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CATTLE EGRET MIGRATION AND METEOROLOGICAL CONDITIONS

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ABSTRACT

Potential relationship between meteorological conditions and the timing and path of Cattle Egret migration from colonies in the Hunter Valley (NSW) to locations in Victoria, Tasmania and New Zealand were investigated for the period 1987-1989. Meteorological maps obtained for a period of up to five days previous to known movement dates were analysed to identify possible migration paths. Three potential outward and two potential return paths were identified which make use of wind-flows around high and low systems. The results show that Cattle Egrets may well utilise weather systems in their migration and point to the need for further research for clarification.

INTRODUCTION

This paper reports the results of preliminary investigation into meteorological conditions when Cattle Egrets (*Bubulcus ibis*) migrate. Many of the egrets fly from breeding colonies in NSW and southern Queensland to southern parts of NSW, to Victoria, Tasmania and New Zealand in autumn after the breeding season. The egrets return to their breeding colonies in spring. The study is part of a longer-term project aimed at determining whether climatic conditions affect the movements.

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 flights occur (Walker & Venables 1990). Research in the Northern Hemisphere has linked bird migrations with the weather (Nisbet & Drury 1968, Williams 1978, for example), and excellent reviews are presented by Elkins (1988) and Walker & Venables (1990). Results indicate that, although weather can influence global and regional migrations, the birds can move freely, quite independent of atmospheric forces. However, rapid changes in weather systems can create unexpected and stressful hazards.

Research on bird migrations in the Southern Hemisphere has been much more limited. In the southwest Pacific, around Australia and New Zewaland, movement of insects and other biological materials across the Tasman Sea has been evaluated (Close *et al.* 1978) and both the historical and current movement of dust under appropriate wind conditions studied (McTainsh 1989). However, neither insects nor dust have the control over destinations that migratory birds have.

Cattle Egrets first began to colonise Australia in the 1940s, arriving from Southeast Asia, possibly via Indonesia. Movement on a migratory basis to New Zealand was first observed in 1973 (Heather 1978). Whether initially travelling by instinct, by random dispersal of young birds from their natal colonies, or by mass migrations caused by interruptions in food supply (Williamson 1969), Cattle Egrets now regularly migrate from Queensland and northern NSW to more southerly locations in NSW, Victoria, Tasmania and New Zealand and return. Migrating flocks arrive at wintering locations generally in April and May and return to New South Wales in October and November (Maddock 1990). Migrations are usually in waves, and different flocks of birds may arrive at one location over the two-month period.

Formal records of migrating Cattle Egrets are sparse and depend on observers recovering metal bands from dead birds, observing colour-banded birds or reading patagial tags. Since 1987, Project Egret Watch observers have concentrated on compiling details of individual birds and flocks as they arrive and depart. The results, reproduced in Tables 1 and 2 (partially from Maddock 1990), provide enough information to allow a preliminary study of possible migration routes and how the birds may be assisted or deterred by meteorological conditions. The purpose of this study, therefore, is to provide initial answers to the following questions:

What is the likely impact of different weather conditions on egret migrations and why?

What migration routes are likely?

At what altitude do the egrets fly?

Given present estimates of flight speed, how long will migrations to different destinations take?

For purposes of the preliminary study, we considered migrations between the Hunter Valley of New South Wales and southern Victoria, Tasmania, and New Zealand (see Figure 1 for location map) during the years 1987 to 1989. Other years are being analysed in a follow-up study.

METHODS

Individual marking of Cattle Egrets at breeding colonies in northern NSW and Queensland began in the 1970s. Colour banding began in the 1980/81 season and patagial tagging in the 1981/82 season. Project Egret Watch did colour banding at Shortland (Hunter Valley, NSW) in 1983/84 and 1984/85, and patagial tagging began at Shortland and the nearby Seaham colony in 1985/86. Between 1985/86 and 1988/89, 580 Cattle Egrets were tagged at the Hunter Valley colonies.

