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CATTLE EGRET MIGRATION, SATELLITE TELEMETRY AND WEATHER IN SOUTH-EASTERN AUSTRALIA

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Two adult Cattle Egrets, captured near Raymond Terrace in the Williams River Valley, New South Wales, in April 1994 were each fitted with a PTT100, battery-powered transmitter and with patagial tags. After release, the birds were tracked by Argos system satellite on an eight hours on and 40 hours off duty cycle and ground searches were carried out to locate them by their tags. Weather maps from the Bureau of Meteorology associated with each satellite interrogation were evaluated. After remaining in the vicinity of the capture site for several weeks, the birds were further tracked until signals were lost, one on a migration route in the Lower Hunter floodplain and the other on a southerly migration to Bega in south-eastern New South Wales, following patterns described in Maddock and Geering (1994). The movements occurred in light winds under the influence of a high pressure system. The results of this pilot study suggest the potential for using small satellite transmitters for migration studies of egrets, to assist in validation of other field techniques and to provide data not obtainable by other techniques.

INTRODUCTION

The influence of weather on the long-distance migration of birds has often been cited as a major reason for migration timing, flight time and flight behaviour. Birds are affected by the weather on a wide variety of scales, from local changes in wind that may affect their flight pattern, to climatic change which may influence their destinations and the times of year in which flights occur (Walker and Venables 1990; Nisbet and Drury 1968; Williams and Williams 1978; Elkins 1988 for example).

Research on bird migration in the Southern Hemisphere has been limited. Using information from volunteer ground observers in the Shortland Wetlands Centre's Project Egret Watch, the general features of the migratory pattern for the Cattle Egret *Ardeola ibis coromandus* have been established (Maddock and Geering 1994). The definition of 'migration' used in Maddock and Geering (1994) and in this study is Baker's (1978) all encompassing concept of 'an act of movement from one spatial unit to another'. A continuum of movement phenomena exists and definitions of migration and migration types are of necessity arbitrary (Baker 1978).

It has been demonstrated that Cattle Egrets nesting in colonies in coastal New South Wales and southern Queensland can migrate to all points of the compass, but the predominant pattern is a southerly autumn to early winter movement down the eastern coast to Victoria and

Tasmania or across the Tasman Sea to New Zealand, with movements occurring in stages, and a return in spring to the natal breeding colonies (Maddock 1990, Maddock and Geering 1993, Maddock and Geering 1994). Migrations can range from very short distances, within the flood plain where the nesting colony is located, to very long distant movements. Staging locations *en route* and final wintering ranges are highly localized, used by the same individuals in consecutive years (Maddock and Geering 1994). Links have been established to meteorological systems operating at the time of movement (Maddock and Bridgman 1992; Bridgman and Maddock 1994).

Recent developments in the construction of small transmitters allow the possibility of direct tracking of individual Cattle Egrets by satellite. The results gained from this method are likely to be far more accurate and detailed than from the volunteer observer network, by providing consistent reporting of locations at precise time intervals over territory which may not be serviced by ground observers. Results can also include overnight reports. Because of the very high cost, only a few birds can be studied using the technique and consequently small samples are usual. Even so, it is perceived as a method which can provide validation of and data complementary to, ground-based studies using observers.

This paper reports the results from a pilot study tracking two egrets for several months in 1994 using the French polar-orbiting Argos satellite. The project aimed to:

1. obtain greater detail about the movements of the egrets than previously obtained from ground-based studies;
2. test if the satellite information was consistent with the findings of the previous ground-based studies;
3. establish the feasibility of the method as a research tool on migration of egret species.

Tracking faunal movements using the Argos satellite system has been successful in a number of Australian projects in the past (i.e. albatross, camels, kangaroos, for example see Priede and Swift 1992). However, all of these animals are considerably larger than the 300 to 600 gram Cattle Egret. In 1993, Microwave Telemetry Inc (Maryland USA) developed the PTT100, a battery-powered transmitter weighing about 28 g (see Fig. 1), which could be attached to the back of a Cattle Egret without affecting its flying ability.

