Feeding ecology of Javan Pond Heron *Ardeola speciosa* and Cattle Egret *Bubulcus ibis* in North Sulawesi, Indonesia, with additional notes on the occurrence of ardeids

J.W.C. Vermeulen
A.L. Spaans

RIN contributions to research on management of natural resources 1987-2

Research Institute for Nature Management

The Research Institute for Nature Management (RIN) was established as a government institute in its present form in 1969. Its task is to provide scientific support for the formulation of government policy and activities in conservation and management of nature and natural resources. This task is carried out by means of ad hoc and long-term research programmes on terrestrial, freshwater, and coastal ecosystems, and on the ecology of individual plant and animal species.

Whenever possible, requests to carry out specific research on the impact of technology on ecosystems, on management practices for nature conservation, and on environmental pollution are incorporated into the research programme. Such research is also carried out on a contract basis. In recent years, the Institute is being involved in a number of projects in developing countries.

The present report series aims to present the work of the Institute to a wider audience and may be quoted with proper reference to the source. Further information can be obtained from:

The Editor
Research Institute for Nature Management
P.O.Box 46
3956 ZR LEERSUM
The Netherlands

This report can be ordered by prepayment of Dfl 10 (postage included) on postal account 516 06 48 of RIN at Leersum - The Netherlands; order number RIN Contr. 1987-2

Feeding ecology of Javan Pond Heron *Ardeola speciosa* and Cattle Egret *Bubulcus ibis* in North Sulawesi, Indonesia, with additional notes on the occurrence of ardeids

J.W. Charlotte Vermeulen & Arie L. Spaans

RIN Contributions to Research on Management of Natural Resources
1987-2

Research Institute for Nature Management
Arnhem
1987

Drawing cover : Dirk J. Moerbeek

CONTENTS

Wetland rice in the Dumoga Valley (photo R.W.R.J. Dekker).

1 SUMMARY

The role of Javan Pond Heron *Ardeola speciosa* and Cattle Egret *Bubulcus ibis coromandus* in the sawah ecosystem of North Sulawesi, Indonesia, was studied during 1985 and 1986. Javan Pond Herons foraged mainly in irrigated ricefields which were recently ploughed or recently planted. Their prey consisted predominantly of dragonfly and waterbeetle larvae, molecrickets, and spiders. Cattle Egrets foraged mainly in wet ricefields which were being ploughed and on dry, harvested ricefields. The Cattle Egret's diet consisted mainly of grasshoppers, crickets, and spiders. A comparison is made of the sampling methods used. The economic importance of the herons in preventing orthopteran pest outbreaks is discussed. Notes on herons in North Sulawesi are included in an appendix.