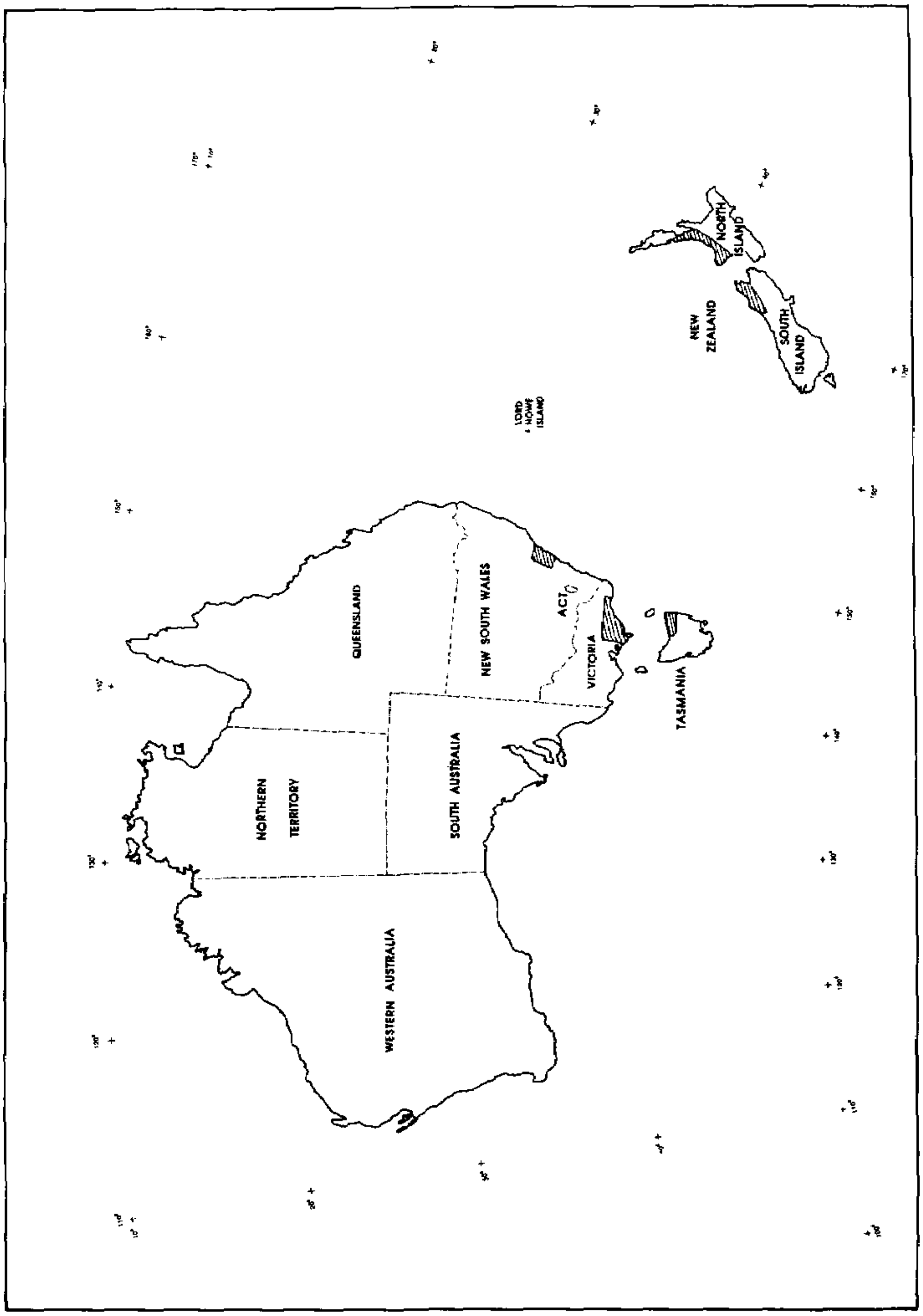

FIGURE 1 — The areas (shaded) between which Cattle Egrets migrate that were used for this study

Since 1985/86 an active observer network has been established throughout southeastern Australia to look for individually marked birds and to record the arrival, residence and departure of migrating flocks and individuals. This network has linked up with the Ornithological Society of New Zealand's Cattle Egret project, which was established in the 1970s to record Cattle Egret presence in New Zealand. Critical first sighting dates for arrivals of birds in New Zealand and Tasmania and for returns to the Hunter Valley 1987-89 were obtained from the Australian and New Zealand networks (Tables 1, 2). The New Zealand locations were Aka Aka (10 April, 15 and 30 May) and Parakai (21 and 30 April 1989), both in the northwestern North Island, where the records provided a reasonable estimate of arrival date and could be related to meteorological conditions. The return dates were determined by the arrival of flocks containing tagged birds at the breeding colonies, although no tagged birds specifically from New Zealand were identified.

Based on the information in Tables 1 and 2, daily weather maps (1200 UTC) were obtained from the Bureau of Meteorology in Sydney for the following standard pressure levels: 900 hPa (about 1 km altitude), 850 hPa (1.5 km), 700 hPa (3 km), and 500 hPa (5.5 km). Weather maps for up to five days previous to dates in Tables 1 and 2 were used to obtain a temporal indication of possible changes during the migration period. Estimates were then made from the wind and pressure patterns of possible migration routes and how often these routes were available for the migration seasons between 1987 and 1989. The evaluation was qualitative rather than quantitative, because neither the weather information nor the arrival information from the network could be considered highly reliable (Nisbet & Drury 1968).

Bird behaviour and weather - some background

The behaviour of Cattle Egrets preparing to migrate is well known to Project Egret Watch (Heather 1982, Maddock 1990). In late March and early April, after the breeding season in New South Wales is completed, flocks of egrets fluctuate in numbers in the Lower Hunter Valley, with several increases and decreases in numbers at the Wetlands Centre and other nearby locations. Birds, identified by their coloured bands or patagial tags, arrive from Queensland and northern NSW, having started movement some time earlier, and may combine with the flocks based in the Valley. Flocks begin the onward migration trip at intervals, creating a "wave" pattern of departures and arrivals. By June they have reached their traditional winter locations in Australia and New Zealand. Of the birds that do migrate, most band recoveries and field sightings have been of birds in their first year of life, but we have over 50 records of Cattle Egrets migrating to the same wintering locations in two or more successive years (M. Maddock & D. Geering, unpubl. data). The migrants spend the winter in New Zealand, Victoria, and Tasmania, returning in the spring. By early December, virtually all have departed the winter range, except that occasionally a few remain over summer without breeding.

