

## The Food and Feeding Ecology of the Cattle Egret, *Ardeola ibis*, when Nesting in South-East Queensland

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### Abstract

The food of the cattle egret was determined from boluses regurgitated by advanced chicks over three breeding seasons, and from the stomach contents of 21 adults. They ate a wide range of animals, mostly taking orthopteran insects (especially the Acrididae), but also skinks, frogs, cicadas and spiders. They fed almost entirely on pastures, preferring moist to dry situations. Most fed in association with cattle but at times many fed independently, most noticeably when on flooded pasture. They pecked ticks and flies directly off cattle, their relationship with which is best described as facultative mutualism. Rainfall-induced variations in pasture conditions between nesting seasons apparently produced differences in diet, in choice of feeding habitats, diurnal activity patterns and frequency of association with grazing stock. The economic significance of cattle egret predation on pest arthropods, and the likelihood of competition for food between cattle egrets and other Ardeiformes, are discussed.

### Introduction

The Indian cattle egret *Ardeola ibis coromandus* has become well established in Australia in recent years and its numbers continue to grow, at least in New South Wales (Morris 1979) and Queensland (D. Seton, personal communication). Apart from a Japanese study (Ikeda 1956) little has been published on the food and feeding ecology of this subspecies. By contrast, the African cattle egret *A. i. ibis* has been well studied; for example in Egypt (Kadry Bey 1942), in South Africa (Skead 1966; Siegfried 1971, 1972), and in Florida (Jenni 1973; Fogarty and Hetrick 1973). This paper describes the diet of advanced chicks of the cattle egret, and their parents' preferred feeding habitats, activity patterns on the feeding grounds, and association with domestic stock, over three nesting seasons, 1979-80, 1980-81 and 1981-82. The stomach contents of adult cattle egrets shot in the 1982-83 season are also described. The feeding habitats of other Ardeiformes sharing the cattle egrets' feeding grounds and possibly competing with this species for food are given.

### Study Area and Methods

The study centred on a cattle egret heronry on the subcoastal plain of south-east Queensland near the township of Gatton (27° 31'S., 152° 20'E.). This is a diversified farming and grazing region with rich, intensively cultivated alluvial plains, natural grasslands, mostly on less fertile higher ground, woodlands, swamps, and lagoons. The climate is subtropical with an average annual rainfall of 762 mm, most of which falls in summer promoting maximum pasture growth then. Pasture production is lowest in late winter and early spring (August and September) (Mills 1972).

The cattle egrets nested from October to February or March, about 3500 pairs nesting in each of the 1979-80, 1980-81 and 1981-82 breeding seasons, and 2700 pairs in 1982-83. The

intermediate egret *Egretta intermedia* also nested at the heronry in 1979–80 and 1981–82, but in smaller numbers than the cattle egret and starting 8 weeks or more later.

The egret's diet was determined mostly from food boluses regurgitated by advanced chicks. Cattle egret chicks regurgitate food when alarmed and, since chicks from 3 weeks old to fledging at about 6 weeks spend much of their time out of the nest in adjacent branches, the food boluses drop to the ground below. A search was made for boluses weekly during December 1979 and twice weekly in December and January of the 1980–81 and 1981–82 breeding seasons, under selected nesting trees which were evenly dispersed through the heronry. Numbers collected were: 1979–80, 106; 1980–81, 155; 1981–82, 416; total 677. Most boluses landed reasonably intact and were readily collected, but those containing mostly cattle ticks or scarab beetles invariably fragmented on impact and were gathered up as best possible. Well digested boluses were rejected. In late January 1983, 6 adult male and 15 female egrets were shot at the heronry as part of another study, and the opportunity was taken to analyse their stomach contents.

Food items were preserved in 70% alcohol pending analysis. Boluses were bulked for analysis by day of collection, but each stomach's contents were analysed separately. Prey items were mostly identified to family and in some cases to species. Each category of prey was weighed to the nearest 0.1 g, and for subsamples of the main prey, the Acrididae, individuals were weighed to the nearest 0.01 g. The range in body length, including the tail, was determined for each prey category. Subsamples of the food were examined microscopically for earthworm setae.

During the period of food bolus collection, regular surveys were made of cattle egrets along a 33-km transect through their feeding grounds near the heronry. Along the transect, 40% of the ground was under cultivation, 59% was pasture land including some open woodland, and less than 1% was semipermanent open freshwater lagoons and earth dams (here termed 'aquatic'). About 85% of the pasture land was described as 'dry', i.e. well drained, and 15% was 'moist', i.e. low-lying poorly drained pasture, the reedy margins of lagoons, and swamps. These proportions were calculated from measured road distances and estimated depth of each type of habitat. Cattle and small numbers of horses and goats grazed the pastures.

