range of the Malleefowl. This resume concentrates on work completed since the 3rd International Megapode Symposium held in Nhill, Victoria in 1997 (Dekker & Jones 1999).

Orange-footed Scrubfowl

The Orange-footed Scrubfowl has by far the largest distribution of all megapodes, being found in a multitude of islands from the Lesser Sunda Islands near Bali in Indonesia, across northern Australia and most of southern New Guinea to the Trobrian Islands off the eastern tip of Papua (Jones *et al.* 1995). Nonetheless, since the first behavioural studies conducted near Cairns in the late 1970s (Crome & Brown 1979), the only direct research on the species has been conducted in coastal Northern Territory, primarily around Darwin. Palmer *et al.* (2000) investigated the site characteristics of incubation mounds in different forest types and found that ease of leaf litter collection was a major influence. While such organic matter was the primary source of incubation heat, solar radiation was also important in the sandy mounds constructed in coastal Vine thickets. Franklin and Baker (2005) investigated the increasing presence of the species in suburban Darwin and found that they lived and constructed their mounds mainly in areas of forest immediately adjacent to house-yards, into which they venture to forage opportunistically.

Very recently, important studies on the species have been carried out on the Indonesian Island of Komodo as part of continuing research into the Komodo dragon *Varanus komodensis* by Australian and Indonesian researchers (Jessop *et al.* in press). These workers conducted extensive surveys of mounds throughout the island to assess the features used by the birds in siting their mounds, and found that the birds preferred sandy or loamy soils in open monsoon forest with minimal shading. On Komodo, nesting activity began in the late dry season (October) and peaked during the late wet season in March. The mounds are crucial to reproduction by the Komodo dragons, 70% of which incubate their eggs along with those of the scrubfowl in the mounds. Nonetheless, there were relatively low levels of egg predation (<17%) and human disturbance was negligible.

There remain many excellent and fascinating opportunities for further studies of this widespread and still abundant species, especially in northern Queensland. Especially important would be conservation-related studies of this secure species that could be applied to many of the threatened *Megapodius* species for which manipulative or replicated research may be impossible or too risky.

Australian Brush-turkey

The Australian Brush-turkey is currently widespread and, in many places especially near certain cities, abundant. Recent surveys in Brisbane (Jones *et al*. 2004) and Gosford (Göth 2007a) indicate a continuing growth in suburban populations, accompanied by a concomitant increase in the number of complaints from residents. Earlier studies (Jones and Everding 1991) had intimated that the presence of brush-turkeys in urban environments was likely to be temporary, principally because of the almost complete mortality of the defenceless young due to, mainly, predation by cats. The pronounced growth in the number of sites within the Brisbane suburbs over a ten-year period (Jones *et al*. 2004) indicates that at least some chicks obviously do survive. However, two anthropogenic activities are also likely to enhance the success of urban brush-turkey populations: the on-going (and mainly illegal) translocations of nuisance birds – usually mound-building males (Jones *et al*. 2004), and the amount of feeding of the birds, whether intended or not, by householders (Göth 2000a).

Despite these extnsions of localised populations, the brush-turkey's overall pre-European distribution has contracted and fragmented significantly, especially in southern New South Wales (Göth *et al*. 2006). A detailed survey of all available historical records of the species (Göth *et al.* 2006) indicated that, during the early 1800s, the species occurred as far south as Cape Howe 37.5°S) on the New South Wales-Victoria border and even in the Snowy Mountains near Jindabyne. To the west, historical sightings include Nyngan, Pilliga and Moree, that do not exist today. The western-most New South Wales extant population is in Mt. Kaputar National Park (150.1°E) (although the most inland population is probably that in Carnarvon Gorge National Park in central Queensland (147°E), 450 km from the coast)).

Although the demise of these southern and western populations has unquestionably decreased the distribution of the species, it is still found almost continuously from Cape York (10.4°S) in Queensland to its current southern-most outpost near Cambewarra (34.8°S) below Wollongong - a remarkable latitudinal range of over 30° (Jones *et al*. 1995, Goth *et al.* 2006). Evolutionary biologists are interested in species with extensive distributions for a range of reasons such as the process of and extent of gene flow and evidence of speciation within populations at the extremities of the species' distribution. One particularly useful technique associated with this field has been comparisons of ectoparasites living on the plumage of the birds from different parts of the range. This approach was applied by Proctor and Jones (2004) to the brush-turkeys sampled throughout the entire range of the species in Queensland. Six species of feather mites and two species of feather lice were identified. However, the extent of sharing of these species, even among populations over 1000 km distant, indicated unexpectedly similar parasite communities and no evidence of population differentiation.