As with birds in the Northern Hemisphere, Cattle Egrets seem to be able to choose conditions at migration departure which allow good weather upon arrival. However, rapid changes of weather en route may disrupt the migration pattern. It is not clear whether Cattle Egrets have some sort of navigational ability (Williamson 1969). Migrations often begin in the early morning and are daytime events. However, three night departures have been recorded from the Hunter Valley (Maddock 1990). In general, migrating birds avoid rainy and foggy weather.

Northern Hemisphere studies provide *information on the* type of synoptic weather situations most suitable for migration in general (Nisbet & Drury 1968, Williamson 1969, Williams & Williams 1978). Migrating birds tend to avoid low pressure systems because poor visibility makes navigation difficult and strong winds prevent controlled flying. Birds caught in a storm may fly in any direction to preserve energy and body fat in order to survive.

Cols, which are lower pressure areas between two adjoining high pressure systems, are acceptable for limited migration. Winds in cols tend to be light and variable, providing no assistance to the birds in terms of following airflow.

Migration is most widespread and intensive during periods of high pressure (anticyclonic) weather, which give clear skies, good visibility, light to moderate winds, and a stable atmosphere. Highs tend to pass through a region over a period of several days, allowing consistently good weather for migration. The lighter and steady winds reduce the risk of drift but allow the birds following winds, which assist their flight and help preserve energy. In the Northern Hemisphere, the best migration weather (northward) is along the western (back) side of a high, associated with steady south to southwest flow, perhaps ahead of an advancing front. In the Southern Hemisphere, the equivalent would be migration southward along the back side of a high in north to northwest flow. As Cattle Egrets use flapping flight more than soaring, a following wind is useful to conserve energy over long distances.

Birds generally avoid migrating into a headwind, which may use too much of a fairly limited energy supply; and bigger birds survive better. Birds will try to use a headwind to climb to gain extra elevation which will allow a long glide and slow descent downwind. Birds may migrate in a crosswind or in a partial following wind which is not strong, but they may drift from the intended route. The review by Walker & Venables (1990) provides examples of birds responding to bad weather by going to ground until conditions improve or by changing the altitude of flight.

Nisbet & Drury (1968) evaluated the relationship between weather variables and the density of bird migrations at Cape Cod, Massachusetts (USA). They discovered that, depending on the type of bird and the length of the migration, the variables affecting the migrations the most were pressure, humidity, temperature, and the presence of an onshore wind. Waterfowl tended to be less dependent on weather variables than other birds. With dense migrations, there seemed to be no linear relationship with weather variables. Day-to-day changes in the weather were as important as conditions on any one day.

TABLE 1 — Recorded arrival dates for Cattle Egrets in New Zealand and Tasmania, the possible route, and the dates of meteorological evaluation, 1987-1989

Reported Arrival	Route	Dates	Best Date	No. of Egrets
		New Zealand		
10 Apr 1989	Southern via Tas	7-10 Apr	8 Apr	2
21 Apr 1989	Southern via Tas	17-21 Apr	19 Apr	21
30 Apr 1989	North around low	26-30 Apr	28 Apr	35
15 May 1989	Southern via Tas	12-15 May	13 May	40
30 May 1989	Southern via Tas	25-30 May	27 May	20
		Tasmania		
18 Apr 1987	South around high	16-18 Apr	17 Apr	**
24 Apr 1987	Same	19-24 Apr	23 Apr	26
8 May 1987	Same	6-8 May	7 May	50-60
5 Apr 1988	Same	3-5 Apr	3 Apr	24
15 Apr 1988	Same	12-15 Apr	14 Apr	24
28 Apr - 1 May 1988	Same	25-30 Apr	29 Apr	8
5 Apr 1989	Same	1-5 Apr	3 Apr	1
12 Apr 1989	Same	11-12 Apr	11 Apr	12
30 May 1989	Same	25-30 May	26 May	78

** No count on this date

TABLE 2 — Recorded return dates in the Hunter Valley, the possible route, and the dates of meteorological evaluation, 1987-1989

Reported Arrival	Route	Dates	Best Date	No. of Egrets
		Hunter Region		
15 Aug 1987	From NZ*	12-15 Aug	13 Aug	**
2 Sep 1987	From Tas	30 Aug-2 Sept	31 Aug	
26 Oct 1987	From Tas	24-26 Oct	24 Oct	
30 Oct 1987	From NZ	26-30 Oct	26 Oct	
23 Oct 1988	From Tas	19-23 Oct	19 Oct	
5 Nov 1988	From NZ	1-5 Nov	1 Nov	
15 Nov 1988	From NZ	7-15 Nov	8 Nov	
26 Oct 1989	From Tas	20-26 Oct	22 Oct	
31 Oct 1989	From Tas	28-31 Oct	28 Oct	
8 Nov 1989	From Tas	5-8 Nov	7 Nov	
15 Nov 1989	From NZ	10-15 Nov	11 Nov	

* This date is somewhat earlier than the normal departure from New Zealand, but it is possible as a path existed.

** It was not possible to record numbers of birds returning to colony. Return dates were determined by the presence of tagged birds known not to have remained in the area over winter present for the first time in the nesting season.

