

# FEEDING BEHAVIOUR OF THE OSPREY *Pandion haliaetus* ON THE NORTH COAST OF NEW SOUTH WALES

GREG P. CLANCY

Zoology and Ecosystem Management, University of New England, Armidale, New South Wales 2351

Present address: PO Box 63, Coutts Crossing, New South Wales 2460 and National Marine Science Centre, Bay Drive, Coffs Harbour, New South Wales 2450, gclancy@tpg.com.au

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The feeding behaviour of the Osprey *Pandion haliaetus* was studied at feeding grounds, feeding perches and nests in the Clarence Valley, north-east New South Wales, from 1991 to 1996. Foraging behaviour was found to be similar to that of Northern Hemisphere birds. Although birds were found to take mostly living fish, one record of possible scavenging was made. The male Osprey was the main provider during the breeding season, bringing food to the nest for the female and nestlings. Details of hunting, delivery of food to the nest area, eating behaviour, courtship feeding, food solicitation, and interspecific competition are presented.

## INTRODUCTION

The Osprey's morphology indicates that it is a highly specialized hunter. The large feet with short, sharp, spines covering the base of the footpads and toes, and long and razor-sharp talons, combined with a flexible outer toe, which can reverse its position to allow a better grasp of a slippery fish, all make the Osprey an efficient hunter (Poole 1989; pers. obs.). These adaptations, as in other specialists, make activities, other than hunting, rather difficult or clumsy. Ospreys are awkward when walking on the ground and can only perch on thick branches of trees or logs, poles, signs etc. with a broad surface area (pers. obs.).

An understanding of the feeding ecology and behaviour of the Osprey is important for management and conservation. The Osprey, at the top of the food chain, is a significant indicator of ecosystem health, as was recognized very early in the identification of the problem caused by chlorinated hydrocarbons (Poole 1989). Factors that could affect foraging efficiency are reduced prey abundance and increased water turbidity, pollution or turbulence.

The hunting, post-capture and feeding behaviour of Ospreys has been well studied in the Northern Hemisphere (Poole 1985, 1989; Forbes 1991; McLean 1991). However, no comprehensive studies of Osprey feeding behaviour have been carried out in New South Wales, although a survey of foraging habitat and hunting during one breeding season was carried out at Ballina (Maciejewski 1993). Earlier surveys were short and provided little more than anecdotal information (Clancy 1980, 1981, 1989), as did one recent study (Rose 2000). The present study describes the feeding behaviour of Ospreys in coastal northern New South Wales and compares it with data from elsewhere in Australia and overseas. Data on hunting, handling of prey, and food solicitation and delivery at nests are presented. This will provide baseline data on the foraging and feeding behaviour of local Ospreys and will allow unusual behaviour, due to unnatural influences, to be detected in the future. Information on the diet of the species has been presented elsewhere (Clancy 2005).

## METHODS

I observed Ospreys feeding near their nest areas while I gathered information on their breeding biology, from 7 July 1991 to 12 December 1996 (Clancy, in press). Activity (food handling and food solicitation and delivery) was observed through a pair of binoculars and/or a spotting scope. Specific behaviour was noted, as was the time to the nearest minute. Behaviour recorded at nests during this study involved:

- food delivery to the nest area by the male for his own consumption;
- food solicitation by the female or young and delivery of food to her or them by the male;
- the method of eating/feeding; and,
- the relative amounts of food eaten by the male, female and young.

The percentages of food eaten by female or young Ospreys were determined by counting the number of bites when the female fed herself or her nestlings.

Twenty-one opportunistic observations of Ospreys hunting were made at various sites. A few of these were made during nest watches within the Clarence Valley. The period of observation in all cases was short (up to 16 minutes but mostly less than 5 minutes). The observations on hunting were carried out incidentally during other fieldwork and are, therefore, limited. The large home range of hunting Ospreys means that the use of a boat or aircraft would be required at all but the most ideal sites to allow detailed monitoring of the birds.

## RESULTS

### *Hunting*

Seventeen hunting events, constituting a single dive for a fish, involved foraging on the wing, and four were made from a perch (Table 1). Hunting on the wing involves a bird patrolling above the water, scanning below for prey. When a potential target is sighted the bird hovers then plunges into the water feet first, sometimes in stages before the final plunge.

Perch hunting was initiated from a nesting platform at Woodford Island twice, once from a dead tree at the same location and once from a nest pole on Goodwood Island. All perches are within a few metres of the Clarence River and command clear views of the water. The method involved a bird scanning the water below the pole or tree. When a potential target was observed the Osprey aligned

TABLE 1

Details of the observed Ospreys hunting methods and outcome.