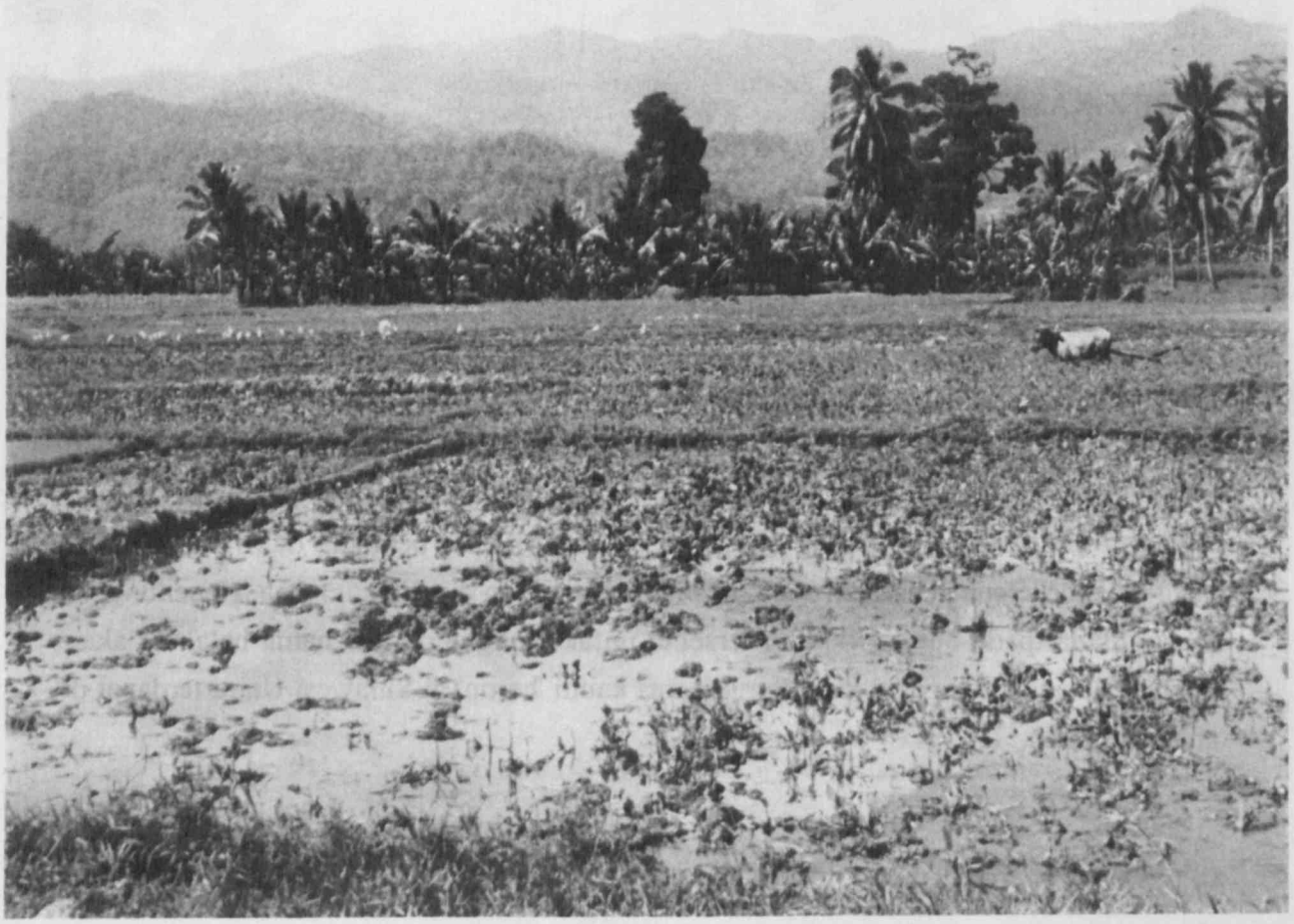
2 RINGKASAN

Peranan daripada burung Blekok Jawa *Ardeola speciosa* (Javan Pond Heron) dan burung Kuntul Kerbau *Bubulcus ibis coromandus* (Cattle Egret) dalam ekosistem sawah di lembah Dumoga Sulawesi Utara telah diteliti pada tahun 1985 dan 1986. Burung Blekok Jawa mencari makanan chususnya di sawah yang barusan dibajak dan yang belum lama ditanami. Mangganya yang terpenting adalah larva dari capung dan kumbang air (waterbeetle), jangkrik tanah dan labah-labah. Burung Kuntul Kerbau mencari makanan kebanyakan di persawahan yang baru dibajak dan sawah kering yang habis dituai. Makanan daripada jenis burung ini chususnya terdiri dari belalang dan jangkrik, dan labah-labah. Metode penarikan contoh yang berbeda akan diperbandingkan. Kepentinggan ekonomis daripada burung burung tersebut untuk menghindarkan hama belalang akan dibahas. Catatan mengenai jenis burung dari kaum 'heron' di Sulawesi Utara terdapat di dalam lampiran.

3 SAMENVATTING

In 1985 en 1986 werd de rol van de Javaanse rijstreiger *Ardeola speciosa* en de Koereiger *Bubulcus ibis coromandus* in het sawah-ecosysteem van Noord-Sulawesi, Indonesië, bestudeerd. De Javaanse Rijstreiger foerageert vooral op natte rijstvelden die recent zijn geploegd en op natte velden met jonge rijst. Larven van libellen en waterkevers, veenmollen en spinnen zijn de voornaamste prooien. De Koereiger zoekt zijn voedsel vooral op natte rijstvelden waarop wordt geploegd en op droge, geoogste rijstvelden. Voor

deze soort zijn sprinkhanen, krekels en spinnen de belangrijkste prooien. Verschillende monstermethoden worden besproken en met elkaar vergeleken. Het economische belang van de reigers bij de preventie van sprinkhanenplagen wordt bediscussieerd. Aanvullende waarnemingen van de reigersoorten van Sulawesi worden vermeld in een bijlage.