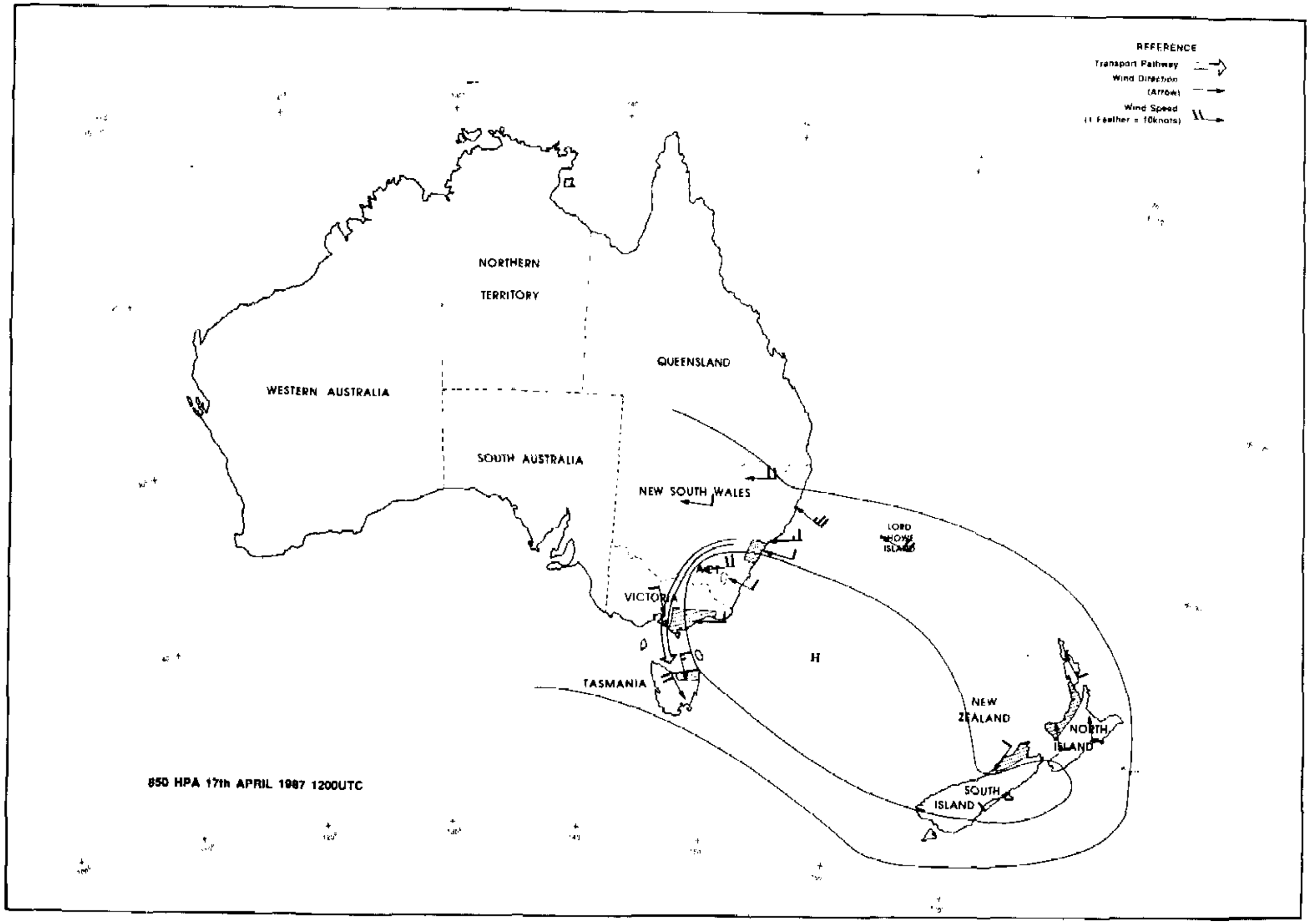

FIGURE 2 — The migration pathway to Tasmania from the Hunter Valley around the back side of a high, illustrated by weather conditions on 17 April 1987

