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## CATTLE EGRET: SOUTH TO TASMANIA AND NEW ZEALAND FOR THE WINTER

By MAX MADDOCK

### ABSTRACT

The results of monitoring changes in Cattle Egret numbers in New Zealand and eastern Australia, recovery records for long-distance movements of marked birds from colonies in eastern Australia, and records for wing-tagged and colour-banded birds in the Hunter Valley of NSW indicate that a pattern of movement from the colonies occurs in waves in a south to south-easterly direction to Victoria, Tasmania and New Zealand during autumn and a return in spring. This movement can be described as migration. Although there is some circumstantial evidence, there is no confirmation that the same birds travel the same routes to the same destination each year. In the wintering areas they tend to restrict their activities to well-defined local territories. Significant numbers of birds remain in their natal area, however, where they may move relatively little, restricting foraging to a very limited local area for long periods, or be somewhat nomadic within a restricted region.

### INTRODUCTION

The remarkable expansion of the Cattle Egret *Bubulcus* (or *Ardeola*) *ibis* from its origins in Africa to its present range, including Asia, the Americas and Australasia, during the 20th century has been well documented (Blaker 1971, Siegfried 1978, Hemingway 1987). It has been suggested that this expansion has been facilitated by the birds' capacity to fly long distances and by the rapid development of grazing land, which provided habitat similar to the short grass margins of freshwater wetlands in Africa, where it associated with the Cape Buffalo (Siegfried 1978).

Asian Cattle Egrets *Bubulcus* (*Ardeola*) *ibis coromandus* effectively began to colonise Australia from about the 1940s (Morris 1970) and subsequently reached New Zealand in the 1960s (Turbott *et al.* 1963). Their annual arrival at breeding colonies and dispersion after breeding are little understood. Egrets have been banded at various breeding colonies in eastern Queensland and New South Wales since the early 1970s, and recoveries from these projects throw some light on the extent and timing of movements between breeding seasons.

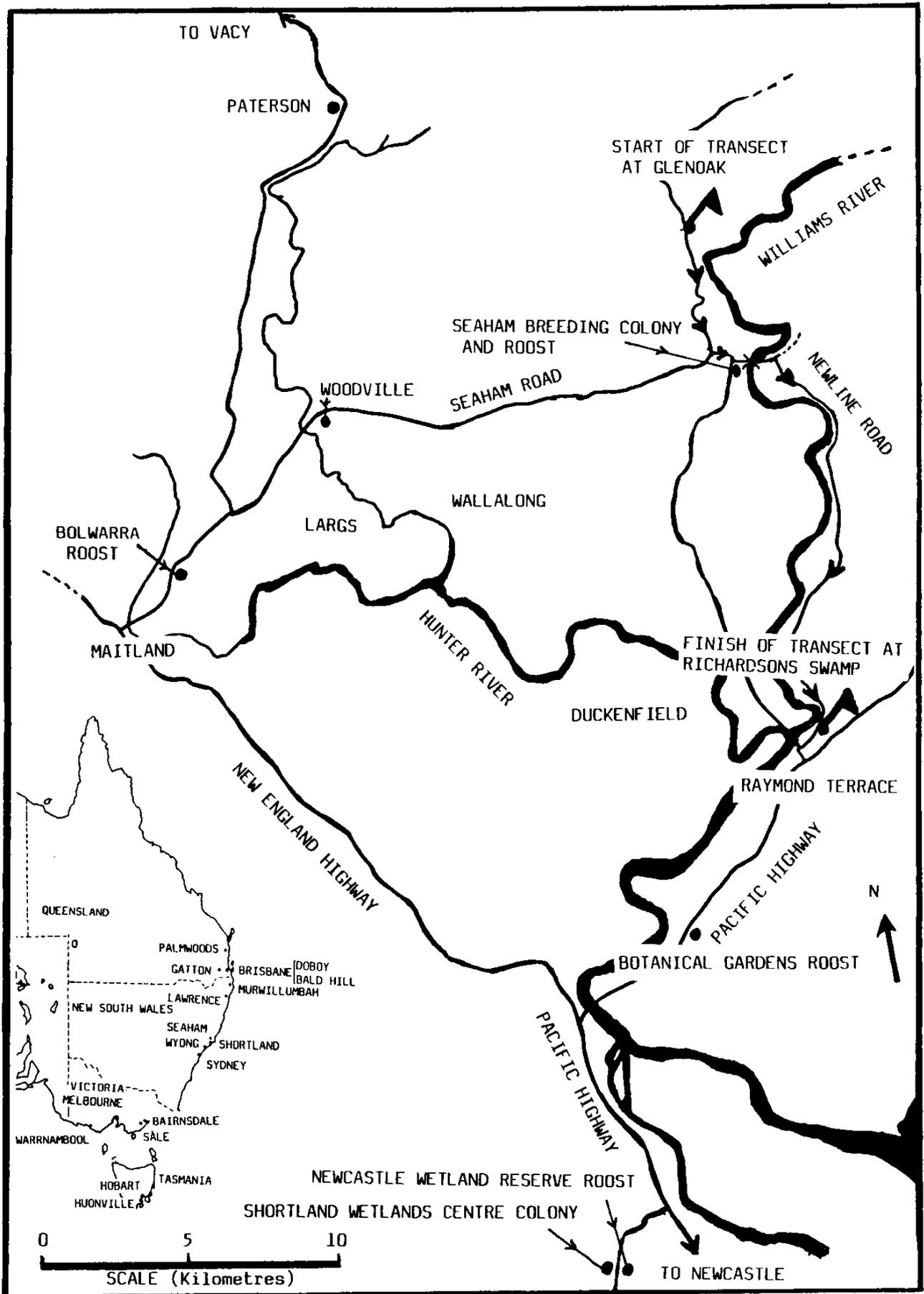


FIGURE 1 — Location maps: Hunter Valley, NSW, and insert showing other colonies and key recovery locations

This paper draws together results from published literature, the Hunter Wetlands Trust's Project Egret Watch, other Australian projects and New Zealand studies. It summarises what is known to date about the range extension of Cattle Egrets since their arrival in Australia and their annual movements and provides evidence that out-and-return migration takes place, although it cannot be confirmed that the same birds take the same routes to the same destination each year. Further lines of research are suggested.

## METHODS

Project Egret Watch, a Hunter Wetlands Trust research project into the breeding biology, ecology and migration of Cattle Egrets (and three other egret species), began marking Cattle Egrets with colour bands at the Shortland colony, Newcastle NSW, in the 1983-84 breeding season. This site is now called the Shortland Wetlands Centre (32°53'S, 151°42'E). Since the 1985-86 season the project has been attaching patagial tags to the wings of the egrets at both the Shortland colony and a colony at Seaham Swamp Nature Reserve on the Williams River, about 32 km north of the Shortland colony (32°43'S, 151°38'E) (Figure 1). In the 1988-89 season, a joint project with David Geering was launched to attach patagial tags at the Lawrence colony, near Grafton, northern NSW (29°30'S, 153°6'E).

The Cattle Egrets using the Newcastle Wetland Reserve evening roost site at Shortland, about 0.5 km from the Wetlands Centre breeding colony, were counted regularly during the winters of 1986 and 1987. From May 1987 to May 1988, I counted almost daily the numbers seen feeding along the 20 km stretch of road from my residence at Glenoak to Raymond Terrace, passing the Seaham breeding colony and evening roost (Figure 1). Numbers using the roost were counted at irregular intervals.

A network of observers in Queensland, NSW, Victoria, Tasmania, South Australia, and New Zealand has been recruited to Project Egret Watch to report fluctuations in numbers and movements of egret populations and to look out for marked birds. The numbers of egrets using winter evening roosts in the Lower Hunter Valley and along the 20 km stretch of road in the Williams River Valley have been counted regularly since 1986. In addition, Cattle Egrets have been studied by the Ornithological Society of New Zealand since 1977, co-ordinated by Barrie Heather, the results of which have been published in *Notornis* (Heather 1978, 1982, 1986, Morrison 1987, Jackson & Olsen 1988).