A total of 22 transects were made, at regular intervals, during the three breeding seasons; together they spanned the hours from 0650 to 1650. One person drove a vehicle while a second recorded the location, activity and habitat occupied by each cattle egret and its association with domestic stock. Egrets more than a few metres from a grazing beast and obviously foraging independently were recorded as 'not associated'. Other Ardeiformes seen were also recorded.

## Results

### *Weather*

Different weather conditions (Table 1) in the three seasons of bolus collection may have influenced the cattle egrets' diet. In the 1979–80 season mean day temperatures were about 4°C higher than in later seasons. In 1979–80 there was little fresh growth on dry pastures, but the swamps contained water and were oases of fresh grass. By the 1980–81 season many of the swamps had dried out following a very dry winter and spring, and thus the pastures were more uniformly dry than in 1979–80. Heavy rainfall in the 1981–82 breeding months produced lush pastures, and flooded swamps and adjacent moist pastures.

### *Composition of Food Boluses*

A total of 14 468 food items were identified in 677 boluses. Intact boluses had a mean volume of 9 ml but this was not necessarily the entire stomach contents as chicks often regurgitated two boluses in succession. The food was entirely animal, with 69–81% invertebrates and 19–31% vertebrates by weight. The prey ranged from tiny spiders and flies weighing less than 0.1 g to a 50-g skink *Egernia modesta*. Prey was identified most fully in the 1979–80 and 1980–81 boluses, as listed in Appendices 1–3. Fig. 1 compares the main components of the chicks' diet among the three years of bolus collection.

Orthopteran insects (grasshoppers, locusts and the black field cricket *Teleogryllus commodus*) constituted by far the largest portion of the food boluses both by number

(68–84%) and weight (50–64%). The great majority of the orthopterans were the short-horned grasshoppers and locusts (Acrididae) (Appendix 2) including a number of pest species such as *Austracris guttulosa* and *Gastrimargus musicus*. The cicada *Parnkalla muelleri* and various spiders were common prey, and present in smaller numbers were the cattle tick *Boophilus microplus*, a variety of non-orthopteran insect species, woodlice, and centipedes. There were no adult lepidoptera, millipedes or earthworms, nor any aquatic invertebrates. Soil-dwelling scarab larvae appeared in boluses only after heavy rain.

**Table 1. Temperature and rainfall for September–January in the years of the study, and long-term averages**

From the Commonwealth Bureau of Meteorology's Cooper Laboratory Recording Station 4.6 km south of the Gatton heronry. Values for the months of food collection are in bold type