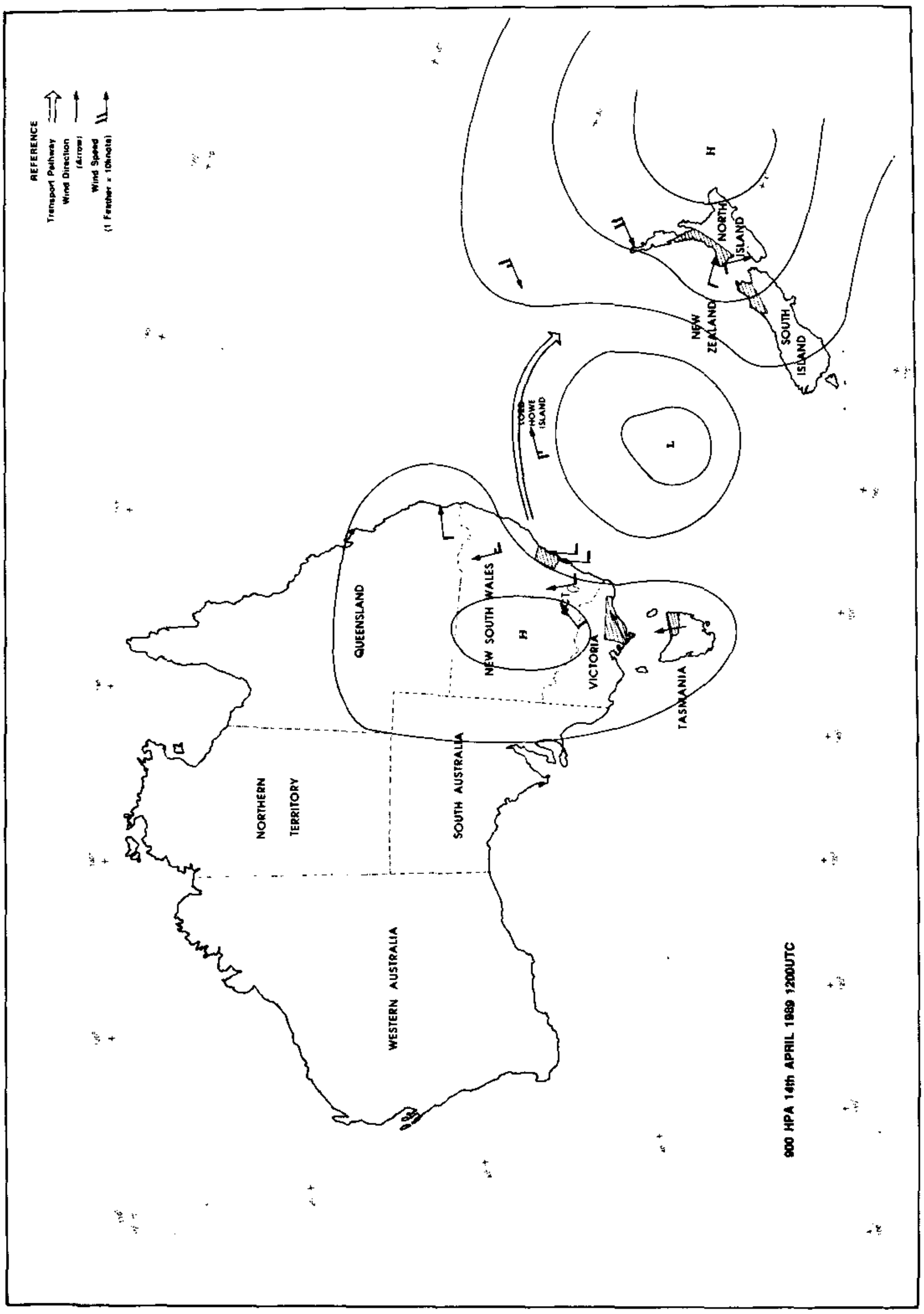

FIGURE 3 — The migration pathway to New Zealand from the Hunter Valley around the northern boundary of a weakening low pressure system, illustrated by weather conditions on 14 April 1989