## TO NEW ZEALAND AND TASMANIA

Cattle Egrets were first recorded in New Zealand in 1963 (Turbott *et al.* 1963) and possibly earlier (Brown 1980). The subsequent seasonal appearance and disappearance of the birds have been fully recorded since 1977 (Heather 1978, 1982, 1986, Morrison 1987, Jackson & Olsen 1988). In Tasmania, after initially being recorded in 1965 (Thomas 1965), the occurrence has followed a very similar pattern. In New Zealand, most egrets generally arrive in April-May and depart in October-November. A few remain over summer but do not breed, although they may gain breeding colour (Heather 1978, 1982, 1986). From reports received from Project Egret Watch observers,

the situation in Tasmania is very similar. Banding recoveries and reports from Project Egret Watch observers in Victoria show that parts of Victoria also receive a winter influx. The Chalmers (1972) report on Cattle Egrets in Gippsland, Victoria, and reports from the Warrnambool (Victoria) district in 1987 produce a very similar picture to that in Tasmania and New Zealand.

The Tasmanian and New Zealand records mark a current Australasian endpoint to one of the most remarkable cases of range extension by a bird species on record. With their regular autumn appearances and summer disappearances, is the movement of Cattle Egrets to New Zealand and Tasmania for the Southern Hemisphere winter a genuine migration or simply long-distance "directional dispersal" as referred to by Siegfried (1978) for the African race of Cattle Egret (*B.i.ibis*)? Are the egrets going to New Zealand and Tasmania part of the same annual pattern or are they separate movements?

### Asia to Australia

The early history of the arrival of the Asian race of the Cattle Egret in Australia is obscure but the weight of evidence available points to immigration from Asia (Hewitt 1960). A few were imported from India and released in the Kimberleys (WA) in 1933 (Serventy & Whittell 1962). However, Hewitt (1960) gained tenuous evidence that they were in the Northern Territory before then, with a possible record as early as 1907, and stated that the balance appears to be strongly in favour of the immigrant theory. Their expansion can be related to the increase in availability of moist pastureland populated by livestock.

Siegfried (1965) maintained that long-distance dispersal probably was always a feature of Cattle Egret movement and that their establishment beyond Africa coincided with the development of water management schemes and livestock production elsewhere.

Jenkins & Ford (1960) reported an irruption of Cattle Egrets into south-west Western Australia in 1959. They were first recorded in Victoria in 1949, South Australia in 1964 (Morris 1979) and Tasmania in 1965 (Thomas 1965) and began breeding in Queensland in 1963 (Woodall 1986). Morris traced the spread in eastern Australia from 19 nesting pairs at Ulmarra Swamp near Grafton in 1954 to 2300 pairs breeding in five colonies in NSW by the 1978-79 breeding season.

Pratt (1979) reported a growth in numbers of Cattle Egrets at Murwillumbah (northern NSW) from 9 in September 1971 to the order of 30 in 1972-73, breeding starting in 1976 with about 60 nests. She reported that some 800 nests had been built in mid-November 1979.

Gilligan (1979) reported annual appearances of Cattle Egrets at Seaham Swamp Nature Reserve, on the floodplain of the Williams River, north of Newcastle, NSW, in late February and early March, but stated that until 1978 they departed by November, often in breeding plumage. Numbers were small before 1976, when there was an increase, with some staying till December. Breeding began in December 1978 with 42 nests. Breeding has continued since, 370 nests being counted in the 1986-87 season and 507 in 1987-88 by the Project Egret Watch team. Van Gessel & Kendall (1972)

reported the Cattle Egret as a casual visitor to Kooragang Island, east of Shortland, in the 1970s, a maximum of 19 having been recorded in February 1972. In February 1979, Newcastle naturalist Gary Weber reported a colony of 45 Cattle Egret nests in trees growing in water near Steelworks Golf Club at Shortland, about 32 km south of Seaham. He counted 84 pairs returning to nest in 1979-80 (G. Weber, pers. comm.). In the 1981-82 season, breeding began on the present Shortland Wetlands Centre site, about 0.5 km north of the golf club when 108 pairs bred in company with Great Egrets (*E. alba*), Intermediate Egrets (*E. intermedia*), Little Egrets (*E. garzetta*) and Little Pied Cormorants (*Phalacrocorax melanoleucos*) (total 348 nests). The Shortland colony has remained ever since, and 1393 Cattle Egret nests were counted in a total of over 2000 egret nests in the 1987-88 season (G. Baxter, pers. comm.).

In all these areas, the predominant habitat is flood plain pastureland with grazing domestic animals.

## RESULTS

### Analysis of movement from banding records

Egrets have been marked by the Australian Bird Banding Scheme (CSIRO and more recently National Parks and Wildlife Service) metal leg bands, colour banding systems and wing tags at up to nine breeding colonies in coastal Queensland and New South Wales since the late 1970s. Table 1 summarises long-distance recoveries of Cattle Egrets in their first year, some published, some unpublished and provided to me by banders at other colonies, and some my own records. Table 2 summarises similar records for second-year or older birds, and Table 3 collects together all the New Zealand recoveries.

Queensland birds banded as nestlings in the preceding December-January have been recorded in March-May in the Hunter Valley of NSW (1985, 1986, 1987), Victoria (1985), Tasmania (1984) and New Zealand (1983). Birds from northern NSW colonies have been recovered in March-May in the Hunter Valley (1985, 1987, 1989), central coastal NSW (1989), south coastal NSW (1981, 1983), Tasmania (1978, 1984, 1985), Victoria (1988, 1989) and New Zealand (1984, 1985). One first-year bird from Shortland (NSW) was seen in New Zealand in 1987. These were all birds that had travelled long distances (up to 2400 km) in the first 3 to 5 months of life.

Winter recoveries of first-year birds (June, July, August) from northern NSW and Queensland colonies have been made in the Hunter Valley, NSW (1985, 1986), south coastal NSW (1981, 1985), Victoria (1978, 1981, 1989), Tasmania (1979, 1982, 1985) and New Zealand (1983, 1985, 1988). Cattle Egrets from Shortland were located in Tasmania in June 1986 and in Victoria in June 1989.

Recoveries later than August have been recorded for a Gatton (Queensland) bird in Victoria in September 1980, a Murwillumbah (NSW) bird at Ocean Grove (Victoria), a Shortland bird at Sale (Victoria) in 1988 and a Lawrence (NSW) bird at Bairnsdale (Vic) in 1989.

TABLE 1 — Cattle Egret long-distance southward movement  
recovery/sighting: first-year birds