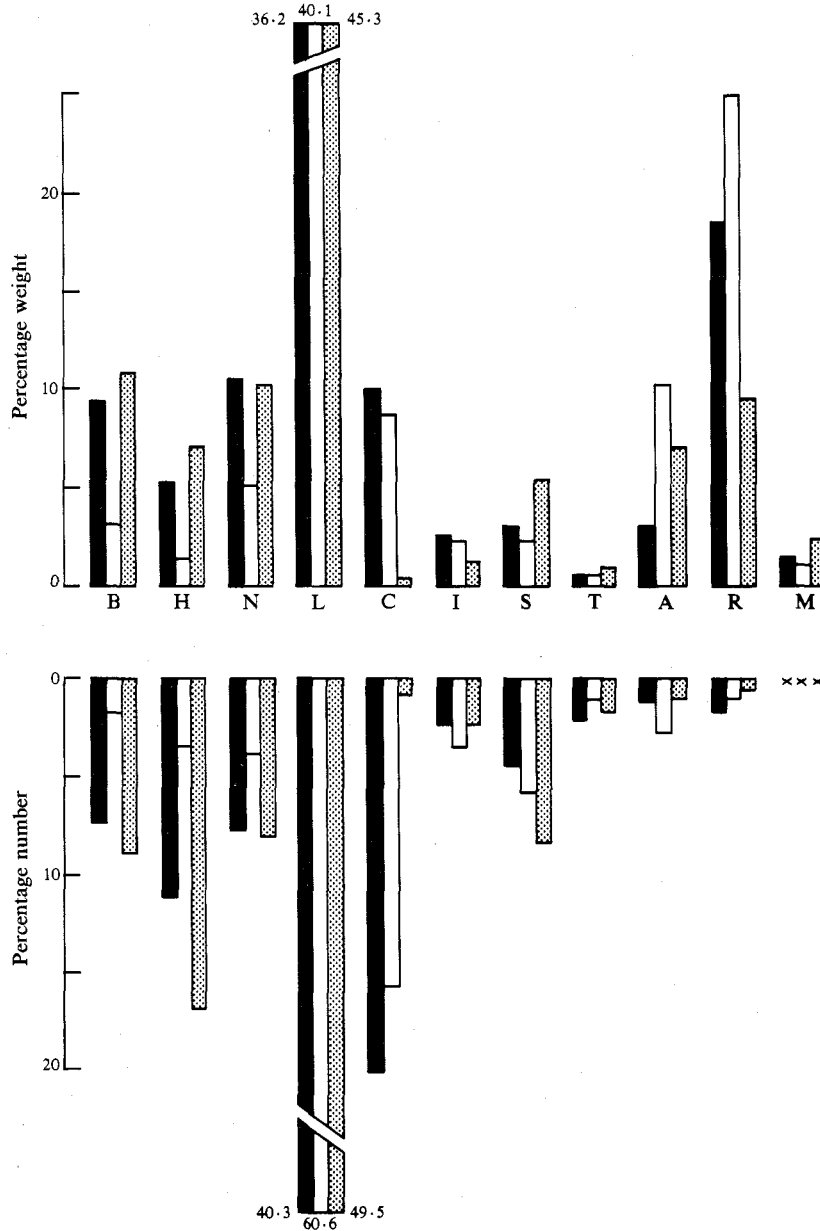
	September	October	November	December	January
Maximum temp. (°C)					
1979–80	25.0	27.5	30.5	<b>34.2</b>	33.9
1980–81	29.0	28.5	31.1	<b>29.5</b>	<b>30.6</b>
1981–82	26.7	27.2	27.4	<b>30.9</b>	<b>30.4</b>
1982–83	25.0	27.3	30.4	31.1	<b>30.9</b>
Mean 1965–79	24.4	27.2	29.7	30.7	30.8
Rainfall (mm)					
1979–80	11.2	41	92.5	<b>82.9</b>	29.4
1980–81	0.1	100.2	42.6	<b>78.2</b>	<b>51.6</b>
1981–82	5.3	13.3	172.5	<b>131.1</b>	<b>161.9</b>
1982–83	80.9	84.6	5.7	158.8	<b>91.4</b>
Mean 1965–79	37.2	79.5	90.9	98.2	133.9

Lizards were the major vertebrate prey (Appendix 2), especially skinks, which made up 10 of the 13 lizard species taken. Of the six species of anurans, the most numerous were the northern dwarf tree frog *Litoria fallax* and young cane toads *Bufo marinus*. One marsupial mouse *Antechinus flavipes* and several house mice *Mus musculus* were found. No bird remains were found in boluses, but a large cattle egret chick was observed attempting to swallow a dead smaller one.

**Table 2. Composition of boluses collected about 0930 and 1630 h on 14 January 1983**

	Number		Weight (g)	
	Morning	Afternoon	Morning	Afternoon
Grasshoppers and locusts	659	638	265.1	226.7
Field crickets	73	43	39.0	28.0
Other insects	15	6	4.7	1.2
Spiders	58	59	17.6	14.5
Frogs	21	12	15.3	47.0
Lizards	10	5	38.1	10.2
House mouse	0	1	0.0	14.3
Unidentified	—	—	26.0	9.5
Number of boluses	65	66		

Siegfried (1971) found that the stomach contents of cattle egrets shot in the morning differed from those of birds shot later in the day. Only 3 of the 24 collections of boluses were made after noon, but their composition seems little different from that of those collected in the morning. To make a better comparison, items collected in one morning were compared with those collected in the afternoon of the same day (Table 2), and were found to be very similar in composition.



**Fig. 1.** Major food items of the cattle egret in the breeding seasons of 1979-80 (solid bars), 1980-81 (open bars) and 1981-82 (stippled bars), as percentages of the total numbers and total weights of identifiable items for each season. *B*, black field cricket; *H*, long-horned grasshoppers; *N*, long-nosed grasshoppers; *L*, short-horned grasshoppers and locusts; *C*, cicadas; *I*, other insects; *S*, spiders; *T*, cattle tick; *A*, Anura (frogs and cane toad); *R*, reptiles (lizards); *M*, mammals.  $\times$  indicates amounts less than 0.1%.