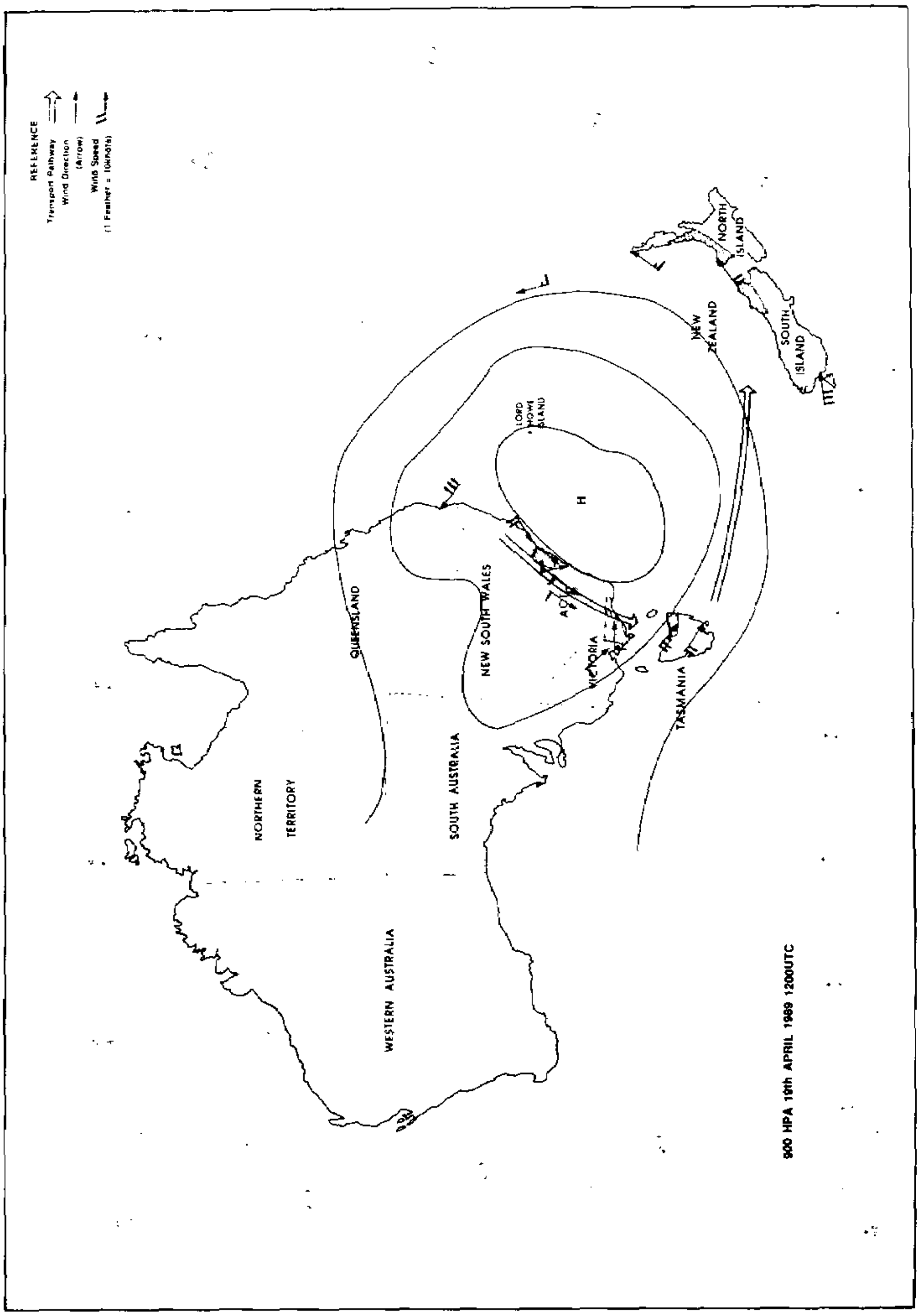

FIGURE 4 — The migration pathway to New Zealand from the Hunter Valley via Tasmania, around a high pressure system, illustrated by weather conditions on 19 April 1989

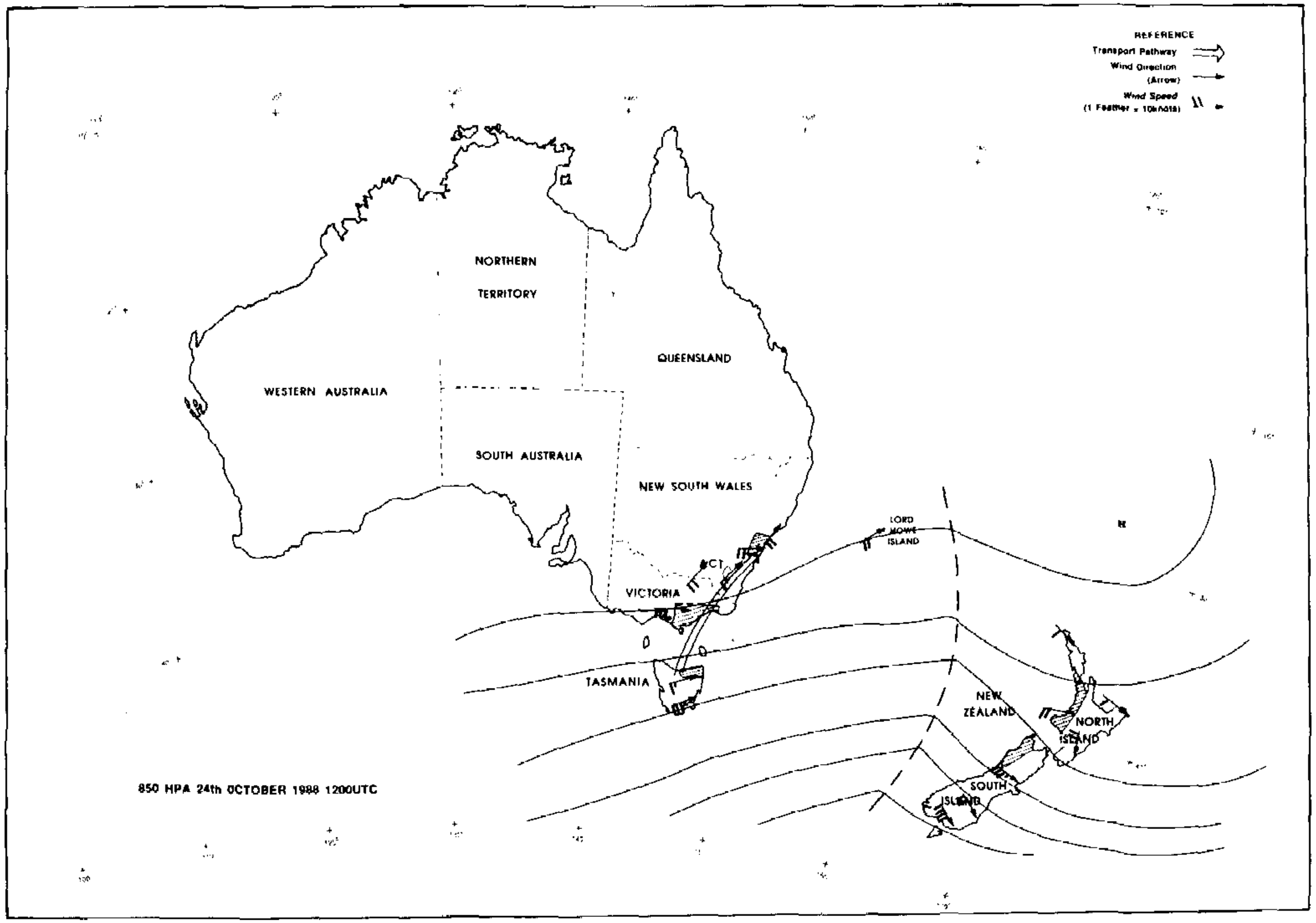

FIGURE 5 — The migration pathway to the Hunter Valley from Tasmania in the southerly airflow ahead of an advancing high pressure system, illustrated by weather conditions on 24 October 1988