COLONY OF ORIGIN	LOCATION RECOVERY/SIGHTING	DATE/SEASON Banded	DATE RECOVERY/SIGHTING	DISTANCE FROM COLONY km	REFERENCE
Doboy (QLD)	Shortland (NSW)	84/85	09/04/85	617	ABBS 85
Near Brisbane (QLD)	Maffra (Vic)	24/12/81	12/06/82	1740	Corella 7(1)83 RR
Gatton (QLD)	Werribee (Vic)	14/12/80	08/09/81	1380	Corella Mar 82 RR
	Stewart Island (NZ)	22/12/82	09/06/83	2500	Corella 8(1)84 RR
	Geeveston (Tas)	22/12/82	27/06/83	1840	Corella 8(1)84 RR
	Shortland (NSW)	20/12/83	14/05/84	700	ABBS 85
	Liverpool (NSW)	27/12/83	23/06/84	920	Corella 9(1) 85 RR
	Lakes Entrance (Vic)	27/12/84	22/04/85	1219	ABBS 85
	Moruya (NSW)	27/12/84	13/07/85	955	ABBS 85
Bald Hill (QLD)	Oamaru (NZ)	20/12/82	18/07/83	2400	Corella 8(2)84 RR
Palmwoods (QLD)	Shortland (NSW)	16/01/85	17/04/85	700	ABBS 85
	Largs (NSW)	10/01/85	04/06/86	682	Corella 11(4)87 RR
Murwillumbah (NSW)	Stratford (Vic)	11/12/77	07/07/78	1250	PC (Willows)
	Lane Cove (NSW)	14/01/79	18/05/79	650	ABBS (Willows)
	Burnie (Tas)	14/01/79	18/08/79	1600	Corella Mar 80 RR
	Birregurra (Vic)	29/01/81	11/06/81	1450	PC (Willows)
	King Island (Tas)	04/02/82	20/06/82	1550	Corella 7(2)83 RR
	Simpson (Vic)	09/02/82	06/06/83	1550	ABBS Willows
	Ocean Grove (Vic)	31/12/82	10/11/83	1400	Corella 8(3)84 RR
	Seaham (NSW)	16/01/87	01/04/87	507	ABBS 85
Lawrence (NSW)	Nichols Rivulet (Tas)	17/12/83	18/03/84	1640	Corella 8(4)84 RR
	Te Horo (NZ)	17/12/83	23/04/84 o	2400	Corella 8(3)84 RR
	Waitotara (NZ)	17/12/83	30/04/84	2300	Corella 8(3)84 RR
	SS Flinders Range 60 miles at sea - (South Tas)	31/12/84	25/03/85	1607	ABBS 85
	Shortland (NSW)	84/85	12/04/85	398	ABBS 85
	Levin (NZ)	84/85	26/05/85 o	2356	ABBS 85
	Richmond (Tas)	84/85	06/06/85	1554	ABBS 85
	Millers Forest (NSW)	84/85	13/07/85	385	ABBS 85
	Crookhaven Hds (NSW)	24/12/84	14/07/87	636	ABBS Lane
	Wilson's Prom Light Stn	17/12/87	24/04/88	1232	PC (Geering)
	East Lumsden (NZ)	04/01/88	18/05/88	2245	PC (Geering)
	Bolwarra (NSW)	23/12/88	22/03/89 o	387	EW
	Bolwarra (NSW)	21/12/88	29/03/89 o	387	EW
	Bolwarra (NSW)	07/01/88	23/03/89 o	387	EW
	Wyong (NSW)	05/01/88	23/04/89 o	413	EW
	Bolwarra (NSW)	05/01/88	23/04/89 o	387	EW
	Wyong (NSW)	21/12/88	26/04/89 o	413	EW
	Bolwarra (NSW)	21/12/88	27/04/89 o	387	EW
	East Seaham (NSW)	07/01/88	03/05/89 o	377	EW
	Bairnsdale (Vic)	05/01/89	01/06/89 o	1080	EW
	Bairnsdale (Vic)	23/12/88	20/06/89 o	1080	EW
	Bairnsdale (Vic)	21/12/88	27/07/89 o	1080	EW
Grafton (NSW)	Granton (Tas)	10/01/78	27/03/78	1550	ABBS (Willows)
	Wallacia (NSW)	07/78	29/12/77	510	ABBS (Willows)
	Taharoa Beach (NZ)	24/12/79	04/05/80	2128	ABBS (Willows)
	Berry (NSW)	19/12/80	19/05/81	620	Corella Mar 82 RR
	Kangaroo Valley (NSW)	16/12/82	10/03/83	600	Corella 8(1)84 RR
Shortland (NSW)	Huonville (Tas)	01/02/86	22/06/86	1199	Corella 11(1)87 RR
	Lake Ellesmere (NZ)	22/01/87	25/05/87 •	2181	ABBS
			26/05/87 *		
	Sale (Vic)	14/12/87	23/10/88	737	ABBS
	Geelong (Vic)	10/01/89	17/06/89	850	ABBS

RR - Recovery Roundup

ABBS 85 - Australian Bird Banding Scheme (1985)

ABBS - Australian Bird Banding Scheme notification of sighting to banders and observers

PC - Personal communication bander to author

EW - Project Egret Watch Observer

• Same bird Shortland No.1/4/80

o Subsequently seen on number of occasions during winter same general location

TABLE 2 — Cattle Egret long-distance southward movement  
recovery/sighting: second-year or older birds

COLONY OF ORIGIN	LOCATION RECOVERY/SIGHTING	DATE/SEASON BANDING	DATE RECOVERY/SIGHTING	DISTANCE FROM COLONY km	REFERENCE
Doboy (QLD)	Shortland (NSW)	12/82	29/03/85*	617	ABBS
	Shortland (NSW)	12/82	21/07/85*	617	ABBS
	Shortland (NSW)	12/82	31/10/87*	617	ABBS
	Mt Compass (SA)	19/12/82	23/07/85+	1628	Corella 10(1)86 RR
	Shortland (NSW)	10/12/80	20/11/85+	617	ABBS 85
	Seaham (NSW)	12/82	20/12/86+	593	ABBS
	Moruya (NSW)	83	12/07/87+	981	ABBS 85
	Mandalong (NSW)	80/81	14/07/89+	660	EW
Cotton (QLD)	Shortland (NSW)	83/84	11/04/85+	598	ABBS (TO AUTHOR)
	Seaham (NSW)	27/12/83	28/08/86+	566	Corella 11(2)87 RR
	Shortland (NSW)	83/84	30/04/85+	598	ABBS
	Seaham (NSW)	20/12/83	21/12/86+	700	ABBS
	Moruya (NSW)	03/01/83	12/07/87+	955	ABBS
Palmwoods (QLD)	Shortland (NSW)	10/01/83	11/04/85+	566	ABBS (TO AUTHOR)
Murwillumbah (NSW)	Simpson (Vic)	09/02/82	06/06/83	1500	Corella 8(2)84 RR
	Lorn (NSW)	19/12/79	13/08/85+	376	ABBS 85
	Largs (NSW)	80/81	29/06/86+	513	ABBS (TO AUTHOR)
Grafton (NSW)	Bombala (NSW)	14/12/77	29/07/79	900	Corella Mar 80 RR
	Warrnambool (Vic)	29/12/77	15/08/79	1390	ABBS Willows
	Newcastle (NSW)	14/12/77	03/08/80	400	Corella 5(1)81 RR
	Apsley (Vic)	19/12/80	19/04/82	1400	Corella 7(1)83 RR
Shortland (NSW)	Lake Ellesmere (NZ) o	22/01/87	27/03/88+ 19/04/88+ 09/08/88	2181	ABBS (TO AUTHOR)

RR - Recovery Roundup

ABBS 85 - Australian Bird Banding Scheme (1985)

ABBS - Australian Bird Banding Scheme notification to banders and observers.

EW - Project Egret Watch Observer

\* Probably the same bird, live sighting

+ Live sighting

o Same bird as in Table 1.

Second-year or older birds recovered have been mainly from northern NSW and Queensland colonies. These were in March to May in the Hunter Valley (3 in 1985) and Victoria (1982). June-July-August recoveries were in the Hunter Valley (1980, 1985, 1986 and 1989), south coastal NSW (1987) and Victoria (1979, 1983). The one exception was a Shortland bird seen in New Zealand in March and April 1988 and recovered, dead, at the same locality in August 1988. This same Shortland bird had been seen twice as a first-year bird at the same locality near Christchurch in May 1987. As there were no sightings reported in the interim between May 1987 and March 1988, it is not known whether the bird returned to Australia or remained in New Zealand.

Most Australian sightings later than August have been in the Hunter Valley (1985, 1986, 1987, 1989). The exceptions are that of a colour-banded Shortland bird seen twice near Sale in Victoria in early September 1988

TABLE 3 — Movements Australia — New Zealand recovery/sighting

COLONY OF ORIGIN	LOCATION NEW ZEALAND	DATE/SEASON BANDED	DATE SIGHTED/RECOVERED	AGE OF BIRD	DISTANCE km	REFERENCE
Bald Hills (QLD)	Oamaru	20/12/82	18/07/83	1	2400	Corella 8(2)84 RR
Gatton (QLD)	Stewart Island	22/12/82	09/06/83	1	2500	Corella 8(1)84 RR
Lawrence (NSW)	Te Horo	17/12/83	23/04/84	1	2400	Corella 8(3)84 RR
	Waitotara	17/12/83	30/04/84	1	2300	Corella 8(3)84 RR
	Levin	84/85	26/05/85	1	2356	ABBS
	East Lumsden	04/01/88	18/05/88	1	2245	PC (Geering)
Grafton (NSW)	Taharoa Beach	24/12/79	04/05/80	1	2128	PC (Willows)
Shortland (NSW)	Lake Ellesmere	22/01/87	25/05/87 *	1	2181	ABBS
			26/05/87 *	1		
			27/03/88 •	2	2170	
			19/04/88 •	2		
			09/08/88 +	2		

ABBS - Australian Bird Banding Scheme notification to banders and observers

RR - Recovery Roundup

PC - Personal communication Bander to Author

• Same bird: live sighting

+ Found dead.

o Sighted regularly until November

(R. Chatto, pers. comm.) and a wing-tagged Shortland bird at Sale in Victoria in October 1988. The colour-banded bird could only have been a Shortland bird by the band configuration, but its age is not known because the season colour was either missing or obscured. It is not included in Table 1 or Table 2.

Jackson & Olsen (1988) reported regular winter sightings of a bird carrying the Lawrence colony colour-band pattern and another bird carrying a single orange band in New Zealand's Horowhenua up to November of 1985 and 1986. A bird carrying a single orange band was again sighted up till November 1987 (W.R. Jackson, pers. comm. to B.D. Heather).