Although the Acrididae were always the most numerous prey, the relative proportions of the main prey categories differed among the breeding seasons (Fig. 1). Thus in 1980–81 the black field cricket, long-horned grasshoppers (Tettigoniidae) and long-nosed grasshoppers (Pyrgomorphidae) were relatively scarce, whereas the Acrididae were more numerous. Cane toads were found in many boluses this summer, and yet were absent in the 1979–80 and 1981–82 seasons. In 1981–82 lizards and especially cicadas were scarcer, but spiders were more abundant in previous years.

On average items of prey were 96% heavier in 1981–82 than in 1977–80 or 1980–81, and mean weights of all major prey were greater then, except for long-nosed grasshoppers and lizards (Table 3). Both adult and nymphal Acrididae were significantly heavier in 1981–82 than in either of the previous two seasons, and the adults were also significantly heavier in 1979–80 than in 1980–81 (Table 3).

Table 3. Mean weights of prey

Results of median test: 1 and 2,  $Z = 3.076$ ,  $P < 0.01$ , 120 d.f.; 1 and 3,  $Z = 4.43$ ,  $P < 0.001$ , 163 d.f.; 4 and 5, not significant; 4 and 6,  $Z = 2.269$ ,  $P < 0.01$ , 389 d.f.

	Mean weight (g)		
	1979–80	1980–81	1981–82
Prey			
Field cricket	0.260	0.382	0.498
Long-horned grasshopper	0.093	0.088	0.135
Long-nosed grasshopper	0.290	0.630	0.410
Acrididae	0.187	0.142	0.296
Spider	0.139	0.082	0.270
Frog	0.49	0.77	1.38
Lizard	2.19	4.44	4.09
All prey	0.209	0.214	0.415
738 individually weighed Acrididae			
Adults	0.297 <sup>1</sup>	0.247 <sup>2</sup>	0.517 <sup>3</sup>
Nymphs	0.145 <sup>4</sup>	0.130 <sup>5</sup>	0.174 <sup>6</sup>
Total number of prey	3933	4853	5682

### Stomach Contents

A total of 2317 prey items were identified in the stomach contents of the 21 adults shot. The largest 'stomach-full' of food weighed 68 g, and filled the stomach and lower oesophagus. The largest number of items in a stomach was 313. On average 30% of the stomach's contents were unidentifiable, much of this being digested material in the gizzard. Prey in the proventriculus and oesophagus were mostly intact.

These adult stomachs contained the same major prey categories as the chick's food boluses and in much the same proportions (Table 4), except for much larger numbers of the green blowfly *Lucilia serricata* and smaller numbers of lizards.

There were large differences in contents between stomachs. For example, one stomach contained 94 short-horned grasshoppers, 4 long-horned grasshoppers, 17 long-nosed grasshoppers, 4 crickets, 3 cicadas, a spider and 12 frogs; while another had 312 cicadas (all *Parnkalla muelleri*) and one long-nosed grasshopper. The frequency of occurrence of prey categories in stomachs also differed considerably (Table 4). Thus all four types of orthopterans occurred in more than 60% of stomachs, whereas the cicada and cattle tick, although quite numerous overall, were present in less than 20%.

There were no obvious differences between the stomach contents of male and female cattle egrets either in composition or in the mean weights of prey items. These weights were not compared statistically but for some prey categories the mean weight was greater in the females and for others greater in the males.

### Transect Data

During the 22 transects, 3–169 (mean 65) cattle egrets were recorded per transect (Table 5). The mean number seen per transect in the 1981–82 season was more than twice that in the previous two seasons, indicating less feeding dispersion in 1981–82 because the number of birds at the heronry was about the same.

Table 4. Stomach contents of 21 adult cattle egrets

	N	Percentage of total items	Weight (g)	Percentage of total weight	Percentage of stomachs
Field cricket	125	5.4	54.4	11.8	61.9
Long-horned grasshoppers	294	12.7	34.0	7.4	61.9
Long-nosed grasshoppers	114	4.9	37.2	8.0	85.7
Short-horned grasshoppers and locusts (Acrididae)	771	33.3	224.6	48.6	90.5
Cicada <i>Parnkalla muelleri</i>	357	15.4	52.5	11.4	19.0
Diptera, mostly <i>Lucilia serricata</i>	408	17.6	18.8	4.1	42.9
Other insects	48	2.1	6.2	1.3	57.1
Spiders	71	3.1	7.8	1.7	47.6
Cattle tick	103	4.5	4.5	1.0	14.3
Anurans	24	1.0	16.4	3.6	33.3
Skinks	2	0.1	1.6	0.3	9.5
Unidentifiable	—	—	204.0	—	—

Most of the cattle egret's day was spent feeding but in the 1980–81 breeding season a substantial proportion (22.5%) of the time was spent flying; in 1981–82, 29.2% were seen resting and feeding occupied only 56.4% of their time. The few aggressive encounters seen were for access to a grazing cow and for conspicuous prey on the bare earth wall of a dam.