Study area in the Dumoga Valley showing recently ploughed ricefields (photo R.W.R.J. Dekker).

4 INTRODUCTION

In the 1970s, the Dumoga Valley, North Sulawesi, Indonesia, was opened up for agriculture and transmigration causing an increase in land use of wetland ricefields irrigated by World Bank sponsored irrigation projects. The surrounding Dumoga-Bone National Park protects the water catchment of these projects. The area harbours large heron populations, mainly Cattle Egret *Bubulcus ibis* and Javan Pond Heron *Ardeola speciosa*. The present project concerns the feeding ecology of these two species to evaluate their role as predators of harmful insects in wetland rice and thus in the possible prevention of pest outbreaks. A decrease of the heron populations can be expected due to an increase in the use of pesticides, clearance of heron nesting and sleeping sites, and synchronization of rice cultivation which will accompany further development of the area. An optimal landscape planning of the area integrates development with nature conservation by guaranteeing the occurrence of natural pest predators in cultivated areas. Protection of the heron species in the area by protecting their nesting and sleeping sites in marginal marshy areas could prevent outbreaks of certain ricepests and lead to a lower pesticide use on the long term, with all economical and environmental benefits for man involved. Protection of the marginal marshy areas will also benefit other bird species in this ecosystem.

The role of Javan Pond Heron and Cattle Egret in the sawah ecosystem of North Sulawesi was studied during 1985 and 1986. Both species are abundant in the research area. There they forage mainly in the wetland ricefields like herons in other parts of the world where wetland rice is cultivated on a larger scale (Fasola 1983, Ruiz 1985). The feeding ecology of the Asian subspecies of the Cattle Egret, *B. ibis coromandus* has not been studied as extensively as *B. ibis ibis* (Ikeda 1956, Heather 1978, Hancock & Kushlan 1984, McKilligan 1984), while hardly any research has been conducted on *A. speciosa* (Hancock & Kushlan 1984). This report gives results on the feeding ecology of both species. As data on the herons of Sulawesi are scarce and incomplete (Hancock & Kushlan 1984, White & Bruce 1986, Uttley 1987), general remarks on their status in North Sulawesi are included in Appendix III.