The latest date of sighting was 20–21 December 1986 of two Queensland birds at Seaham, but these birds were almost certainly present for only a few days. The Dobby bird seen at Shortland on 31 October 1987 (see Table 2) was in breeding colour but, although in a part of the breeding colony under intense observation, it was not seen again. It had been seen previously in the Shortland district in March and July 1985.

The Gatton (Queensland) Cattle Egret tagged by Neil McKilligan in December 1983 and seen at Shortland in May 1984 (see Table 1) was seen again by McKilligan (pers. comm.) at the Gatton colony in November 1984. The Shortland Cattle Egret located at Sale in Victoria in October 1988 was seen again at the Seaham colony and in the surrounding district between December 1988 and March 1989. These are the only records known to me of egrets recorded back at the natal colony area after having been seen in the field more than 300 km south of their place of banding.

Records of strong northward movements from the breeding colonies have been few. The longest was by a member of the 1986 Shortland cohort, of which one went to Tasmania in 1986. It was banded in January and found dead at Macksville, northern NSW, in June 1986, 271 km NNE from Shortland. This is the only northern recovery of a Shortland bird. A Seaham bird banded in November 1988 was seen alive at Cundletown near Taree (northern NSW) (103 km N) in February 1989 (D. Geering, pers. comm.).

A Cattle Egret banded at Grafton (NSW) in February 1976 was recovered at Samford (Queensland) in July 1983 (240 km north, Australian Banding Scheme, J. Willows). Another bird banded at Grafton in February 1976 was recovered at the Tweed River on the Queensland border in September 1978 (Australian Banding Scheme, J. Willows), a movement of only 152 km.

### **Number fluctuations: Lower Hunter (NSW)**

Fluctuating numbers at observation points in the Lower Hunter suggest a pattern of arrivals and departures, particularly in autumn after the breeding season and again in spring before the breeding season. The numbers at the Newcastle Wetland Reserve (Shortland) roost and along the Glenoak-Raymond Terrace road transect (Figures 2,3) gave closely similar patterns of peaks and lows in both years.

Along the road transect (Figure 3), I had seen large numbers before I began definitive counts at the end of May 1987.

The small numbers from the end of October towards the end of January 1988 coincided with the breeding season at the Seaham colony. The build-up in late January matched the beginning of movement of fledged young birds from the colony to foraging areas in company with parents.

A decline followed from mid-February to mid-March, and then another population peak occurred on the transect to 800 birds during early April, followed by a significant drop to fewer than 200. The missing birds may have set off for New Zealand, Tasmania or Victoria but confirmation of this hypothesis would require subsequent sightings of marked birds.

At the Shortland roost (Figure 2), numbers were high in March and early April 1986 (over 500). No counts were made between 7 April and 23 May, but it was obvious that numbers had dropped and when counted only 200 were present. This fell to fewer than 100 on 31 May. A further five influxes and declines occurred during June, reaching a maximum of 180 on 18 June. During July and August, and into September, numbers were again around 200. At the end of September numbers again increased to about 300.

During winter 1987 a similar pattern of fluctuations was recorded at Shortland (Figure 2), although total numbers were much larger, with troughs in April, June and early July and increases in mid-May, the end of June, mid-July and early September. Two further declines and peaks occurred during September, followed by an increase by mid-October.

The breeding season began at Shortland in early November, with more than 1300 Cattle Egret nests, over double the total number of egret nests of all four species the previous season.

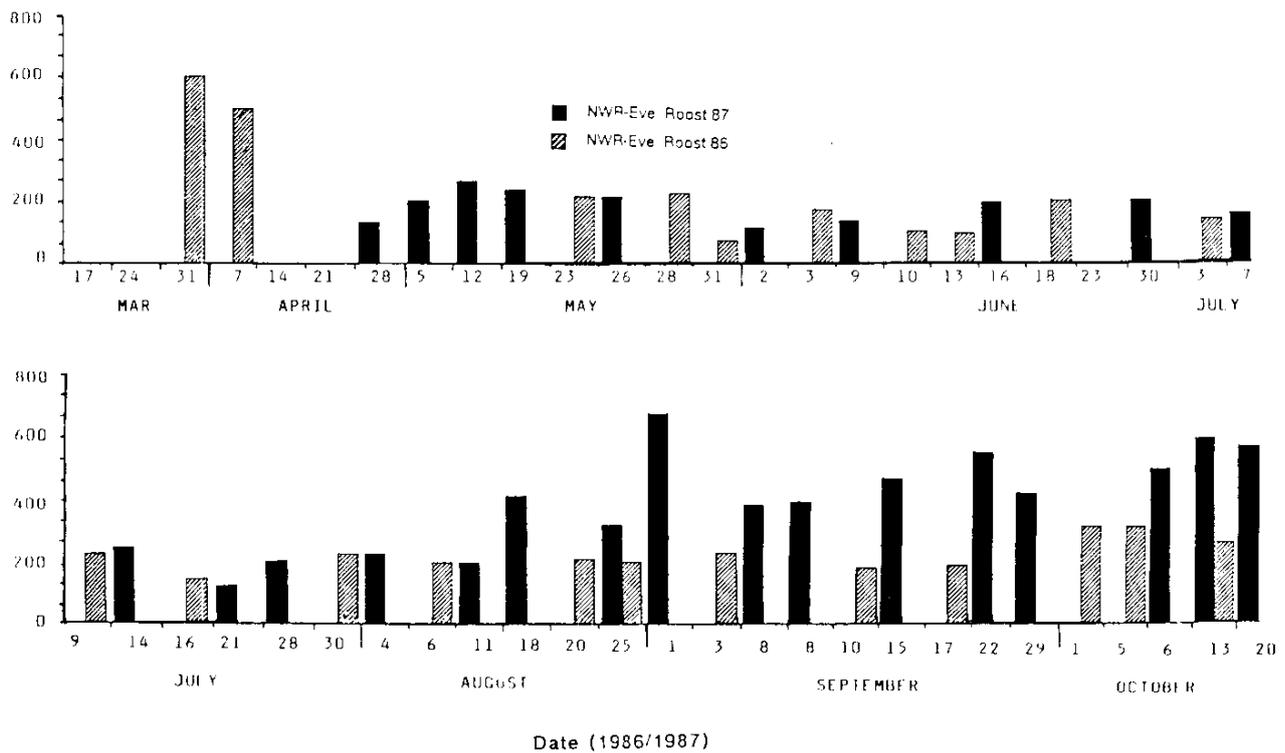


FIGURE 2 — Numbers of Cattle Egrets using Newcastle Wetland Reserve (Shortland) evening roost — winter 1986 and 1987

The Shortland roost could not be monitored regularly in 1988, but nevertheless significant fluctuations were recorded, consistent with previous records. On 20 April 1988, 750 Cattle Egrets were present, but on 5 May only 227 used the roost.

At the conclusion of each breeding season, a temporary roost forms at Richardson's Swamp at the southern end of the road transect referred to earlier, near Raymond Terrace (Figure 1). The number of birds using this roost in 1987 increased until 14 May, when more than 700 birds were present. Just on dusk that evening, the whole flock took off and headed south into the darkness. More birds arrived at the roost after their departure, and it is not known whether any of these were returning birds from the flock which had taken off, but when the roost settled, only 250 were present. Hence at least 450 birds had left the roost. On the evening of 28 May only 35 birds were present and these took off at dark and headed south, leaving the roost empty, not to be reoccupied until the end of the 1988 breeding season.

In company with the Secretary of the Hunter Wetlands Trust, Glenn Albrecht, I had previously observed a southerly directed departure at dark, at the Newcastle Wetland Reserve in the autumn of 1985, when about 200 birds departed, leaving the roost depleted in numbers on subsequent evenings.

In 1988, numbers at the Richardson's Swamp roost increased from 22 February to 1 March (at a time when only 150 birds, mainly fledglings, were still at the Seaham breeding site out of the more than 1000 adults and about 2600 young produced at the colony during the breeding season), then

declined, followed by an increase to more than 800 on 6 April, corresponding with a population increase along the transect (Figure 3). On 28 April, only 90 were present at Richardsons, and on 2 May the roost was empty and remained empty thereafter, while numbers along the transect were down. The pattern of roost occupation is summarised in Figure 4.