Among the most significant implications of the megapode incubation system is the complete absence of post-hatching parental care for the offspring. Despite being extremely precocial at emergence, the young nonetheless start their lives without protection, guidance or even the possibility of social learning. While many commentators (Priddel & Wheeler 1996, Jones 1999, Göth 2001) have identified this situation as being of critical importance to understanding much subsequent development and behaviour in megapodes, generally –especially in relation to survival of individuals in threatened populations - the daunting logistical challenges have greatly limited most research on the topic. The existence of numerous high-density populations of the Australian Brush-turkey has provided an ideal opportunity for detailed studies, most of which have been conducted by Dr Ann Göth. Working initially in southern Queensland, Dr Göth completed a comprehensive series of studies on aspects of predator recognition (Göth 2001), foraging preferences (Göth & Proctor 2002), 'underground 'behaviour' following hatching (Göth 2002), chick survival and habitat preferences (Göth & Vogel 2002, 2003), and the ontogeny of social behaviour (Göth & Jones 2003).

This work continued and focussed with Dr Göth's move to Sydney, where fortuitously her arrival coincided with a marked expansion of populations in the vicinity of the northern suburbs of the city. Sophisticated studies of carefully reared captive chicks at the University of Macquarie elucidated the importance of visual ((Göth & Evans 2004a,b) and auditory (Barry & Göth 2005) cues, while increasingly detailed experiments have explored the importance of learning and testosterone in the development of mound building (Göth & Astheimer 2006) and further details of the fascinating area of female choice of mounds and mates (Göth 2007b). It is no exaggeration to suggest that this coherent and remarkable body of work is revolutionising our understanding of many aspects of megapode ecology, behaviour and even evolution.

However, it is a discovery during routine experiments on incubation in brush-turkey eggs that is possibly the most important of all these studies: the possibility of temperature-dependent sex ratios. While the phenomenon of temperature-dependent sex determination is well-known among a wide range of reptile species (Janzen & Paukstis 1991), the possibility of a similar influence in birds has always been impossible simply because sex in birds is genotypically determined at the point of fertilisation (Pike and Petrie 2002). Nonetheless, sex ratios in some birds is known to differ dramatically from parity, due mainly to pre-fertilisation hormonal influences of the female, or differential treatment of the hatchings (Hasselquist & Kampenaers 2002). Although incubation spans the period between these pre-fertilisation and post-hatching influences on sex ratios, this fundamental process has been deemed to be an unlikely source of variability because the temperature regime of almost all birds - being produced by the brooding bird's body heat will be identical for all eggs within the nest. Megapodes, however, differ from almost all other birds by incubating their eggs by exploiting external sources of environmental heat, which, although typically manipulated to facilitate thermal stability nonetheless exhibit significant differences between mounds and within the same mound (Booth & Jones 2002). Could this variation in incubation temperature lead to changes in the sex ratio of the resulting chicks?

Characteristically, Göth acknowledges that it was a conversation with a North Queensland aboriginal elder, Warren Canendo, which triggered this line of research. Warren was adamant that pronounced differences in the seasons resulted in different numbers of males or females (Göth & Booth 2005). While our current level of understanding would suggest that this was unlikely, Ann was sufficiently intrigued to test the idea experimentally. In the wild the incubation temperatures of brush-turkey mounds may vary from 30°C to 38°C though the average is about 34°C (Göth 2007c). Ann Göth and her colleague David Booth placed eggs collected from natural mounds in artificial incubators set at three temperatures well within this range: 31°, 34° and 38°C (Göth & Booth 2005). The results were clear: at the lower temperature, more males hatched, more females hatched at the higher temperature while the sex ratio at 'normal' temperatures was exactly equal. However, this result was only evident during the earliest stage of development, approximately the first 10 days. After this stage, the sex ratio remained equal, regardless of temperature.

As well as numerous theoretical implications, there are also some important practical possibilities of this remarkable finding. First, it raises the possibility that females could influence the sex of their offspring through the careful selection of the placement of the eggs at the time of laying. This is certainly possible, as it is already well known that the birds are capable of assessing the temperature of the incubation substrate, an activity observed in all megapode species. Such apparently adaptive manipulations of sex ratio of offspring prior to birth or hatching has been found in other animals but this is not in previously in birds (Pike & Petrie 2002).

A further finding from these experiments was that incubation temperature also strongly influenced the mass but not size of hatchlings (Göth & Booth 2005, Göth 2007c)); chick weight increased significantly with incubation temperature. Other investigations (Göth 2002, Göth & Evans 2004a) have demonstrated that this has important consequences for a range of behaviours including the speed of emergence from the mound, and even the probability of survival of chicks (Göth & Vogel 2003). Generally, larger chicks live longer.

This is the second pragmatic finding to emerge directly from these other potential theoretical studies: conservation plans that include artificial incubation may need to assess the potential impacts of incubation temperature on the sex ratio of the chicks being produced and of influences on survival after release.

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