Location	R = River E = Estuary B = Ocean Beach	Date	Method	Height dive began (metres)	Successful	Period of Observation (minutes)
Goodwood Is.	E	26.03.93	perch (pole)	16	yes	4
Dart Island	E	07.07.93	on wing	not recorded	no	not recorded
Angourie	B	24.10.96	on wing	20	no	5
Woodford Is.	R	23.05.94	on wing	not recorded	no	3
Woodford Is.	R	06.06.94	perch (tree)	15–20	yes	16
Woodford Is.	R	31.07.94	on wing	20	yes	5
Woodford Is.	R	31.07.94	on wing	20	no	3
Woodford Is.	R	28.09.95	on wing	20	no	3
Woodford Is.	R	10.10.95	perch (pole)	8	yes	3
Woodford Is.	R	29.10.95	perch (pole)	8	no	2
Woodford Is.	R	15.08.96	on wing	12	yes	2
Lawrence	R	27.06.96	on wing	10–20	no	3
Southgate	R	25.10.96	on wing	20	no	5
Sandon River	B	19.06.93	on wing	10–12	yes	3
Sandon River	B	19.06.93	on wing	10–12	no	2
Susan Is.	R	19.06.95	on wing	not recorded	no	2
Susan Is.	R	12.07.95	on wing	20	no	2
Coffs Harbour	B	09.05.96	on wing	8	no	2
Nambucca Heads	E	14.06.93	on wing	c.20	no	3
Nambucca Heads	E	19.10.96	on wing	8–10	not known	1
Port Macquarie	E	14.01.94	on wing	15–20	no	10

its body in the direction of the fish (this was often accompanied by head bobbing) and prepared to dive. The bird made the attack by dropping from the perch and plunging directly into the water at the fish.

The majority of hunting attempts were unsuccessful (70%) with less than a third (30%) being successful. The outcome of one attempt was unknown. Three of the four hunting events that were made from a perch were successful.

#### *Delivery of food to nest area*

Thirty-eight of the 41 food deliveries to nests, observed during 213 hours of observation, were by male birds. They delivered food to nest areas for their own consumption, to feed their mates, or for nestlings or fledglings (Table 2). Often the male consumed part of the fish before delivering it to the female. On 46 per cent of occasions the male fed himself and then presented the food to the female. On ten occasions the male gave fish directly to the female and on two occasions he fed the young without feeding himself. Nearly half (46%) of deliveries to the nest when young were present, were made directly by the male with him not consuming any of the fish. On nineteen occasions (95%)

that the female received a fish from the male, after the young had hatched, she proceeded to feed the nestlings.

Three observations (7.3%) were made of a female returning with food for her own consumption, all at the Lawrence nest. This happened when her mate had failed to deliver food. No young were produced at this nest during the last three years of the study. Overall, males delivered 0.17 fish per hour.

An average of 0.6 fish per hour was brought by the male to the Woodford Island nest, which contained two nestlings, in September/October 1995. Observations were carried out on six non-consecutive days and ranged in duration from 42 to 656 minutes.

An Osprey, at the Lawrence nest in 1996, was watched feeding on the tail section of a Hairtail *Trichiurus savala*. The bird dropped the tail tip, which I recovered and examined and found to possess a strong odour, suggesting that the fish may have been dead for some time. The Hairtail does not normally possess a strong odour when fresh (John Paxton, Australian Museum, pers. comm.), suggesting that the fish may have been collected sometime after its death, that is, it may have been scavenged or

TABLE 2

Observed food delivery by Ospreys to the nest area (total hours of observation = 213).

Activity	Pre-eggs	Eggs	Nestlings	Fledglings	Total
Male fed himself only	4		3		7
Male fed himself then female	5	4			9
Male fed himself, then female and she fed nestlings			10		10
Male fed female		1			1
Male fed female and she fed nestlings			9		9
Male fed nestlings			1		1
Male fed fledgling/juvenile				1	1
Female fed herself	3				3
Totals	12	5	23	1	41

alternatively, it may have been lying in the nest or on a perch for some time.