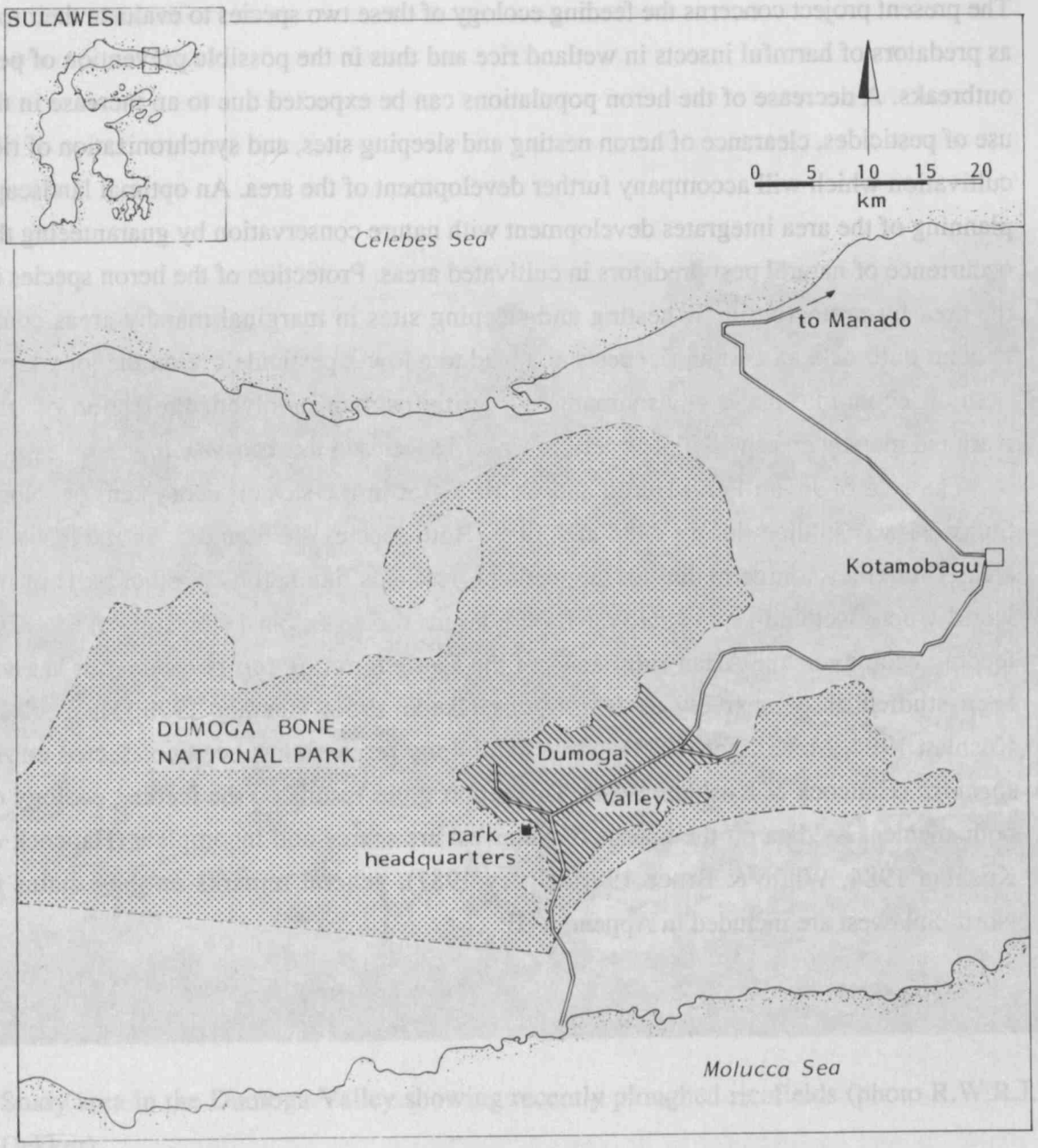


Figure 1. Geographical position of the study area.

5 STUDY AREA AND METHODS

The feeding ecology of Javan Pond Heron and Cattle Egret was studied in an area of 20 x 6 km in the western part of the Dumoga Valley, North Sulawesi, Indonesia (Fig. 1). This part of the valley was predominantly lowland tropical rainforest until some 20 years ago when logging started and settlements were built. Indigenous and transmigrant farmers came to the area to cultivate wetland rice and soya beans. Two irrigation schemes provide water for more than 10,000 ha of wetland rice. The Dumoga-Bone National Park, 300,000 ha of uninterrupted rainforest surrounding the Dumoga Valley on three sides (Fig. 1), protects the water catchment of the irrigation schemes.

Nowadays the valley harbours large numbers of herons as a result of the favourable conditions developed during the cultivation of the area. Moreover, the asynchronous cultivation of wetland rice results in a suitable foraging habitat throughout the year, while marginal swampy habitats between ricefields and reed-beds along rivers provide good nesting and sleeping sites. The fairly low levels of pesticide use are not yet a threat to the quality of the environment.

To collect data on foraging habitat suitability and preference, the numbers of Javan Pond Herons and Cattle Egrets foraging in ricefields in different stages of development were counted along a transect of 16 km on seven mornings between 24 June 1985 and 14 May 1986. Ricefields included : (a) recently ploughed fields and fields which were being ploughed, (b) fields with young rice (until six weeks after planting), (c) fields with older rice (from six weeks after planting until harvesting), (d) recently harvested fields, and (e) temporarily fallow lands either with or without cattle. Birds were observed with Zeiss binoculars (10 x 40) and a Hensoldt Wetzlar telescope (40x).

To collect samples on the diet, nests and nesting colonies were visited regularly. When alarmed, young herons often regurgitate their food (Siegfried 1966, Kushlan & Kushlan 1975, McKilligan 1984). These regurgitations were collected from the ground. Nestlings which had not yet emptied their stomach, were stimulated to do so by gently massaging their abdominal region as described by Siegfried (1971). Young Cattle Egrets reacted better to this treatment than young Javan Pond Herons did. Stomachs of young birds found dead under nesting trees and those of adults found as traffic victims, shot by local people, or tangled in fishing rope, were collected as well.