The PTT100 emits a signal of specific frequency, the location of which can be recorded by the Argos satellite. This project provided the

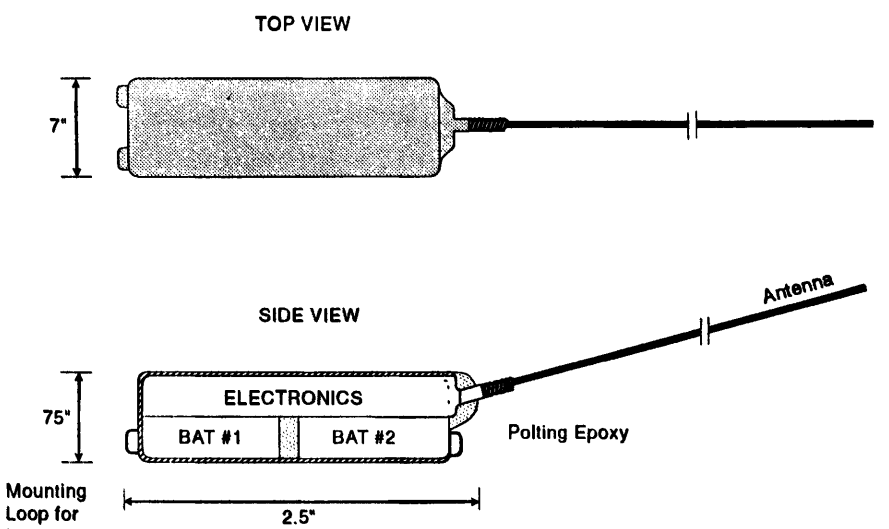

Figure 1. *A sketch of the PTT100 battery powered transmitter.*

first opportunity to test this new transmitter under Australian conditions on a small species.

METHODS

Two adult Cattle Egrets using Richardson Swamp as a night roosting site were captured by cannon netting on 9 April, 1994. Richardson Swamp is about two kilometres north of Raymond Terrace on Newline Road in the Williams River Valley (Fig. 2). The transmitters were secured to the back of the egret below the neck using a harness, placed so that it did not interfere with wing movements. The egrets were also tagged with bright yellow patagial tags of the type previously found successful in Project Egret Watch studies. They were labelled TO1 and TO2 for clear visibility from a distance.

After release, the egrets were tracked on a satellite duty cycle of 8 hours on and 40 hours off. The length of transmission 'on' was needed to ensure the polar orbiting Argos satellite was within range. The period 'off' was chosen to ensure at least six months battery life for the transmitter, in an attempt to track both outward and return migration patterns.

The satellite transmission signals were retransmitted to a central storage facility in Melbourne and then interrogated regularly via electronic mail using a personal computer in Newcastle. Egret locations were then mapped. Regular contact with the volunteer observer network provided occasional visual verification of location by identifying the birds by their tags in the field. Interrogation continued until loss of signal transmission from the egret.

Synoptic weather maps obtained from the Bureau of Meteorology were used to assess meteorological conditions operating during times of movement.

RESULTS

The egrets were located by the satellite and were verified in the field by tag sightings near the release site until the end of April, before they began extended migration. The movements of the two egrets are shown in Figure 2 (local) and Figure 3 (long distance). The relationship between visual sightings in the field and satellite reports on the nearest date and time are given in Table 1.

TABLE 1

Sightings of TO1 and TO2 in the field related to relevant satellite report.

Egret No. TO1				
Date	Time	Report	Latitude/Longitude	Location
10 April	1730	Visual	32°45′15″S/151°43′38″E	Irrawang Bridge
	2104	Satellite	32°45′29″S/151°45′50″E	Richardson Swamp
14 April	0832	Satellite	32°42′32″S/151°39′04″E	Hinton – Wallalong
	1230	Visual	32°43′37″S/151°41′30″E	Mt Kanwary
16 April	0745	Satellite	32°42′50″S/151°38′02″E	Phoenix Park
	1448	Visual	32°43′00″S/151°38′47″E	Hinton
19 April	1715	Visual	32°43′37″S/151°38′45″E	Brisbanefield
20 April	1847	Satellite	32°43′12″S/151°38′38″E	Brisbanefield
Egret No. TO2				
Date	Time	Report	Latitude/Longitude	Location
10 April	1800	Visual	32°45′10″S/151°45′11″E	Richardson Swamp
	2107	Satellite	32°44′46″S/151°45′14″E	Irrawang Bridge
12 April	1650	Visual	32°45′10″S/151°45′11″E	Richardson Swamp
13 April	0424	Satellite	32°46′12″S/151°46′23″E	Raymond Terrace
18 April	2113	Satellite	32°45′32″S/151°43′05″E	Irrawang Bridge
19 April	1640	Visual	32°45′15″S/151°43′38″E	Irrawang Bridge
24 April	1715	Visual	32°44′00″S/151°43′00″E	Nelsons Plains
25 April	1455	Visual	32°44′00″S/151°43′00″E	Nelsons Plains
25 April	1732	Satellite	32°44′49″S/151°45′14″E	Richardson Swamp
27 April	1730	Visual	32°45′15″S/151°43′38″E	Irrawang Bridge
27 April	2115	Satellite	32°43′41″S/151°43′12″E	Nelsons Plains
28 April	1735	Visual	32°45′15″S/151°43′38″E	Irrawang Bridge
02 May	0711	Satellite	32°44′49″S/151°41′49″E	Duckenfield
02 May	1730	Visual	32°45′15″S/151°43′38″E	Irrawang Bridge
02 June	0731	Satellite	36°40′30″S/149°49′55″E	North Bega
	1100	Visual	Not recorded	North Bega