Table 5. Summary of transect observations on cattle egrets

	1979–80	1980–81	1981–82
No. of egrets	366	547	512
No. of transects	8	10	4
Mean No. of egrets per transect	45.8	54.7	128
Percentage of egrets:			
Preening	4.1	2.2	7.6
Drinking	1.9	0.6	0.2
Resting	3.3	6.0	29.2
Flying	12.3	22.5	5
Fighting	0	0	1.4
Feeding	78.4	68.7	56.4
Percentage of egrets feeding in:			
Moist pasture	77.2	25.9	34.4
Dry pasture	22.8	73.3	63.8
Other habitat	0	0.8	2.8
Percentage of stock herds in:			
Moist pasture	64.4	32.8	24.4
Dry pasture	35.6	67.2	75.6
Percentage of egrets feeding with stock	81.7	95.7	74.0
Percentage of grazing stock herds with egret(s)	74.6	38.4	54.7
No. of stock herds	59	177	53

The cattle egrets fed almost entirely on pastures (98–100%) but a few patrolled the edge of a ploughed field capturing prey in its verge of long grass, some foraged over the roots of a fallen tree and others fed on an earthen dam wall. In 1979–80, 77% of the egrets and 64% of

the stock concentrated their feeding on the small areas of moist pasture but the proportion was reversed in the following two seasons, when most egrets and cattle fed on dry pasture. Nevertheless, the density of cattle egrets and cattle on moist pasture was always at least twice that on dry pasture. Average densities of cattle egrets were 4.2 per hectare of moist pasture and 1.1 per hectare of dry pasture.

Most egrets (74–96%) fed, in characteristic manner, with stock, following grazing cattle, horses, goats and (elsewhere in the area) sheep, capturing prey disturbed from the grass. They were seen snapping flies off cattle, and, of 44 cattle ticks selected at random from boluses and examined microscopically, three had broken hypostomes and six had cement cones around their hypostomes, indicating that the parent egrets had picked them directly off the cattle. All 44 were engorged adult females.

No more than 75% of stock herds had egrets in attendance each season, which suggests that there was no overall shortage of host animals. However, sizeable proportions of the egrets (4–26%) fed independently of stock each season, so apparently the feeding habitats

Table 6. Numbers of Ardeiformes, excluding cattle egrets, per habitat along the transect, for three breeding seasons combined

	Cultivated land	Dry pasture	Moist pasture	Aquatic	Total
Pacific heron <i>Ardea pacifica</i>	0	0	7	2	9
White-faced heron <i>Ardea novaehollandiae</i>	0	1	0	1	2
Great egret <i>Egretta alba</i>	0	0	0	9	9
Little egret <i>Egretta garzetta</i>	0	0	0	2	2
Intermediate egret <i>Egretta intermedia</i>	0	1	36	5	42
Glossy ibis <i>Plegadis falcinellus</i>	0	0	5	1	6
Sacred ibis <i>Threskiornis aethiopica</i>	0	3	5	1	9
Straw-necked ibis <i>Threskiornis spinicollis</i>	100	95	62	4	261
Royal spoonbill <i>Platalea regia</i>	0	0	0	18	18
Yellow-billed spoonbill <i>Platalea flavipes</i>	0	0	1	4	5
Total	100	100	116	47	363

preferred by the egrets did not always correspond with the distribution of stock. The use of dry and moist pastures did not differ significantly between egrets and stock under normal conditions, but significantly more egret flocks fed in flooded moist pastures in 1981–82 than would have been expected from the proportion of cattle herds grazing there ( $\chi^2 = 5.88$ ,  $P < 0.02$ , 1 d.f.). Every herd in these flooded pastures had egrets in attendance but 82% of the egrets fed independently. Although the egrets' preferences were not quantified, they seemed to avoid short-cropped dry pastures, with or without cattle, and favoured those with tussocks of long grass.

The cattle egrets' feeding range from the heronry was not mapped but they were seen travelling up to 29.3 km to the west, where they were, perhaps, halted only by the steep wooded slopes of the Great Dividing Range.