Hibbert-Ware (1940), Hoogerwerf (1950), and Bredin (1983) studied the diet of herons by analysing pellets. Pellets regurgitated by young and adult herons, consist of undigestable food parts, comparable with owl pellets. Each pellet gives an indication of the food collected by one bird during one day (Bredin 1983). Pellets of Javan Pond Herons were collected under their nests, and at monospecies and mixed sleeping sites, while

pellets of Cattle Egrets were found at mixed sleeping sites only.

Pellets found at mixed sleeping sites were compared with those found under nests and at monospecies sleeping sites of Javan Pond Heron. When they looked the same, they were attributed to this species. The other pellets were attributed to Cattle Egret as some 90% of the herons at the mixed sites belonged to this species. Pellets which were atypical or not fresh (dry or mouldy) were excluded from the analysis. This has the disadvantage that individuals which had eaten an atypical meal and thus produced an atypical pellet, have been excluded from the analysis, but the probability that all remaining pellets are of Cattle Egret is higher.

All samples were preserved in 70% alcohol pending analysis. To sort out the samples, they were rinsed with water, filtered through a fine cloth, and analysed in water in petri-dishes with an Olympus SZ-III microscope (stereo zoom, 7-40x). Prey species, both fragments like mandibles, legs, and heads, and entire food items were counted per species or group and collected in labelled vials. To ease identification, vial contents were compared with insects caught in ricefields with a sweepnet, waternet, lighttrap, or by local children. Most food items could be identified up to genus or species level with additional expertise of participants of Project Wallace, the expedition of the Royal Entomological Society of London to North Sulawesi during the whole of 1985 (see Acknowledgements). For each sample, the name of species or group and the number of individuals were registered.

Means are given ± standard deviations.

6 RESULTS

6.1 Foraging habitat and feeding behaviour

Javan Pond Herons foraged mainly in recently ploughed, wet ricefields, including fields which were being ploughed ($\bar{x}$= 18.8±14.86 birds.ha^{-1}, Appendix Ia), and in recently planted, wet ricefields ($\bar{x}$= 1.4±0.73 birds.ha^{-1}). Especially in submerged muddy fields which had been ploughed and harrowed, high densities were found (e.g. 50 individuals on a 75x100m ricefield). In recently planted fields, the birds usually foraged solitarily. On every transect count, approximately 80% of all Javan Pond Herons were found on ploughed fields (range 73.0%- 94.3%, $\bar{x}$= 81.7±7.42) and the number of Javan Pond Herons per ha in this habitat was inversely related to the availability of these fields. Only few Javan Pond Herons were observed foraging in ricefields with rice older than six weeks ($\bar{x}$= 0.1±0.26 birds.ha^{-1}), on harvested plots ($\bar{x}$= 0.2±0.20 birds.ha^{-1}), or on fallow lands ($\bar{x}$= 0.2±0.26 birds.ha^{-1}). The species was also seen fishing along lakes and rivers, on submerged foothpaths (sometimes perching on a branch), and in estuaries along the coast (R.W.R.J. Dekker). Some individuals followed ploughs like Cattle Egrets. However, contrarily to Cattle Egrets, they continued to forage after ploughing had stopped.

Cattle Egrets foraged mainly in recently ploughed, wet ricefields including fields which were being ploughed ($\bar{x}$= 8.6±4.63 birds.ha^{-1}, Appendix Ib), and on dry, harvested or fallow lands ($\bar{x}$= 3.8±7.87 and 3.4±2.25 birds.ha^{-1}, respectively). The highest densities were usually recorded on fields which were being ploughed, with Cattle Egrets following the plough. They often foraged in groups, sometimes associated with cattle, both in dry and wet habitats. Detailed results of the transects counts are given in Appendix I.