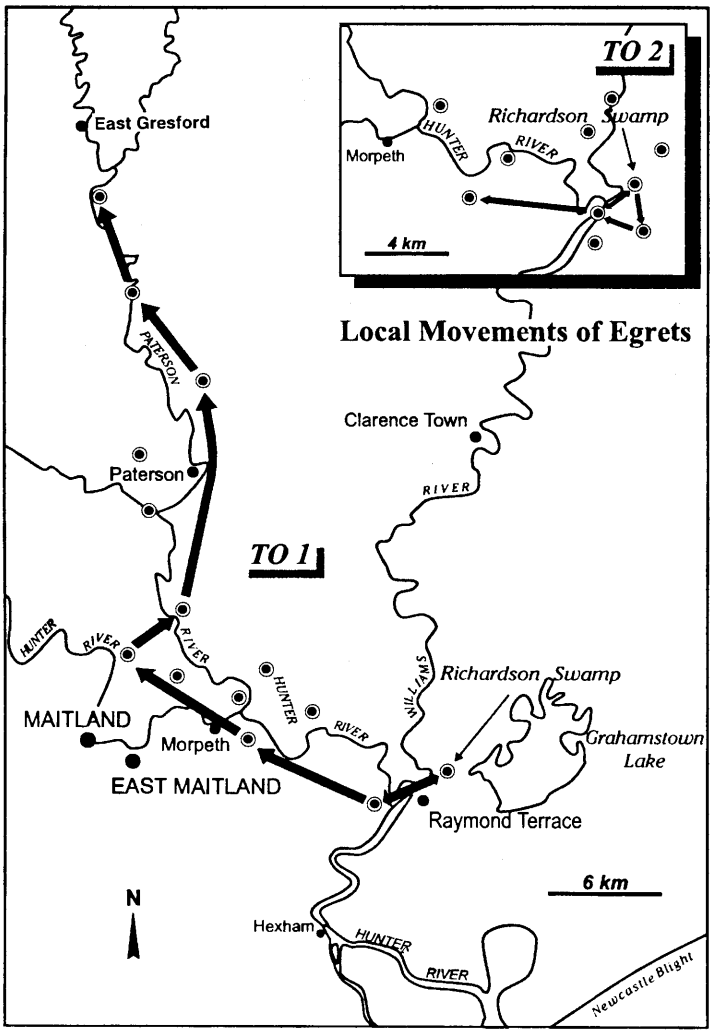

Figure 2. *The middle Hunter Region, New South Wales, with the local movements of egrets TO1 and TO2. Circles indicate observed locations of the egrets from the satellite; arrows indicate assumed movement.*

Field observations of the tagged birds as they were flying, foraging, resting on a perch and in a night roost did not reveal any evidence of discomfort being experienced with the transmitters. Their behaviour patterns were consistent with those of untagged birds in the flocks accompanying them and with those of untagged and tagged birds regularly observed in the past.

The signal for Egret TO1 was lost on 15 May 1994, with the last known location near Gresford (Fig. 2). TO1 utilized several pasture areas as it steadily moved inland through the region from the release point at Richardson Swamp. Visual sightings from Project Egret Watch Observers confirmed the general location on four occasions (Table 1).