#### *Other Ardeiformes Sharing the Cattle Egrets' Feeding Grounds*

Ten other species of Ardeiformes were observed along the transect (Table 6). Of these only the straw-necked ibis *Threskiornis spinicollis* approached the cattle egret in abundance, and then only in the dry 1980–81 season, when 286 straw-necked ibis and 547 cattle egrets were recorded. The straw-necked ibis fed in cultivation, dry and moist pastures and to a small extent in open water. The intermediate egret was the next most abundant, especially in 1981–82 when the moist pastures were flooded; 86% were seen in moist pasture. Individuals of the other eight species of Ardeiformes were few, and most fed in moist pastures or aquatic areas.

## Discussion

### *Diet of the Cattle Egret*

From about 10 days old egret chicks feed directly from the parent, ingesting everything the adult regurgitates (author's unpublished observation). This, and the close similarity between the composition of the food boluses regurgitated by advanced chicks and the adult egrets' stomach contents, leave little doubt that the food boluses provided representative samples of the cattle egrets' summer prey.

In south-east Queensland the cattle egret eats a wide diversity of pasture animals, and here, as in Africa and Florida (Skead 1966; Siegfried 1971, 1972; Jenni 1973; Fogarty and Hetrick 1973), grasshoppers, locusts, crickets, spiders and frogs are important food items. In Queensland lizards and the cicada *Parnkalla muelleri* are also major cattle egret prey, although in the overseas studies lizards were of minor importance and cicadas are not mentioned. The cattle egrets studied here were never seen feeding in open water nor were any aquatic prey found in their boluses. Elsewhere, aquatic organisms are a very minor part of their diet except that Ikeda (1956) found 33% of the food of cattle egrets feeding at the edge of rivers and ricefields to be the larva of a diving beetle. The cattle egrets did not probe into the soil in search of food, and the soil-dwelling scarab beetle larvae captured were probably brought to the surface by heavy rain. Earthworms were absent, and coleopterans and lepidopterans were scarce, in the diet of these cattle egrets, whereas Siegfried (1971) found Coleoptera and Lepidoptera to be major summer foods of cattle egrets feeding on irrigated, improved pastures in South Africa. These differences in diet between different parts of the world seem more likely to reflect differences in pasture land faunas rather than any geographic variation in egret food preferences.

Siegfried (1971) found that the cattle egret's diet varied seasonally, earthworms being the main food during the (rainy) winter and spring seasons. Similarly, Heather (1982) says (Australian) cattle egrets wintering in New Zealand eat mostly earthworms, and this could also be the case for the many cattle egrets which spend the winter in southern Australia, which also receives winter rains.

A comparison of the stomach contents of adult cattle egrets reveal them to be catholic and opportunistic predators. Concentrations of a prey species such as the cicada, cattle tick, or green blowfly in some stomachs are most simply explained by clumped dispersions of such species; however, the possibility of variation in food selection among individual cattle egrets, as suggested by Siegfried (1972), cannot be ruled out. Male cattle egrets are 15% heavier than females on average (N. McKilligan, unpublished data) but this does not seem to be related to any differences in the type or size of prey taken by this small sample.

### *Choice of Feeding Habitat, and Relationship with Grazing Stock*

Cattle egrets increase their prey capture rate by feeding in association with grazing cattle (Heatwole 1965; Dinsmore 1973). They will therefore generally seek such an association. The coincidence of cattle egret and cattle distribution is probably further increased by both being attracted to areas of fresh pasture growth; the egrets because of the higher densities of grasshoppers there (Key 1959). The egrets did, however, choose between cattle herds and sometimes chose to feed independently, indicating that other factors influence their choice of feeding habitat. Flooded pastures seemed especially attractive to them, judged by their foregoing opportunities to feed with cattle on nearby lush pastures in order to feed there. Their preference for tussocky rather than short-cropped, dry pasture probably resulted from the former providing more foliage cover and thus harbouring more insects than did uniformly short grass.

Rice (1956) describes the cattle egret as being an obligate commensal of cattle, but in this study a sizeable proportion of egrets fed independently of cattle, and when with cattle they picked flies and ticks off their hosts as well as using the grazing beasts as beaters; the cattle



egret serves the cow as a 'cleaner'. It would seem best then to describe the relationship between cattle egret and cow as facultative mutualism (*sensu* Sprent 1963, pp. 13, 14).