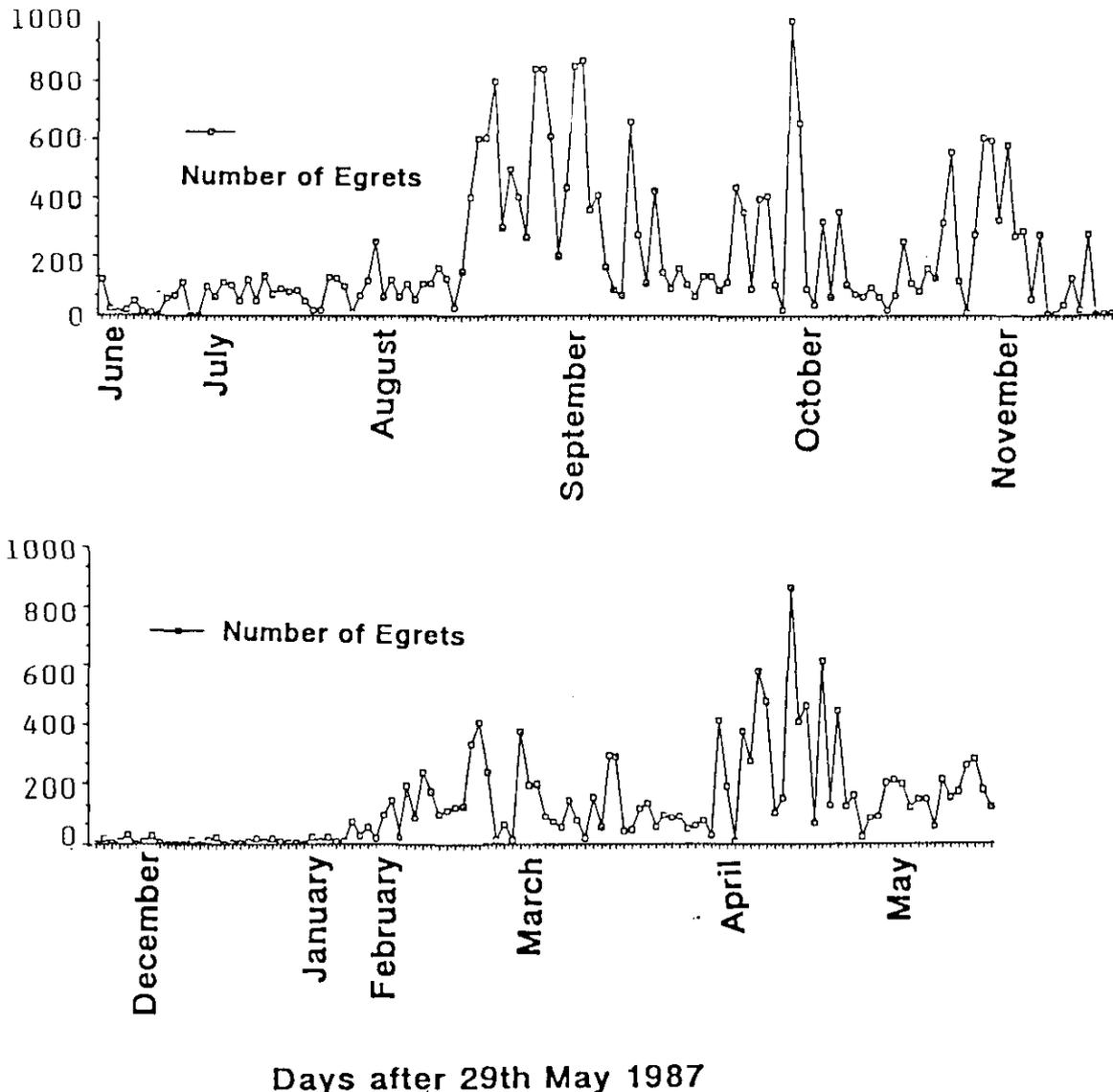


FIGURE 3 —Numbers of Cattle Egrets counted along Glenoak-Raymond Terrace transect between end of May 1987 and end of May 1988

A temporary roost of 20 Cattle Egrets became established at the Hunter Botanical Gardens, about half-way between Richardson's Swamp and Shortland, on 22 March 1988 (see Figure 1). Numbers, although not counted, had obviously increased significantly on 6 April. Next evening the roost was empty and remained unoccupied for the rest of the winter.

The Seaham evening roost forms each year after the breeding season. The birds usually use the breeding colony area for some time after nesting finishes and then shift to a grove of trees near the eastern shore of the swamp, close to the bank of the Williams River. This roost has been regularly

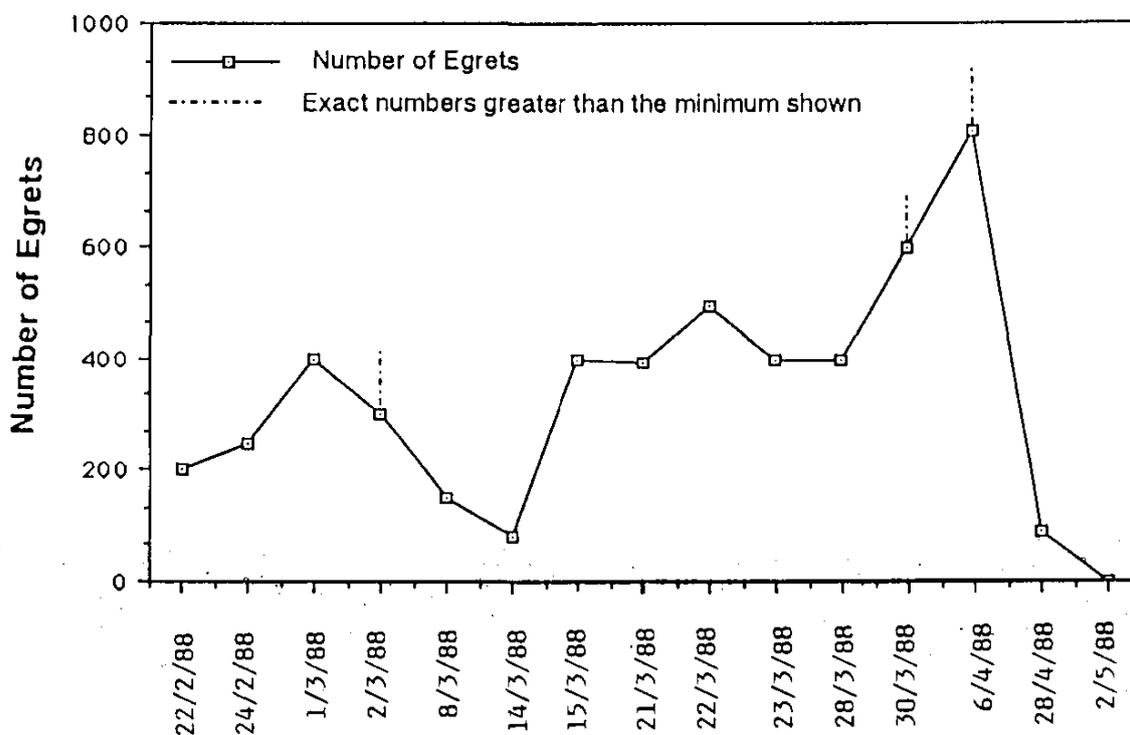


FIGURE 4 —Numbers of Cattle Egrets using Richardson's Swamp evening roost February–May 1988

monitored over three seasons, although the birds have been counted only intermittently. A similar pattern of significant fluctuations has been noted to that identified at Shortland. From 5 April 1987, when 235 were present, the number had built up to about 500 on 25 April. On 26 April the roost was empty, and it was not occupied again until 6 August, coinciding with the beginning of the marked increase of birds using the transect (Figure 3) and the increase in birds using the Shortland roost (Figure 2).

### Monitoring egrets after tagging

The peaks in numbers between the end of the breeding season and mid-winter, linked with the pattern of recoveries and sightings of colour-banded and tagged birds from northern colonies, indicate that large numbers of birds, both adults and fledglings, leave their home colonies and travel south soon after the young become independent and are followed by other successive waves of birds throughout the autumn. Cattle Egrets from colonies in northern NSW and Queensland arrive in the Lower Hunter Valley and join up with local birds at the established Seaham and Shortland roosts as well as at a temporary roost at Richardson's Swamp, using the pasture areas around them for foraging.

It is known that other roosts often form in the region during the winter (for example, at Morpeth, Woodville and Bolwarra near Maitland, at Millers Forest and Paterson). Counts undertaken in winter 1989 suggest that similar

events occur in these roosts. The presence of five wing-tagged Lawrence birds at the Bolwarra roost near Maitland during March and April 1989 before disappearing adds support.