TO2's signal was lost on 27 June 1994 at Bega, on the south coast of New South Wales (Fig. 3). Nine locations were confirmed in the field by tag sightings, when it was seen in company with other Cattle Egrets (Table 1). TO2 left the Hunter Region between 13 May and 15 May, 1994,

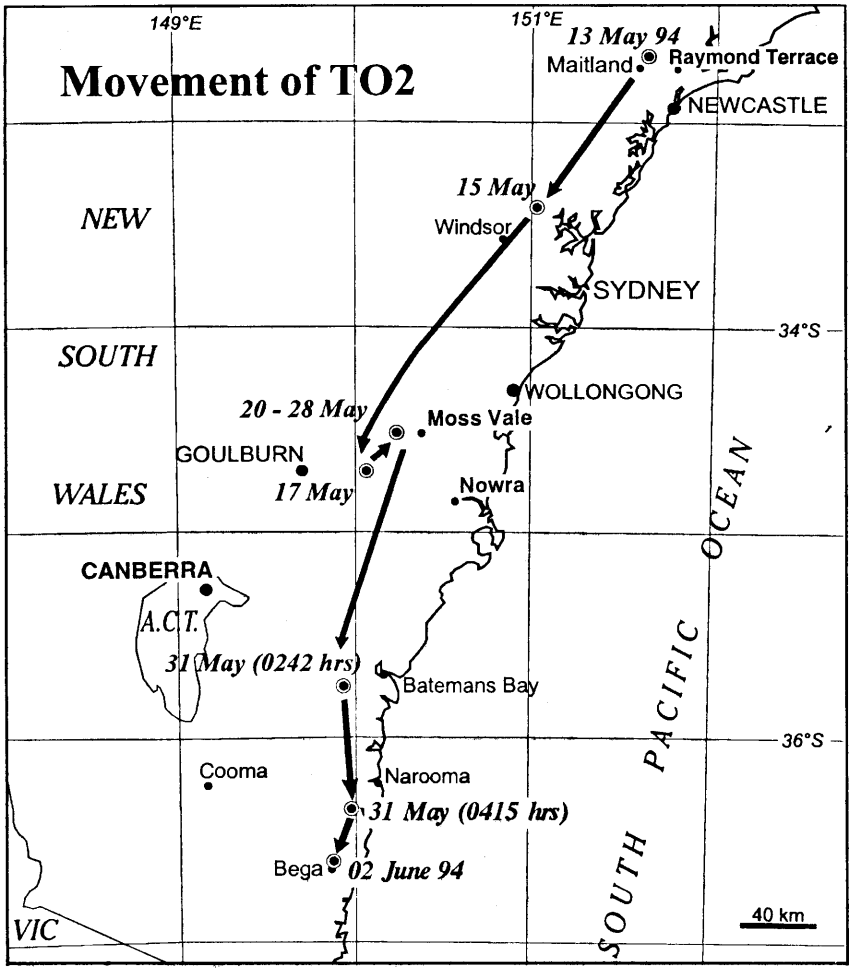

Figure 3. *Location and movements of egret TO2 during its migration between the Hunter Region and Bega, New South Wales. Circles indicate observed locations of the egret from the satellite; arrows indicate assumed movement. Dates of records between 13 May and 2 June 1994 are shown. On 31 May, times of satellite records are shown in brackets.*

arriving in the Hawkesbury area, north of Sydney, on 15 May (Fig. 3). From there, it migrated in three stages to its final location at Bega, where its presence was confirmed by sighting of its tag, again in company with other birds (Fig. 3, Table 1). TO2 had remained in the area near Moss Vale for 11 days (17 to 28 May), with a short reversal migration (Baker 1978), before moving to the near-coastal location between Narooma and Bega (Fig. 3).

On 31 May, the satellite provided locations while TO2 was in flight at night between 0242 hours and 0415 hours local time (see Fig. 3). It covered a distance of 64.5 km, indicating an average ground speed of 43 km/hr.

Figure 4 presents the weather map for 31 May 1994 representing the period of migration around 0400 hours local time (1800 Universal Time Code (UTC), 30 May). The weather in eastern New South Wales was controlled by a high pressure system, but the approach of a cold front on the eastern border of Victoria may have provided the light north westerly winds.