#### *Variation in Food and Feeding Patterns among Breeding Seasons*

The similar compositions of the cattle egret's diet (Fig. 1) in the 1979-80 and 1981-82 breeding seasons were probably due to the availability of freshly growing pastures in both seasons, despite the much lower rainfall in 1979-80 which restricted this growth to swampy land. By contrast, many swamps were dry in the 1980-81 season, rainfall was low, and the egrets were forced to feed to a much greater extent on dried-out pastures. This apparently caused the poorer representation in their diet of the black field cricket, long-nosed grasshoppers and long-horned grasshoppers, which prefer moist conditions, and in the greater proportion of the more xerophilous Acrididae. Under such dry conditions the abundance of cane toads in the boluses in 1980-81 is surprising. None were found in boluses in 1979-80 or 1981-82 although the species was common in the area these summers. Since even young cane toads are likely to be distasteful to egrets, they may have been eaten as a last resort at a time of exceptional food scarcity. The proportion of egrets feeding with cattle was very high (96%) in 1980-81, further indicating a shortage of food as, presumably, this association is most necessary when food is scarce. Siegfried (1978) also noted that this association was most frequent in dry months. The very wet summer of 1981-82, when the grass grew lushly everywhere, seemed the most favourable of the three for the cattle egrets; judged by their spending more time resting and less feeding, by their feeding closer to the heronry, by their more often feeding independently of stock (26%) and, most conclusively, by the significantly heavier prey taken then.

#### *Economic Role of the Cattle Egret*

In the course of a summer the 7000 or so cattle egrets nesting in the Gatton area consume a huge number of orthopterous insects, including known pest species such as *Austracris guttulosa*, *Gastrimargus musicus* and *Teleogryllus commodus*. Key (1959) says that grasshoppers in Australia 'must surely be rated second only to the rabbit as grazing competitors of domestic stock'. The egrets also eat the spiders, frogs and lizards which are the natural predators of these pests, but on balance it seems likely that here, as in South Africa (Siegfried 1971), the net effect of the cattle egrets' predation is to reduce the level of grass-eating insects, to the benefit of the grazier.

Overseas opinion is that the cattle egret is not an important predator of cattle ticks (Jenni 1973). Observations in northern Australia support this (Wilkinson 1970). Although the tick is only a small part of the cattle egrets' diet in this area, I conservatively estimate that collectively they ate about 1.27 million adult ticks during the weeks they were feeding chicks each year. According to a local stock inspector this predation is probably insufficient to significantly reduce the cattle tick population over the whole of the egrets' local feeding range (Trevor Reid, personal communication), but a grazier whose cattle are close to the heronry, where the egrets' impact would be greatest, says his cattle have had markedly fewer ticks since the egrets arrived there 8 years ago (Cyril Sanger, personal communication).

The cattle egret was also useful, in some years at least, in reducing the numbers of flies which annoy cattle, and as a predator of the cane toad. Blaker (1965) suggests that cattle egrets in South Africa 'may be of considerable importance as controllers of dipterous pests of cattle', but this seems unlikely here, because flies formed a sizeable proportion of the egrets' food in only one summer out of four (in the stomach contents collected in 1982-83).

#### *Does the Cattle Egret Compete with Native Ardeiformes for Food?*

Of the native Ardeiformes in the study area only the straw-necked ibis (in 1980-81) and the intermediate egret (in 1981-82) were numerous. The ibises fed in a wider range of habitats than the cattle egrets, and elsewhere in Australia (Carrick 1959) have been shown to

take a wider diversity of prey than did the cattle egret in this area. Behaviourally and morphologically the ibis is better adapted to taking cryptozoic prey, whereas the cattle egret is superior in catching small, rapidly moving, visible items. Most intermediate egrets fed on moist pastures and were only abundant when these were flooded and food seemed plentiful. The intermediate egret and the cattle egret may have competed seriously for food in the 1979–80 season, when the cattle egrets also fed predominantly on moist pastures. Few white-faced herons were recorded along the transect, but observations of this species elsewhere suggest that of the native Ardeiformes its feeding ecology is closest to that of the cattle egret. The status of the white-faced heron in this area before the arrival of the cattle egret is not known, so we do not know whether it has suffered competitive exclusion by the colonizing species. There is obviously overlap in the feeding habitats and probably in the prey taken by cattle egrets and the above native species. This could lessen the chances of survival or reproduction of both groups when food is scarce. The central coastal areas of eastern Australia, which have attracted the greatest number of cattle egrets, are important dry-season refuges for birds such as the straw-necked ibis, which nest in inland swamps (McKilligan 1975). A detailed comparison of the food, feeding ecology and feeding behaviour of the cattle egret and these native species at a time of food shortage is needed to assess the extent to which they compete for food.