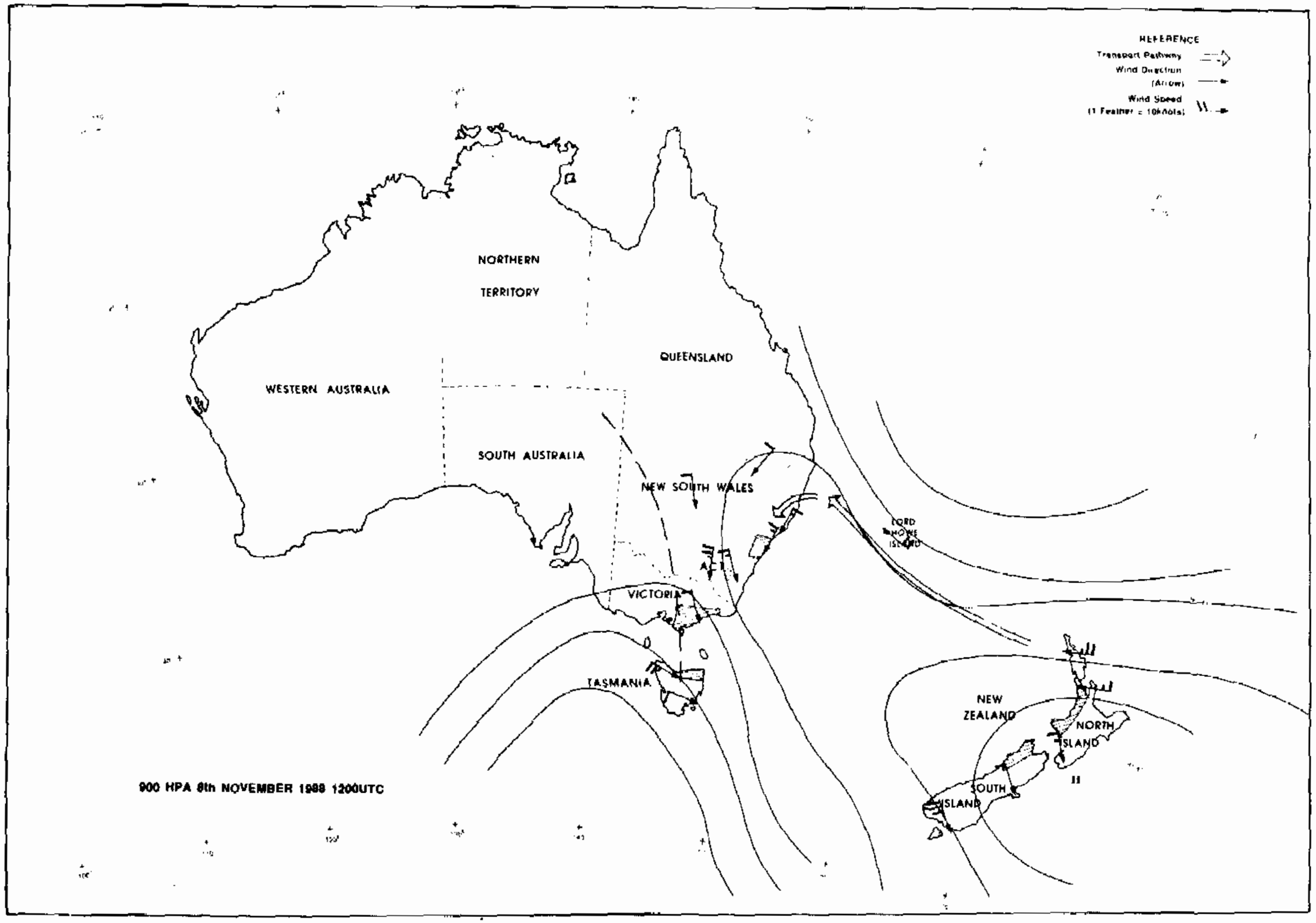

FIGURE 6 — The migration pathway to the Hunter Valley from New Zealand along the northern edge of a high pressure system, illustrated by weather conditions on 8 November 1988

RESULTS

Pathways

Dates which indicated a clearly appropriate meteorological system are given in Tables 1 and 2. The numbers of birds for each occasion are given, except for the returns to the Hunter, which were determined by the presence of newly arrived tagged birds at the colony, where numbers increased on a daily basis. Evaluation of the weather maps for the migration dates in Tables 1 and 2 shows five potential pathways, three outbound and two returning:

1. One path from the Hunter region to Tasmania behind the centre of a high pressure system uses the northwest airflow ahead of a front (Figure 2, the weather map on 17 April 1987). A large high pressure ridge extends from southeastern Australia across the southern Tasman Sea to New Zealand. Airflow north of about 33° S is onshore (E), but further inland to the southwest it backs to the north and then northwest. The northerly airflow provides a direct following wind for egrets migrating to southern Victoria and northern Tasmania.
2. From the Hunter region to New Zealand a pathway follows around the northern boundary of a weakening low pressure system (Figure 3, the weather map on 14 April 1989). A weak low pressure system, sandwiched between two ridges (over southeastern Australia and New Zealand), dominates the Tasman Sea. Moderate airflow from the west-south-west would allow egrets to move offshore from the Australian coast and travel with the low toward New Zealand. The route passes over Lord Howe Island (Figure 1), although few egrets appear there each year and do not remain for long. Egrets may have navigation problems on this pathway if they encounter clouds and rain.
3. The third pathway is along the back side of a high from the Hunter region to Tasmania, and onward across the south Tasman Sea to New Zealand (Figure 4, 19 April 1989, similar to that in Figure 2). This combines the distance to Tasmania and New Zealand from the Wetlands Centre, and is more unlikely than the pathways discussed above. However, reports of egrets reaching ships between Australia and New Zealand under westerly airflow (Maddock 1990) suggest the possibility. Perhaps egrets which have reached Tasmania some time earlier could use the southern pathway to New Zealand as a second migration stage.
4. Return from Tasmania to the Hunter Region utilises the southerly airflow ahead of an advancing high, or behind a cold front (Figure 5, the weather pattern on 24 October 1988.) As winds directly behind a cold front tend to be strong and gusty, the egrets may wait until the front has passed further east and the wind has become more moderate and more regular. The south-south-west airflow illustrated in Figure 5 would allow a direct passage from northern Tasmania and southern Victoria to the Hunter.
5. The return from New Zealand is likely to occur along the northern edge of a high pressure system (Figure 6, 8 November 1988). A large high is centred over New Zealand, with a ridge extending northwest to the southeastern Australian coast. Airflow along the northern edge of the ridge is east-south-east, which would provide a consistent following wind for egrets returning.

Altitude of flight

The maps presented in Figures 2 to 6 are all 900 or 850 hPa weather maps, likely to represent the altitude (1-2 km) at which egrets probably fly. Flights below 1 km are less likely because local variations of the land may cause local wind direction changes, and friction between the airflow and either a land or a water surface would lower airspeed, limiting the value of following winds on the flight.

After careful inspection of the 700 and 500 hPa maps, we have concluded that flight above 2 km altitude is generally unlikely. Often the airflow at these higher levels is in a different direction from that at lower altitudes. High pressure systems in particular are normally quite shallow vertically and so egrets are not likely to migrate at above 2 km. Often at 500 hPa, a low-level jet stream may be encountered, with winds reaching more than 25 m/s, probably too rapid for controlled flight by egrets.

Speed of flight

Maddock (1990) described some simple attempts to estimate the speed of flight of Cattle Egrets, suggesting 50 km/h as a reasonable travelling speed. Over short distances, 90 km/h has been estimated from an automobile. To fly between the Hunter and New Zealand, approximately 2100 km, at an average travel speed of 50 km/h would take 42 hours. At 90 km/h, the trip would take 23-24 hours.

It seems unlikely that the egrets would be able to sustain a flying speed of 90 km/h for very long, even with a following wind. Under the right meteorological conditions, speeds higher than 50 km/h may be possible, and migration to New Zealand could take less than 1.5 days. With no land areas for resting (except Lord Howe Island, where few egrets are seen), the birds would want to conserve fat and energy during the flight across the Tasman. Egrets migrating between the Hunter and Tasmania would have much less stress, particularly if they travel in stages, as evidence indicates they do (M. Maddock & D. Geering, unpubl. data). Except for Bass Strait, they probably travel over land. They could easily travel the approximately 1100 km in a day with a flight speed of 50 km/h and a following wind.

A non-stop migration between the Hunter Region and New Zealand via Tasmania, as shown in Figure 4, is unlikely. The distance is over 3300 km and at 50 km/h with a following wind would take at least 6 days. Such a long flight would exhaust the egrets' reserves of body fat and they would not reach their destination. A rest period in Tasmania would make this route more feasible. Return by the reverse route seems unlikely.

CONCLUSION

The limited date available from the 1987-89 sightings provides strong circumstantial evidence that meteorological conditions greatly influence the timing and path of Cattle Egret movements. The study identified three possible outward and two possible return pathways. Further research is needed to obtain confirmation. In our opinion, the altitude of flight is likely to be 1-2 km and the speed of flight between 50 and 90 km/h. Migrations to Tasmania could be accomplished in 24 hours, but those to New Zealand are likely to take in the order of 36-48 hours.

Ground observations are only a limited means of studying Cattle Egret migrations in Australasia. Ground observers cannot track the birds' movements, often miss the first and some subsequent arrivals and departures of migrants, cannot distinguish stages in long-distance migration from local and regional movements, and have difficulty with birds that "disappear" for long periods of time.

The data presented in this paper came from observations recorded up to the end of November 1989, when although very active, the network was much smaller and more limited in locations than it is now. The results were encouraging and gave impetus to continue in an attempt to get more conclusive results, based on more precise dates of movement.

One suggestion for improvement is to use weather radar (Nisbet & Drury 1968), which requires proper wavelength settings for the size of the birds. Another possibility is to place a satellite or ground tracking device on several of the birds while they are still in the nest. The tracking device must weighless than 5 grams, yet emit a powerful enough signal to allow tracking over a considerable distance. There is, however, no guarantee that the birds chosen as hosts for the signal device will ever migrate. These possibilities are being investigated.

In the meantime, work is continuing on relating meteorological data to arrival dates obtained since 1989. In southeastern Australia movement dates and locations of staging points are much better known, and much more precise dates for arrivals in New Zealand have been obtained. Unfortunately, although three tagged birds were identified in New Zealand in 1990-91, these birds have not been seen back in Australia.

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