#### *Eating behaviour*

Ospreys started eating the head of the fish, usually near the mouth (pers. obs.; Cupper and Cupper 1981) and ripped the two opercular bones from the head and discarded them within the first few minutes. Fish were often still alive when eating commenced and frequently thrashed about while being eaten. Generally, when eating a mullet (*Mugil*, *Liza* or *Myxus*) all parts other than opercular bones were consumed, although some birds rejected the viscera and occasionally fins and other bones were dropped. When Yellowfin Bream *Acanthopagrus australis* were eaten, the large and sharp anal spines, as well as the opercular bones, were discarded. Dorsal and pectoral spines of Blue Catfish *Arius graeffei* and Fan-belly Leatherjacket *Monacanthus chinensis* were also routinely discarded.

At the Woodford Island nest, on 15 July 1992, the male bird dropped a freshly caught mullet (estimated 200 mm long) from his perch in the nest tree. He stared down at the 'lost meal' before taking off, circling around the base of the nest tree a few times and landing on the ground. My view of the bird on the ground was partly obscured, but the Osprey apparently walked a short distance to retrieve the mullet, which was still alive. He returned to his perch with the fish and proceeded to eat it. Five minutes later he delivered the partly eaten fish to the female on the nest. She began to eat it and feed the nestlings. At the same nest, in 1995, the male delivered a living mullet to the female on the nest. The fish began to thrash about and the female had to restrain the prey, which could have easily flipped out of the nest had it not been held firmly.

Adult and nestling Ospreys feeding on mullet at the Woodford Island nest in 1995 ate an average of 7.8 bites per minute. Mullet ranging in length from 250–450 millimetres took between 14 and 82 minutes to be completely consumed.

#### *Courtship feeding*

Male Ospreys were seen to deliver fish to females during courtship, however insufficient data were gathered to compare delivery rates of males at different nests.

#### *Food solicitation*

The proportion of food that the female ate increased during the meal, as the young became satiated and demanded less (or no) food. When the fish was large, the young became satiated when much of it remained. This resulted in the female consuming a large percentage of the food. At one feeding session during this study the female consumed 62 per cent of the meal (a mullet) while feeding 26 per cent and 12 per cent, respectively, to her two nestlings (based on percentage of bites). This may have been atypical as the nestlings became satiated quickly and may have eaten a greater proportion of earlier meals.

The begging call of the female gives the impression that the vocalist is either hungry or agitated. She usually begs

when the male is present at, or near, the nest, often as he is consuming a fish. If he does not have a fish he may fly off to hunt after she calls. A male bird at the Lawrence nest, during 1995 and 1996, frequently continued eating, ignoring demands from the begging female. He did, however, occasionally deliver food to her, but no young were produced by this pair during these years.

#### *Interspecific competition*

A number of fish-eating raptors occur sympatrically with Ospreys in north-eastern New South Wales: White-bellied Sea-Eagle *Haliaeetus leucogaster*, Brahminy Kite *Haliastur indus* and Whistling Kite *Haliastur sphenurus*. There were no records of the Osprey interacting with any of these raptors whilst hunting. Ospreys chased these species from the vicinity of nests, which was probably nest defence (Clancy, in press).

## DISCUSSION

In contrast to most birds, raptors have occasional, large, feeds separated by long periods of inactivity (Olsen 1995). The Osprey follows the typical feeding pattern of raptors. Much of an Osprey's day is spent resting or preening, interrupted only by the infrequent fishing forays or flights from the nest to deter a potential predator.

#### *Hunting*

The hunting techniques used were similar to those described by Poole (1989, 1994). Poole found that Ospreys did most of their searching from five to 40 metres above the water. This is consistent with my observations, which ranged from 8 to 20 metres. He also found that hunting from a perch was uncommon, except on certain wintering grounds, such as in Senegal where Ospreys congregate and perch in low mangroves to hunt. Flying is more demanding energetically than perching, but perch hunting may be rare because few perches provide a good view of potential prey. Also fish may not be active near available perches and the area able to be scanned from a perch would be limited. Maciejewski (1993) also found that Ospreys hunting at the Richmond River, Ballina, spent more time hunting on the wing than from a perch. Olsen (1995) divided raptors into 'searchers' and 'attackers'. The Osprey would be classified as a 'searcher' as it spends most of its foraging time flying, gliding and hovering until a suitable fish is located and attacked. The attack phase is relatively short, unlike that of 'attackers', such as the Peregrine Falcon *Falco peregrinus*.