### Acknowledgments

I would like to thank Bronwyn Smith, Nicole Teale, Heather Moffat and Robert Haak for their assistance in the field and/or in the laboratory; Ted Dahms and Greg Czechura, of the Queensland Museum, for identifying certain prey items; Dr D. Kemp, Division of Tropical Animal Health, CSIRO, for examining cattle ticks; and Don Seton, Michael Russell and Alan Young for their advice on the manuscript. I am also very grateful to Mr A. Jahnke for allowing me access to the egret heronry, which is on his property. Financial support came from the Darling Downs Institute of Advanced Education's Research Committee and the Queensland Grain Growers Association.

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### Appendix 1. Composition of Food Boluses in the 1979-80 and 1980-81 Breeding Seasons

Measurements for size range are of body length including tail. NR, not recorded

Food items	Number of individuals		Wet weight (g)		Size range (mm) (both seasons)
	1979-80	1980-81	1979-80	1980-81	
Crustacea					
Isopoda (woodlice)	0	3	0	0.4	10
Insecta					
Odonata					
Anisoptera (dragonflies)	2	9	0.5	1.82	NR
Blattodea (cockroaches)	11	40	2	3.21	5-25
Mantodea (mantids)	22	19	9.5	6.18	10-90
Dermaptera (earwigs)	0	1	0	0.05	15
Orthoptera					
Tettigoniidae (long-horned grasshoppers)	477	172	44.5	15.14	8-40
Gryllidae (field crickets)	297	184	77.9	32.8	5-30
Pyrgomorphidae (long-nosed grasshoppers)	307	85	87.81	53.3	10-60
Acrididae (short-horned grasshoppers and locusts)	1587	2940	298.35	416.4	5-55
Phasmatodea (stick insects)	1	1	0.5	0.5	15
Hemiptera					
Cicadidae (cicadas)	790	757	82.2	92.76	8-20
Alydidae	0	2	0	0.05	10-12
Reduviidae (assassin bugs)	0	1	0	0.04	10
Fulgoridae (lantern flies)	0	2	0	0.4	10-18
Coleoptera (beetles)	2	18	0.5	2.82	3-15
Diptera (2-winged flies)					
Tabanidae	1	3	0.2	0.11	5-10
Asilidae (robber flies)	10	16	1.55	2.96	10-40
Bombyliidae	0	2	0	0.08	8-15
Syrphidae (hover flies)	2	0	0.02	0	NR
Platystomatidae	0	1	0	0.1	7
Muscidae	12	6	0.26	1.1	5-7
Calliphoridae (blowflies)	5	14	0.50	0.63	5-10
Tachinidae	0	2	0	0.18	5-10
Hymenoptera					
Formicidae (ants)	1	1	0.10	0.02	6-15
Lepidoptera (larvae only)	27	39	4.07	3.09	2-40
Chilopoda (centipedes)	0	3	0	1.9	40-65
Arachnida					
Araneae (spiders)	171	276	23.7	23.43	2-25
Acarina (cattle tick)	83	59	3.9	4.3	5-10
Amphibia	54	138	24.75	106.2	10-60
Reptilia	69	58	151.05	257.3	20-350
Mammalia	2	1	10.7	11.1	120
Unidentified	—	—	61.55	128.86	—
Number of food boluses examined	106	155			

## Appendix 2. The Major Species of Prey in Food Boluses, 1979-80 and 1980-81

### *Acrididae*

Identified by Dr E. C. Dahms

*Austracris guttulosa*

*Froggattina australis*

*Oedalus australis*

*Austroicetes* sp.

*Gastrimargus musicus*

*Pycnostictus seriatus*

*Caledia captiva*

### *Amphibia and Reptiles*

Identified by Dr G. Czechura. Numbers identified in parentheses

Amphibia: Anura

*Lialis burtoni* (1)

Leptodactylidae

Agamidae

*Cyclorana alboguttatus* (1)

*Amphibolurus muricatus* (2)

*Limnodynastes tasmaniensis* (11)

Scincidae

*Platyplectrum dumerilii* (3)

*Carlia foliorum* (3)

Hylidae

*Carlia munda* (1)

*Litoria caerulea* (1)

*Carlia schmeltzii* (1)

*Litoria fallax* (64)

*Carlia vivax* + *C. pectoralis* (21)

Bufonidae

*Ctenotus robustus* (13)

*Bufo marinus* (89)

*Egernia modesta* (5)

Reptilia: Sauria

*Eremiascincus richardsonii* (1)

Pygopodidae

*Lampropholis delicata* (17)

*Delma plebia* (5)

*Morethia boulengeri* (2)

Manuscript received 29 April 1983; accepted 7 July 1983