DISCUSSION

The results suggest that the PTT transmitter was successful in providing more frequent and accurate information on local movements of egrets than could be obtained from field observations of marked birds alone. If even more detailed

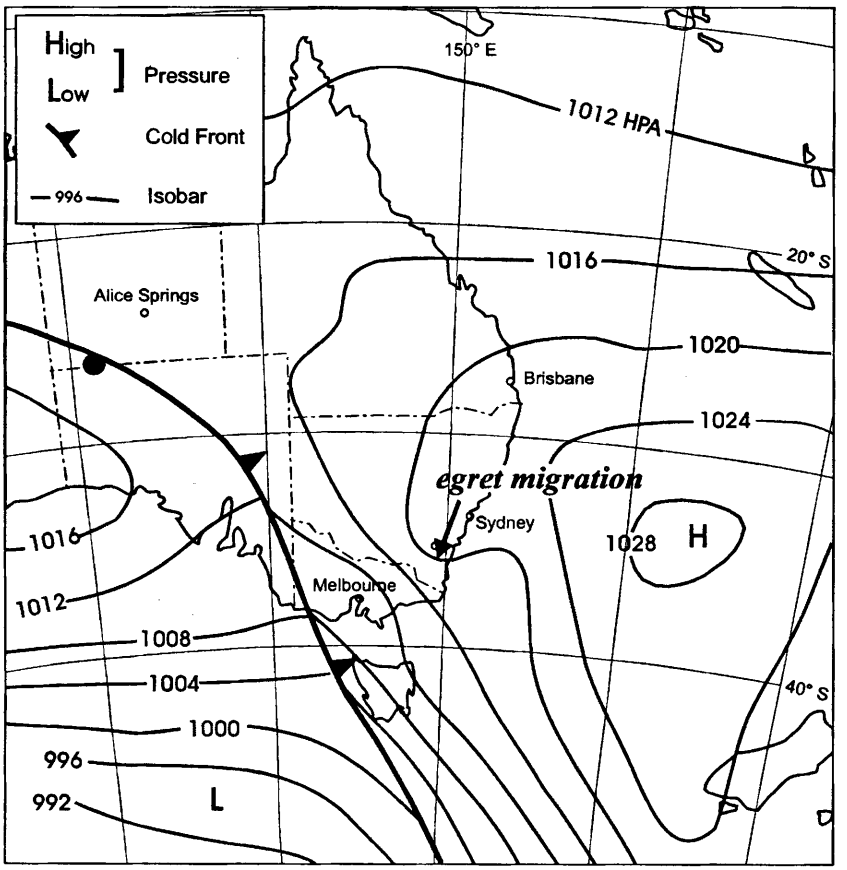

Figure 4. *Synoptic map for 1800 Universal Time code (UTC) on 30 May 1994 (0400 hours local time, 31 May 1994). The arrow indicates the general direction of migration for egret TO2.*

information is required, the interrogation cycle for the satellite could be set at a much shorter time interval. This would result in battery life being much shortened, allowing only short-term studies. The level of accuracy claimed by the manufacturer is within 50 m but it was not possible to verify this claim in this study. If true, it would give far more precise locations over time and space than could be achieved by ground observers. If obtained from a larger sample, such information could be used for habitat planning purposes.

The patterns followed by both birds in the early stages were consistent with the local level of movements determined by tag sightings for some Cattle Egrets after the nesting season (Maddock and Geering 1994). TO1 followed a path closely similar to that taken by Seaham No 208 between 27 February and 16 July 1988, before it began its return migration to the breeding colony (Maddock 1992). However, the satellite provided more detail of the intermediate stages of movement than observers obtained in the 1992 study.

Information provided by Egret TO2 is consistent with migration habits of Cattle Egrets determined from the previous studies (Maddock 1990; Maddock and Bridgman 1992; Bridgman and Maddock 1994; Maddock and Geering 1993; Maddock and Geering 1994) and more accurate than hitherto available on long distance southward winter movements.

1. TO2 migrated by short stages, resting for anywhere up to 11 days before moving to the next location. The movement route was similar to that estimated from sightings of Cattle Egret flocks and tagged birds in previous years, except that the intermediate stages near Moss Vale were much further inland than previously predicted. That some Cattle Egrets from coastal New South Wales colonies have crossed the Great Dividing Range is supported by previous sightings of a tagged Shortland Cattle Egret recovered near Wodonga (Victoria). A tagged bird, from which insufficient information was obtained to determine the actual colony, was seen near Lake George near Canberra (Project Egret watch records) and a Lawrence (near Grafton) bird located near Glen Innes in northern New South Wales. The presence of small flocks in the Canberra area each winter (D. Purchase, pers. comm.) may also have originated from coastal colonies. However, there are no previous records of birds staging so far inland *en route* to south-eastern coastal areas.