Ospreys during this survey generally hunted live fish, although there was one possibly scavenged fish. Unconfirmed reports of scavenging have been received from local fishermen, presumably of recently discarded living fish. One Osprey pair nesting along the Clarence River is regularly fed dead fish by local residents. Despite this, scavenging would appear to be rare in local Ospreys. The single apparent case of scavenging in this study occurred following major flooding of the Clarence River, at a time when water visibility would have been limited due to high sediment loads, making fishing very difficult. Therefore, Ospreys may only scavenge when foraging is difficult. Poole (1994) stated that recently dead and dying

fish are scavenged on occasion, but such cases are rare enough that Ospreys almost always depend on live prey.

Competition for food by nestlings was not recorded during this study, but McLean (1991) found that threatening postures and what he termed 'kleptoparasitism' among siblings (nestlings) were common. This 'kleptoparasitism' may be better described as competition for food.

Insect- and fish-eating raptors have higher success rates than bird- and mammal-eaters (Olsen 1995). Poole (1994) estimated that dive success in Ospreys ranged from about 60 to 70 per cent when hunting slow-moving fish to less than 40 per cent for faster moving species. Lambert (1943) recorded a dive success by Ospreys of 89 per cent. I found that only 30 per cent of attempts (where the outcome is known) were successful, whereas Ospreys at Ballina had a success rate of 45 per cent (Maciejewski 1993). Both Maciejewski and I found that perch hunting was more successful than hunting on the wing (75% vs. 38%). Although our data are based on only 20 and 33 observations, respectively, the success rate of foraging in New South Wales Ospreys is comparable to Poole's estimate for fast moving fish and foraging Ospreys in Florida, where 36 per cent of 283 dives were successful (Grubb 1977). Ospreys in the Spencer Gulf of South Australia were recorded as hunting at night, apparently to avoid the effects of wind on the water surface (Hollands 1984). Local Ospreys hunted in estuaries or along rivers where the effects of wind would be less severe than at ocean sites. Nevertheless, hunting behaviour of Ospreys at Ballina was thought to be affected by overcast weather and possibly windy conditions (Maciejewski 1993). Further data on dive success in New South Wales Ospreys are needed to further test whether food is limiting or hard to catch for this population.

#### *Delivery of food to nest*

The average number of fish brought to the Woodford Island nest, containing two nestlings, during this study was 0.6 per hour or six per day. A pair of Ospreys at Hemmant, Queensland, with one large nestling less than two weeks from fledging, ate at least 22 fish over three days i.e. 7.3 fish per day (Marchant and Higgins 1993, Birds Australia Nest Record Scheme). Cupper and Cupper (1981) observed between two and 17 fish being delivered daily to a nest near Mackay, Queensland, with the higher numbers involving smaller fish. In Massachusetts, USA, six to eight fish were delivered daily to each of three nests containing three young (Poole 1989). All of these data indicate similar delivery rates.

#### *Eating behaviour*

The method of eating used by the female Osprey at Lawrence, in 1995, was typical feeding behaviour of the species. Kenward (1990) found that if an animal ceases to struggle without being killed, raptors have no scruples about eating the creature alive. The fact that fish are still alive when eating commences occasionally causes Ospreys to drop the slippery, thrashing animal. This would have been the case at the Woodford Island nest in 1992, when

the male dropped his prey but recovered it from below the nest. Cupper and Cupper (1981) found that fish brought to a nest in Queensland were freshly caught and often alive and thrashing about. They also observed the adult releasing a fish before the young had grasped it, resulting in a confused rush by the birds, before one bird secured the fish. On one occasion a fish flipped out of the nest, but no attempt was made to retrieve it.

Some Ospreys consume the viscera of the fish but others discard them; this possibly depends on the gut contents of the fish or degree of hunger. Occasionally the stomach or gut of a fish is found, with other food remains, beneath nests or perches. This may be a more common occurrence than is suggested by the few records as scavengers, such as crows or foxes, quickly clean up these morsels. Olsen (1995) stated "often the gut of larger prey... are discarded" and "occasionally the gut is eaten too, perhaps depending on its contents". A captive Osprey during this study usually rejected all or most of the viscera of the mullet that she was fed.

Poole (1989) found that, in hot climates, fish spoil quickly so that birds may never finish a large carcass. This was not observed during the current study as the fish caught were usually completely consumed at one sitting, with only difficult bones and fins being discarded.

#### *Food solicitation*

During the nestling stage the fish is usually delivered to the female on the nest; she tears it apart and feeds the nestlings, at least until they are large enough to feed themselves (pers. obs.). There was only one record, during this study, of a male bird delivering food directly to nestlings. This behaviour was rarely or never observed in overseas studies (Stinson 1977; McLean 1991; Francour and Thibault 1996).