Counts and observations of tagged birds indicate that some birds remain for a period of weeks before departing again in a southerly direction, probably in company with birds from Seaham and Shortland. Although not the same birds sighted in the Hunter, two Lawrence birds were seen in company with two Shortland birds at Wyong on the central coast of NSW from April to June 1989 and three Lawrence birds spent June and July at Bairnsdale, Victoria, one still being present in September. Three observations showed that the onward movements can take place at night. On the other hand, some marked Seaham and Shortland birds have remained in the natal district during winter.

Throughout the 1986–87 and 1987–88 breeding seasons, daily checks of the colony were made and the progress of wing-tagged birds was noted from date of banding until the colony became empty. I searched for tagged birds along the road transect, referred to earlier (see Figure 1), throughout the year, while Project Egret Watch observers Ian Harvey, Margaret Harvey, and Neville Foster did so between Raymond Terrace and Maitland, the adjacent area used by foraging Cattle Egrets. Table 4 summarises the maximum number of tagged birds in each season for each 7-day period between the date of tagging as nestlings and the end of March.

In 1986–87, only half the number of tagged birds were still in the colony 3 weeks after the tagging session, and only one tagged bird could be found by the end of week 7. Only two tagged birds had died in the colony. In 1987–88 the pattern was similar after two tagging sessions. Only about 25% remained in week 5 after the first session. After the second session in early February a similar fall-off occurred, only 5% of all tagged birds being located at the end of March, when most of the fledglings and adults had left the colony.

We have evidence of some mixing of Seaham and Shortland birds after the breeding season, before they depart. In the breeding seasons since wing-tagging began in 1985–86, Seaham birds have been seen at Shortland. In 1986, a chick tagged at Seaham on 18 January and still in the colony on 28 January was sighted at the Shortland breeding colony on 30 January. In 1986–87 and 1987–88, a Seaham tagged bird was seen with Shortland birds at the Shortland roost in March and April. Both Shortland and Seaham tagged birds have been seen together in the temporary evening roost at Richardson's Swamp (see Figure 1) in March.

At Shortland in 1987, eight tagged birds were still present in March and five in mid-April. Throughout the winter, only two tagged birds were seen, both regularly. In 1986, only three tagged birds were using the roost in March. One of these (Shortland No. 28) was still there on 14 April but it was seen at Huonville, Tasmania, on 20 June.

Colour-banded and wing-tagged birds from Queensland and northern NSW have been seen regularly in the Lower Hunter since observations started in 1984. Most of these have been made in the autumn (see Tables 1 and 2). Northern birds and colour-banded Shortland birds were observed together in the Shortland roost during autumn in 1984 and 1985 and disappeared together as the winter approached.

TABLE 4 — Monitoring of tagged Cattle Egrets, Seaham 1986–87, 1987–88

Week		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Days End		Dec			Jan				Feb				Mar				
		15	22	29	5	12	19	26	2	9	16	23	2	9	16	23	30
86-87	Tag session			1													
	No tagged			34													
	Max. no. Seen elsewhere				20	14	17	13	9	2	1		1		1		2
86-87	Tag session	1						2									
	No Tagged	38						15									
	Session 1		19	14	10	14	11	12	2				3	2	2	2	1
	Seen elsewhere								5	7	6	3	4	2	4	2	1
	Max. Session 2													1	1		
	Seen elsewhere													3			2
	Total	38	19	14	10	14	11	27	7	7	6	3	10	5	7	6	2

A tagged bird from Murwillumbah in northern NSW was seen on two occasions in the Seaham evening roost and once feeding in pasture with a flock of Cattle Egrets on the road transect just south of Seaham, in early April 1986. It was not seen again, despite regular searches.

A colour-banded bird from Doboy in Queensland, recognisable by the back toe being caught up in the lower colour band, was seen twice at Shortland in March 1985 and again in July 1985 feeding with other egrets at Wallsend, about 6 km north of the Shortland evening roost. One bird from Palmwoods in Queensland and another from Murwillumbah (northern NSW) were observed near Maitland, about 20 km west of Seaham in June 1986. Thirteen Cattle Egrets tagged as nestlings at Lawrence during the 1988–89 breeding season have been seen near Maitland and in the Seaham area in the Lower Hunter during winter 1989. The first three arrived during March, two more arrived in April, and a further two in May. Five more were first located in June and another in July.

#### Tagged birds returning to breeding colony

Detailed records are available for 25 birds which were tagged as nestlings at Seaham and Shortland during the 1986–87 breeding season and returned to the colonies in 1987–88, 14 of which also returned for the 1988–89 season. Table 5 shows the presence or absence of these birds at the breeding colonies, evening roosts, or foraging areas on a monthly basis. Eight were not recorded in the district after the end of January 1987 and a further 8 were missing after the end of February. On 26 April 1987, the last of the Seaham birds (No. 104) departed with the Seaham roost flock. By this date only one of the 11 Shortland birds remained. Shortland No. 107 was seen in the Shortland evening roost during the period May to October, gaining breeding colour during October. Seaham No. 46 was seen in pastures about 4 km north of Seaham during June and July, but was not seen after that.



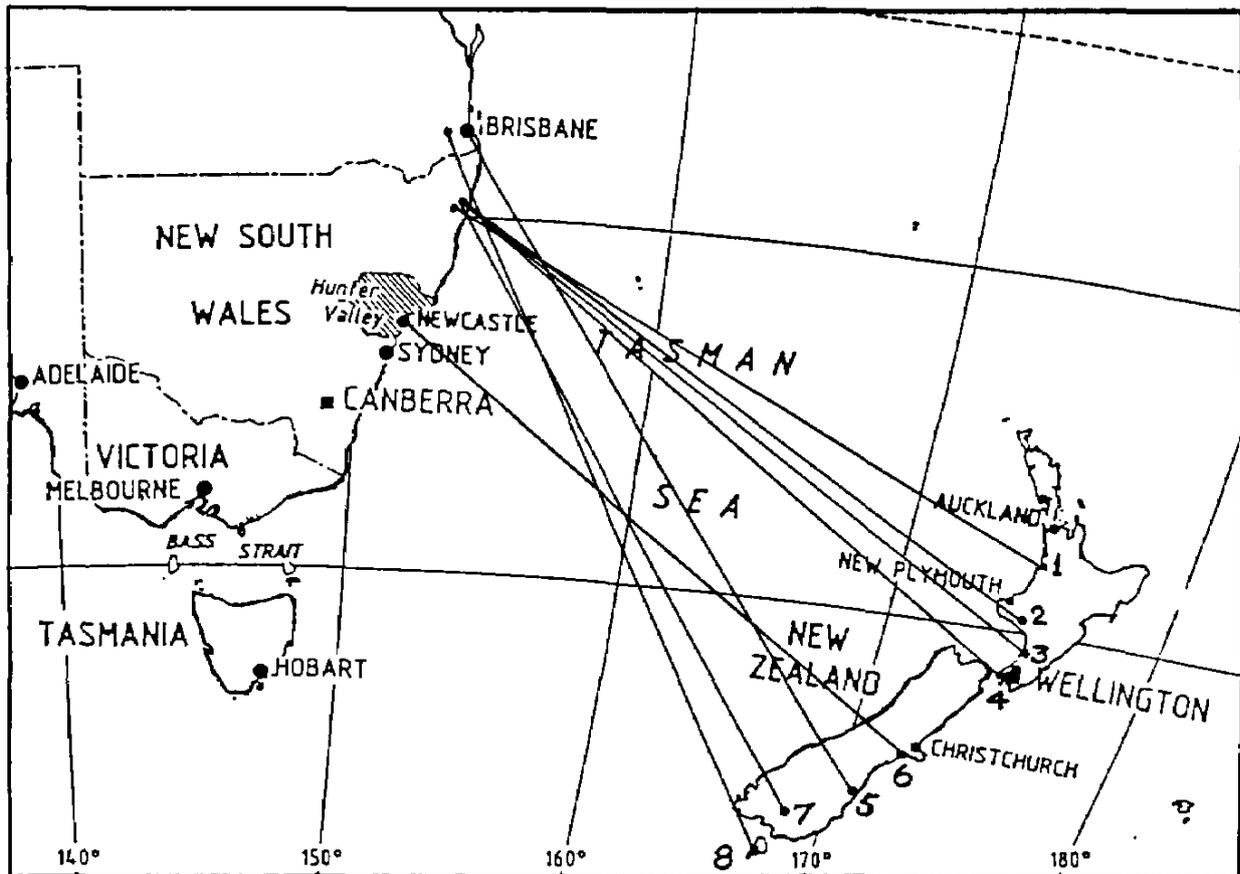


FIGURE 5 —Direct flight lines from Australian colonies to New Zealand recovery sites.