2. The satellite data show that TO2 was travelling at night on 31 May (Fig. 3). Night departures from roost sites have been recorded previously from the Hunter area (Maddock 1990) Thorp (pers. comm.) has reported Cattle Egrets travelling overhead at night in the Shoalhaven area, but this is the first record of confirmed overnight flying over such a long distance.

3. Its movement occurred during periods of light winds under the influence of a synoptic-scale high pressure system. A north-westerly wind will provide a favourable tail wind so long as the weather remains fine and the wind speed does not become very strong. Figure 4 shows an example of a weather pattern during TO2's recorded movement, typical of other periods and also consistent with patterns determined from ground observations of migration of egret flocks and individual birds in previous years (Bridgman and Maddock 1994). Unfavourable strong west-south-westerly winds occurred during the period the bird was present in the Southern Highlands.

The 43 km/hr speed obtained for TO2 from satellite reports on the night of 31 May provided an estimate of the bird's average ground speed whilst in flight. Siegfried (1978) used an estimate of 50 km/hr for what he called 'flap and pause' flight in his discussion on Cattle Egrets crossing the Atlantic, but did not give any information on the source of the estimate. The only previous crude estimate for Cattle Egrets in Australia was 90 km/hr given by Weber (pers. comm.), who matched the speed of his car for several kilometres with a flock flying overhead in daylight. It is unlikely that such a speed could be maintained on a long-distance flight.

As the birds were tagged as adults, captured at a roosting site after the end of the nesting season, it was not possible to identify the colony of origin. They could have been birds from the local colonies at Seaham and Shortland, or birds from a northern colony on their way south through the Hunter. Birds from the local and northern colonies have previously been identified by tags at Richardson Swamp and nearby locations and later staging *en route* south for one or more days in the Shoalhaven area (Maddock and Geering 1994; Project Egret Watch, unpubl. data). The migration path taken by TO2 represents one possible route which could be followed by Cattle Egrets travelling from the Hunter to south-eastern destinations such as those identified in Maddock (1990), and Maddock and Geering (1993, 1994).

There are unanswered questions about why the signals were lost after only 2–3 months of the planned six months period. Unfortunately neither the egrets nor their transmitters were ever recovered. Correspondence with the manufacturer of the PTT100 indicated that if the instrument remains at the same location without moving for several satellite passes, the satellite capture of the transmission signal ceases.

There are other reasons which could result in signal loss, including:

1. a failure of the transmitter system;
2. aerial damage;
3. harness failure causing transmitter loss;
4. predation of the egrets and damage to transmitters in the process.

The results suggest that a further study with a somewhat bigger sample is warranted, and the use of the PTT100 would be appropriate to study the less researched species, Great and Intermediate

Egrets. Great and Intermediate Egrets, particularly birds breeding in the inland colonies, have been recorded moving very long distances (more than 1 000 km) across isolated areas where there are very few potential observers on the ground (Project Egret Watch, unpubl. data). Most of these records, however, consist of only a single sighting away from the natal colony. Although no detrimental effects were noted when the birds were observed in the field, the 28 g transmitter (approximately 7% of body weight) is probably close to the limit for a Cattle or Intermediate Egret to carry, but should be well within the limit for a Great Egret (about 3% of body mass).

CONCLUSIONS

Tracking the movement of Cattle Egrets using a 28 g signal transmitter (PTT100) and the Argos polar orbiting satellite was successful between 9 April and 15 May for one bird (TO1) and successful between 9 April and 27 June for another (TO2). Although the study sample size is small, and on its own could not be used for wide generalization, the results used in conjunction with previous ground-based studies add important information to the understanding of Cattle Egret migration.

The migration pattern (short stages with rest periods), meteorology associated with migrations (high pressure, fine weather, with perhaps weak north-westerly airflow) and at least some migration at night were consistent with previous findings but were more precise in time and space. The information on duration and speed of flight adds a new dimension which could not be obtained by ground observations.

Even though the project did not last the full six months, the potential value of using small transmitters like the PTT100 as an adjunct to more traditional techniques for animal conservation studies is apparent. The study was undertaken with a species which has been very intensively studied in Australia and for which much information had already been established on migration. However, similar sorts of results obtained from Great and Intermediate Egrets could fill very important gaps in the knowledge of their movements, not obtainable by ground studies of the type used for Cattle Egrets. The results also demonstrated the potential of satellite telemetry with smaller birds than have been previously studied.

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