The female usually eats some of the food delivered by the male. Poole (1989) found that a female generally only received about 15 to 20 per cent of the food her mate catches. Females appeared to eat very few bites of food while nestlings were begging or readily accepting food.

Poole (1989) determined in the USA that each bite averaged about 0.6 grams. Accepting that this applies to Australian Ospreys, a female in this study, with two young greater than 40 days of age and between 70 to 80 per cent of fledging size, ate 84 grams, the first nestling 35 grams and the second nestling 16 grams, a total of 135 grams. This agrees with the results of a study in the USA, where the dominant young at one nest ate twice as much as the subordinate young (McLean 1991).

Whether the male Osprey delivers fish directly to the nest may depend upon vocal cues given by the female. The more excited or frantic her begging, the earlier the fish is likely to be delivered to the nest. Other likely determining factors would be the male's hunger and the size of the prey and the age of the young. The female's begging call may be used to encourage him to hunt. In contrast, the begging calls of nestlings were heard infrequently. This may be because the male delivers food regularly, so that the young do not become too hungry.

### Interspecific competition

Ospreys occur sympatrically with the White-bellied Sea-Eagle, Brahminy Kite and Whistling Kite, but of these species only the Sea-Eagle regularly catches live fish.

Sea-Eagles and Ospreys on islands along the Great Barrier Reef both hunt fish; however, Ospreys take more fish (85% of diet) than Sea-Eagles (59%) and there is little overlap between the two in species composition of the prey. One family of seabird and one crustacean were also recorded at Osprey roosts along the Great Barrier Reef. However, caution is required as these non-fish items may have not been eaten by Ospreys (Clancy 2005). Sea-Eagles patrol islands, reefs and deeper water, while Ospreys search reef flats and lagoons, thus avoiding direct competition (Smith 1985; Olsen 1995).

Brahminy Kites, in southern Queensland, were found to have obtained most of the fish component of their diet from scavenging (Smith 1992), thus avoiding direct competition with the Osprey. Ospreys are sometimes subjected to interspecific piracy, since their conspicuous mode of prey transport, and reduced flight agility when carrying prey, make them easy targets. There is one documented case of intraspecific piracy in Ospreys (Forbes 1991).

Interspecific or intraspecific piracy was not recorded during this survey, although Torresian Crows *Corvus orru* often mobbed Ospreys with fish, but to no avail.

### Health of prey

No evidence was found during this study to suggest that Ospreys were taking contaminated or diseased fish. Autopsies carried out on Ospreys from the New South Wales north coast, during the early 1980s (NSW Department of Agriculture), indicated that the birds were contaminated with DDE and other organochlorines. There are insufficient data to determine the significance of this contamination and whether the situation has changed since the banning of these organochlorines, although it is likely that levels have been reduced. No significant difference was found in the thickness of Osprey eggshells collected in Australia pre and post DDT use (Olsen *et al.* 1993). Other pesticides and heavy metals may well have replaced organochlorines as potential contaminants of the Osprey's food.

Bilney and Emison (1983) reported that mullet, in the Gippsland Lakes of Victoria, have relatively high concentrations of mercury in their livers, particularly when the lakes are in flood. The reluctance of some Ospreys to eat the viscera of mullet may mean that the amount of mercury (or other heavy metals) ingested may be low. Discarding of the viscera may be to avoid poisoning by contaminants or the transmission of disease organisms.

### CONCLUSIONS

Like their breeding biology (Clancy, in press), the feeding behaviour of Ospreys in northern New South Wales resembles that of Northern Hemisphere birds. An understanding of the feeding behaviour of the species is

essential for the management and conservation of the species.

Understanding the relationship between the Osprey and its prey (fish) may allow the species to be used as a warning of ecosystem contamination. This is of particular importance to humans as the Osprey shares some of the same fish species that humans regularly consume, such as mullet and bream. Breeding male Ospreys were found to spend much time sitting (loafing, preening, etc.) but carried out virtually all the hunting for the female and young, as well as himself. Food was delivered by the male to the female who fed the young and ate a proportion herself. In about half of feeding events observed he ate part of the fish before delivering it to the female. The viscera of the prey are sometimes discarded, potentially reducing the transfer of contaminants and disease organisms from the fish prey. Hunting success and delivery rates of food to nests are comparable with other Australian and overseas studies and indicates that food is generally not scarce. This is supported by the good breeding success of Ospreys in the area (Clancy, in press). Scavenging is likely to occur occasionally when the river or estuary water is turbid, causing a low hunting success rate. Further data are needed to determine the frequency of this behaviour.