- |                     |                                       |
|---------------------|---------------------------------------|
| 1. Grafton (NSW)    | — Taharoa Beach May 1980              |
| 2. Lawrence (NSW)   | — Waitotara April 1984                |
| 3.* Lawrence (NSW)  | — Levin May 1985                      |
| 4.* Lawrence (NSW)  | — Te Horo April 1984                  |
| 5. Bald Hills (Qld) | — Oamaru July 1983                    |
| 6.+ Shortland (NSW) | — Lake Ellesmere May 1987, April 1988 |
| 7. Lawrence (NSW)   | — Lumsden May 1988                    |
| 8. Gatton (Qld)     | — Stewart Island June 1983            |

\* Seen regularly up til November

+ Found dead same area August 1988

No. 29. Shortland 33 and Shortland 38 were not seen in the winters of 1986 and 1987, but were found in the breeding colony during each breeding season. No. 38 returned for the 1988–89 season after having been missing for the 1988 winter. No. 36 was located at Shortland and nearby foraging areas during both the 1986 and 1987 winters and was seen in the breeding colony as a 1-year-old bird in 1986–87 and near the colony at the beginning of the 1987–88 season.

Seaham No. 29 was missing for the 1986, 1987 and 1988 winters, but was back in the Seaham colony for the three breeding seasons, while No. 4 was not seen at all during 1986 and 1987, was found in the colony during the 1987–88 breeding season, and arrived in October to nest at Seaham during the 1988–89 season.

Fifteen birds tagged as nestlings during the 1987–88 breeding season were absent for the winter of 1988 but returned to the breeding colony as 1-year-olds in November 1988.

### **Flock cohesion and specific locality faithfulness**

The New Zealand studies by Heather (1978, 1982, 1986) and by Jackson & Olsen (1988) have shown that Cattle Egrets return to highly specific localities each year and the apparent cohesion of specific flocks is further supported by some observations of marked birds. In April 1984 a Lawrence (NSW) bird, banded by S.G. Lane as a nestling in December 1983, which had been recovered in a poor state at Te Horo, west Wellington, rehabilitated and released stained yellow with picric acid, remained with the Cattle Egret flock near Levin for the winter (Heather 1986).

Jackson & Olsen (1988) mentioned two colour-banded birds at Lake Horowhenua (Manawatu) in May 1985, one of which could be identified as a 6-month-old bird from Lawrence (NSW). The origin of the other could not be identified as it had only one orange colour band. They also stated that "the two colour-banded birds seen in 1985 had returned". An egret carrying an orange band (presumed to be the same bird) was also seen in the same area in the winters of 1986 and 1987 (W.R. Jackson, pers. comm. to B.D. Heather).

Although it is reasonable speculation that the same birds had returned, the number on the metal band would be needed to confirm such a conclusion. The colour-banding system used at Lawrence and all colonies where colour-banding has been done, except Shortland, has a colony colour on the left tarsus, a season colour on the left tibia, and the metal Australian Banding Scheme band on the right tarsus. Therefore, the best that can be said is that at least birds from the same colony had returned. Nevertheless, the reappearance of two birds carrying identical colour patterns to the two seen the previous year is highly coincidental.

The history of Shortland No. 80 in New Zealand is associated with a highly localised area. The bird was seen on two occasions near Lake Ellesmere (near Christchurch) in late May 1987, seen again in the same area in March and April 1988 and found dead in the same area in August 1988.

Project Egret Watch observers in the central coast region of NSW, Victoria and Tasmania have also reported the arrival of flocks in the same locations each year. These observers, together with observers in the Hunter Valley, northern NSW and Queensland, where Cattle Egrets can be found throughout the year, also report the long-term use of restricted areas by what appears to be the same group of birds. During winter 1989, two Shortland and one Lawrence Cattle Egret were frequently seen in a very localised area of Wyong NSW (D. Rogers, pers. comm.), while three Lawrence birds were seen regularly at the same locations in Bairnsdale, Victoria (L. Turner, J. Reside, G. Wilson, pers. comm.).

The long-term records from observers of birds wing-tagged by Project Egret Watch in the Hunter Valley give clear evidence of the faithfulness of some birds to a highly specific locality and also suggest flock cohesion. A Shortland bird, not listed in Table 1 because the movement recorded was a short one (less than 350 km), was reported as spending some weeks in June-July 1986 in a paddock with a house cow at Kulnura, 59 km south of the colony where it had been tagged (R. Collins, pers. comm.). Kulnura

is about half way between Newcastle and Sydney. The Palmwoods bird recorded at Largs (near Maitland) NSW (see Table 1) was seen on a number of occasions in the same area during June 1985 in a flock of relatively consistent size (M. Lambert, N. Walker, pers. comm.).

Shortland No. 36 was seen 42 times between March 1986 and November 1988 within 4 km of Shortland. Of these, 5 were at the Newcastle Wetland Reserve between 3 July 1986 and 13 October 1986, 5 were in the Shortland breeding colony during the 1985-86 breeding season, 20 were at the Shortland evening roost between 17 March 1987 and 22 September 1987 and 1 was less than a kilometre north of the evening roost on 18 June 1986. The egret was in a small paddock in company with horses and a small group of other egrets, at Jesmond, about 4 km south-west of the evening roost between 4 July 1987 and 1 September 1987, 3 of these sightings being made on consecutive days by different observers.

Seaham No. 104 was seen on more than 200 occasions between tagging date 27 February 1987 and 11 September 1989. All except two sightings were made in the Seaham evening roost, in the Seaham breeding colony, or in pastures within 4 km of the roost. Ninety-five percent of the sightings were made at only seven foraging locations within 2 km direct flying distance north of the roost, usually with a flock containing about the same number of birds.

Shortland No. 107, tagged in January 1987, was seen frequently at the Shortland evening roost during winter 1987 and at a single foraging site about 6 km south-west of the roost. During the winter of 1988 it was again observed in the evening roost, at the same south-western foraging location and once only at a foraging site 6 km south of the roost.

On the other hand, evidence collected on the movement of Seaham No. 208, tagged as a nestling in the 1988-89 season, indicates that at least some birds which remain in the Lower Hunter are somewhat nomadic within the region. It moved from the Seaham district, where it spent January and February, to Duckenfield, 9 km south-west, where it was seen on 27 February and 1 March. It was seen at Bolwarra roost, about 14 km further west on five occasions between 22 March and 29 March before moving about 20 km north to near Vacy, where it was seen on 16 July. It then moved 17 km south-east to the evening roost at Woodville where it was located on 27 August. It was subsequently seen several times there and foraging at nearby Wallalong and Largs until 9 September.

## DISCUSSION

### **Seasonal movement**

After the Cattle Egret became established in the breeding colony at Ulmarra NSW in 1954, numbers expanded rapidly. Breeding began in south-east Queensland in 1963 (Woodall 1986), with the Gatton colony forming in 1974 (McKilligan 1984). The Murwillumbah breeding colony was established in 1976 (Pratt 1979).

Appearances in autumn and disappearances in spring began to be noted in Tasmania, Victoria and New Zealand, and seasonal movements were well

established by the mid-1970s. Breeding in the Hunter Valley was preceded by regular winter visitations, the egrets departing later into early summer in the two seasons leading up to the start of breeding (Gilligan 1979).

Recoveries from all nine colonies where egrets have been banded provide evidence of long-distance movements of 377-2500 km in a general southerly to south-easterly direction after the breeding season. Few northerly movements have been recorded by comparison, only three of them more than 150 km and the longest of 271 km.

Gatton (Q), Bald Hill (Q), Lawrence (northern NSW) and Shortland (NSW) have all produced birds recovered in New Zealand, and Gatton, Murwillumbah (northern NSW), Lawrence and Shortland have all produced birds recovered in both Victoria and Tasmania. All except one New Zealand and one Victorian recovery have been of birds in their first year of life.

The only recovery of a bird in South Australia was a second-year Cattle Egret from Doboy in Queensland. Thus there does not appear any distinct pattern of direction of travel and destination related to colony of origin.