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### REFERENCES

- Bilney, R. J. and Emison, W. B. (1983). Breeding of the White-bellied Sea-Eagle in the Gippsland Lakes Region of Victoria, Australia. *Aust. Bird Watcher* **10**: 61-68.
- Clancy, G. P. (1980). 'North Coast Osprey Survey, 1980'. (National Parks & Wildlife Service: Grafton.) Unpublished report.
- Clancy, G. P. (1981). 'North Coast Osprey Survey, 1981'. (National Parks & Wildlife Service: Grafton.) Unpublished report.
- Clancy, G. P. (1989). A survey of breeding Ospreys *Pandion haliaetus* in north-eastern coastal New South Wales, 1980 to 1982. *Corella* **13**: 9-14.
- Clancy, G. P. (2005). The diet of the Osprey (*Pandion haliaetus*) on the north coast of New South Wales. *Emu* **105**: 87-91.
- Clancy, G. P. (in press). The breeding biology of the Osprey *Pandion haliaetus* on the north coast of New South Wales. *Corella*
- Cupper, J. and Cupper, L. (1981). 'Hawks in Focus'. (Jaclin Enterprises: Mildura.)
- Forbes, L. S. (1991). Intraspecific piracy in Ospreys. *Wilson Bull.* **103**: 111-112.
- Francour, P. and Thibault, J.-C. (1996). The diet of breeding Osprey *Pandion haliaetus* on Corsica: Exploitation of a Coastal Marine Environment. *Bird Study* **43**: 129-133.
- Grubb, T. G. Jr. (1977). Weather-dependent foraging in Ospreys. *Auk* **94**: 146-149.
- Hollands, D. (1984). 'Eagles, Hawks and Falcons of Australia'. (Nelson: Melbourne.)
- Kenward, R. E. (1990). Feeding habits. In 'Birds of Prey' (I. Newton, P. Olsen and T. Pyrzakowski) (Golden Press: Silverwater.)
- Lambert, G. (1943). Predation efficiency of the Osprey. *Canadian Field-Naturalist* **57**: 87-88.

- Maciejewski, S. (1993). 'The Foraging Habitat of the Osprey (*Pandion haliaetus cristatus*) in the Lower Richmond Estuary'. Integrated project. (University of New England — Northern Rivers: Lismore.)
- Marchant, S. and Higgins, P. J. (Eds). (1993). 'Handbook of Australian, New Zealand and Antarctic Birds. Volume 2: Raptors to Lapwings'. (Oxford University Press: Melbourne.)
- McLean, P. K. (1991). Feeding ecology of Chesapeake Bay Ospreys and growth and behaviour of their young. *Wilson Bull.* **103**(1): 105–111.
- Olsen, P., Fuller, F. and Marples, T. G. (1993). Pesticide-related eggshell thinning in Australian raptors. *Emu* **93**: 1–11.
- Olsen, P. D. (1995). 'Australian Birds of Prey'. (University of New South Wales Press: Sydney.)
- Poole, A. (1985). Courtship feeding and Osprey reproduction. *Auk* **102**: 479–492.
- Poole, A. (1989). 'Ospreys: A Natural and Unnatural History'. (Cambridge University Press: Cambridge, England.)
- Poole, A. F. (1994). Family Pandionidae (Osprey). In 'Handbook of the Birds of the World. Vol. 2 New World Vultures to Guineafowl'. (Eds J. del Hoyo, A. Elliott and J. Sargatal). (Lynx Edicions: Barcelona.)
- Rose, A. B. (2000). Observations on Ospreys *Pandion haliaetus* breeding on the lower north coast of New South Wales. *Aust. Bird Watcher* **18**: 274–279.
- Smith, G. C. (1985). An analysis of prey remnants from Osprey *Pandion haliaetus* and White-bellied Sea-Eagle *Haliaetus* (sic) *leucogaster* feeding roosts. *Emu* **85**: 198–200.
- Smith, J. I. D. (1992). 'The Feeding Ecology of Brahminy Kite *Haliastur indus* (Boddaert, 1783), from South-east Queensland'. B.Sc. (Hons) Thesis. University of Queensland: Brisbane. Unpubl.
- Stinson, C. H. (1977). Growth and behaviour of young Ospreys (*Pandion haliaetus*). *Oikos* **28**: 299–303.