Reports from Project Egret Watch observers in the central and southern coastal regions of NSW, Victoria and Tasmania, and the records reported by Heather (1978, 1982, 1986), Morrison (1987) and Jackson & Olsen (1988) in New Zealand, all show an influx of Cattle Egrets in the autumn period after the end of the breeding season. Heather (1986) also indicated that the arrivals occur in waves, with an early influx in April and a major influx in May. Morris (1979) referred to a regular pattern of arrival and departure in New Zealand coinciding with the movements in eastern Australia. The very short stay of a flock of 40 Cattle Egrets seen in March 1988 on tidal flats of the Tomaga River, on the NSW south coast, reported by a Project Egret Watch observer (M. Wulfing, pers. comm.), suggests that it was a travelling group. Sightings of marked birds in June, July and August in the Hunter Valley show that some of the northern-based egrets may terminate their southward movement in the Hunter.

The same observers have reported that the birds start to depart with the onset of spring, most having disappeared by November. Observations in the Hunter Valley show highs and lows in numbers at the established roosts at Shortland and Seaham and along the transect of foraging country between Glenoak and Raymond Terrace. These fluctuations, lined with sightings of marked birds from the north, are also consistent with a hypothesis that waves of birds arrive from the south, stay for a short while and then pass on. No northern bird has been found to remain in or near the two Hunter Valley breeding colonies during the breeding season.

However, it is also clear that some birds do not take part in this southerly movement. Some may not make the journey every year, as suggested in the evidence of Seaham Cattle Egret No. 104. Seaham No. 104 is known to have left its home colony area during its first winter, was missing for a short period in the 1988 winter, but had remained at home between July 1988 and September 1989. Project Egret Watch observers have reported the presence of Cattle Egrets throughout the winter in areas from the Hunter Valley north to Queensland. Shortland No. 107, tagged in January 1987, used the

Shortland roost and nearby foraging areas for all of the 1987 winter, while Shortland No. 36, tagged in January 1986, is known to have remained for all the 1987 winter (as a second-year bird).

### **Possible factors influencing movement**

The fact that the major movements on record are southerly in winter is intriguing. Siegfried (1978) suggested that the movement of the African race of Cattle Egrets away from their natal colonies in Africa is related to climatic factors, stating that harsh cold areas are almost deserted. On the other hand, Harrington & Dinsmore (1975) claimed that the movement of members of the same race in America is not related to weather conditions. The pattern of movement from the Australian colonies southward to Victoria, Tasmania and New Zealand represents a movement from a warm climate to a cold winter climate, in contrast to the South African and American pattern.

Food shortage may account for only some of the egrets undertaking the winter movement away from their colonies. However, this movement is southward and takes them into colder areas where winter insect abundance is possibly lower than in the home range areas. Work done on Cattle Egret diet by McKilligan (1984), Maddock (1986) and Baxter & Fairweather (1989) show that orthopteran insects such as grasshoppers and crickets predominate in the diet during the nesting season. These would not readily be available in the colder climate during the winter. The New Zealand reports, however, indicate that earthworms and flies are important items of diet (Heather 1978, Jackson & Olsen 1988). Siegfried (1971) reported that earthworms made up about 60% by weight of the total food for African race adults in the wet season (April-October). The diet of the egrets and the food available to them in their summer and winter foraging areas need study to clarify this issue.

In New Zealand the numbers for 1988 were down on previous years (B.D. Heather, pers. comm.). However, breeding numbers in the eastern colonies in the 1987-88 season were significantly higher than for previous seasons. For example, the Seaham colony increased from 370 to 507 pairs, Shortland increased from about 800 pairs to more than 1300, and numbers at Lawrence (NSW) were also higher (D. Geering, pers. comm.).

The breeding season and the autumn and early winter of 1988 were wet and mild, which probably resulted in a more abundant food supply. This suggests that climatic factors could have influenced the 1988 migration. The question then arises as to where the progeny from the increased number of breeding pairs went. The road transect data suggest departure of a significant number from the Hunter. Counts were maintained in the Hunter and in the various Project Egret Watch localities from Queensland to Tasmania which will enable comparisons with 1987 winter figures, but it will be some time before these can be collated and analysed. Tasmanian results, in particular, will provide an interesting climatic dimension because a long hard drought was experienced there during the autumn and early winter of 1988 when the egrets were arriving, coinciding with the wet post-breeding season on the mainland.

### **Migration hypothesis**

The waves of egrets passing through the Hunter in spring, the sighting of northern marked birds in the Hunter just before the breeding season and their rapid disappearance, the confirmed return of the Gatton tagged bird (No. U6) to its home colony after being seen at Shortland (McKilligan, in prep.), and the return of Shortland bird No. 127 to the Hunter Valley, coupled with the pattern of number fluctuations and tagged bird sightings, strongly suggest an out and return migratory pattern with the Hunter a transit base for northern egrets. Although birds tagged at Seaham and Shortland have not been reported along the egret travel paths and back in their home colonies, except for Shortland No.127, the pattern of sightings of birds tagged in the Hunter which returned to the breeding colonies is also consistent with a migratory pattern.

Heather (1982) considered migration between Australia and New Zealand as "now certain". The evidence supports a hypothesis that a significant number of Cattle Egrets undertake southward and south-easterly "out and return" migration, but it is also clear that in any one winter large numbers do not move from their home colonies. There is insufficient evidence to conclude whether those which travel follow a true migration pattern to and from the same destinations each year, as has been established for other migratory species such as the shearwaters. Many more recoveries and sightings of individually marked birds will be needed before such a firm conclusion can be drawn. It is unfortunate that no sightings of the Shortland egret seen near Lake Ellesmere in New Zealand were made between May 1987 and March 1988, to indicate whether it returned to Australia and then went back to New Zealand, as this may have thrown some light on the subject.

However, the New Zealand and Tasmanian pattern of flocks appearing on the same farms each year and following the same grazing herds is strongly suggestive of migration. The extremely localised sightings of Shortland No.36 and No.107 and Seaham No.104 for long periods over two seasons in the Hunter, usually in the company of flocks of birds of about the same size, and the New Zealand reports on Shortland No.80 near Christchurch and other marked birds in the Manawatu (Heather 1986) suggest flock cohesion and locality faithfulness at both the natal colony area and at the winter destination.

The evidence is suggestive that groups from the same colony may go to different destinations in any one year, while others from the same colony may remain in the vicinity of their natal colony, as was the case when Shortland No.36 remained at home in 1987 while Shortland No.80 went to New Zealand.

The conclusion that the Australian movements represent a migration are contrary to Siegfried's (1970) finding concerning African Cattle Egrets. He concluded that the evidence provided no real reason to suppose that the movements represent true migration, being mainly accountable in terms of extensive dispersal, some of which may be directional.

Seasonal migration to and from warmer climate has been recorded for the African race in North America (Harrington & Dinsmore 1975). However, the Australasian pattern is from warmer to colder climate, with South Island New Zealand winter temperatures, in particular, being considerably lower than those prevailing in the breeding colony areas.

Siegfried (1978) used an estimate of an average speed of 50 km/h to calculate a potential flight range of 1000 km for a flight duration of 20 hours for the African race. In 1987, a small flock of Cattle Egrets in Australia was clocked over several kilometres at 90 km/h on a car speedometer by matching the speed of the car with that of the flock flying overhead (G. Weber, pers. comm.); thus a 50 km average is not an unreasonable expectation.

Figure 6 shows the direct line between colony of origin in Australia and the location of recoveries in New Zealand. The shortest flight distance from colony to location of recovery in New Zealand is 2181 km from Shortland to Lake Ellesmere. On Siegfried's (1978) base figure, this would take a non-stop flight of almost 44 hours, including crossing the Southern Alps at the end. From Lawrence (NSW) to Levin is almost 2400 km, which would take about 48 hours to fly.

These times are well over the 17.7 hours in the air calculated by Siegfried (1978) for a 300 g Cattle Egret with a 30 g fat reserve. However, Siegfried considered it likely that the potential for non-stop flight is greater, if lower energy is expended on flap and pause flight. Wind stream assistance may be a factor, but the return journey is against prevailing westerlies on the Tasman.

### **Future research**

To put enough pieces of the jigsaw puzzle of Cattle Egret migration into place will require a long-term colour-banding and wing-tagging programme across a range of colonies in eastern Australia, coupled with the extension and consolidation of the co-operative Project Egret Watch and OSNZ observation networks to maintain long-term year-round monitoring of local populations and to follow the movements of marked birds. Dates of arrival and departure at various locations and sightings of the marked birds will need to be correlated with meteorological systems operating at the time, to determine whether wind patterns are involved.

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MAX MADDOCK, *Faculty of Education, University of Newcastle, NSW 2308,*  
*and Shortland Wetlands Centre, NSW 2328*