The feeding behaviour of the Javan Pond Heron has not yet been described (Hancock & Kushlan 1984). Like other pond herons, the species uses the 'Standing and Walking Slowly' method (nomenclature according to Hancock & Kushlan 1984). In young ricefields and on paddy dikes, the Javan Pond Heron usually stands in a 'Crouched Posture', 'Head Swaying' or 'Peering Over'. 'Hopping Behaviour' was observed regularly when frogs were chased from paddy dikes. 'Flycatching' was observed only occasionally, for instance when copulating damselflies (Zygoptera, Odonata) were snapped out of the air. 'Probing' was observed several times in muddy ricefields, e.g. when a molecricket (Gryllotalpidae, Orthoptera) was caught. The prey was rinsed in water before being swallowed. 'Body Swaying', 'Gleaning', and 'Bill Vibrating' have been observed occasionally.

The variation in the Cattle Egret's feeding behaviour in the Dumoga Valley is in

accordance with Hancock & Elliott (1978). The usual behaviour is a steady strut, leading to a short dash forward and a quick stab as described by Hancock & Elliott (1978).

Table 1. Food of nestling Javan Pond Herons (n= 26) and Cattle Egrets (n= 26), based on regurgitations of chicks.

	Javan Pond Heron				Cattle Egret			
	n_i	%	oc	$\bar{x}$±s.d.	n_i	%	oc	$\bar{x}$±s.d.
Insects								
Orthoptera	94	14.3	42.3	3.6± 9.0	510	45.6	96.2	19.6±19.6
Coleoptera	115	17.6	34.6	4.4±13.8	13	1.2	26.9	0.5± 1.0
Odonata	185	28.2	38.5	7.1±20.1	24	2.1	34.6	0.9± 1.6
Blattaria	1	0.1	3.8	<0.05	96	8.6	57.7	3.7± 9.1
Other insects	39	6.0	34.6	1.5± 2.8	150	13.4	69.2	5.8± 8.6
Araneae	119	18.2	23.1	4.6±16.3	314	28.1	96.2	12.1±15.5
Pisces	72	11.0	50.0	2.8± 5.6	8	0.7	11.5	0.3± 1.1
Ranidae	10	1.5	30.8	0.4± 0.7	1	0.1	3.8	<0.05
Other	20	3.1	15.4	0.8± 2.5	2	0.2	7.7	0.1± 0.3
Total	655	100.0		25.2±45.6	1118	100.0		43.0±39.7

n_i= numbers of preys found; %= percentage of each group of total; oc= occurrence (percentage of samples in which a group is present); $\bar{x}$±s.d.= mean number of group per sample with one standard deviation.

6.2 Food of nestlings

Javan Pond Heron

Between March 1985 and May 1986, 26 regurgitations of young Javan Pond Herons were collected, containing between 1-183 food items, with an average of 25.2 (Table 1). Main prey groups in the food were Odonata (dragonflies and damselflies), Araneae (spiders), Coleoptera (beetles), Orthoptera (grasshoppers and crickets), and Pisces (fishes, including some Cichlidae). Within the Odonata, dragonfly larvae (Anisoptera) were the most important prey group (94.6%). Within the Coleoptera, waterbeetle larvae, mainly *Cybister tripunctatus* (Dytiscidae) and *Hydrophilus bilineatus* (Hydrophilidae), were eaten most frequently (79.1%). The orthopteran intake consisted mainly of molecrickets (Gryllotalpidae, 34.0%, *Gryllotalpa* cf. *orientalis*), crickets (Gryllidae, 30.9%, mainly *Loxoblemmus* spec.), and Tetrigidae (27.7% e.g. *Loxilobus insidiosus*). Although spiders were found in large numbers, they were not present in many samples. In only two samples, 96.6% of all spiders occurred. Most Odonata (77.3%) were found in just two samples. The Javan Pond Heron preys predominantly upon aquatic prey (dragonfly larvae, waterbeetle larvae, waterbugs,and fishes). Five stomachs of young Javan Pond Herons found dead in nesting colonies, contained on average 11.6±7.70 items, all being insects and spiders. Groups included Odonata (34.5%, x̄= 4.0±7.28), Coleoptera (25.9%, x̄= 3.0±1.87), Orthoptera (8.6%, x̄= 1.0±0.00), Araneae (3.5%, x̄= 0.4±0.55), and "other insects" (27.9%, x̄= 3.2±2.17, mainly Formicidae (ants), 43.8%, and Lepidoptera (butterflies and moths), 31.2%). The regurgitations and stomachs of young Javan Pond Herons contained the acridiid *Oxya japonica japonica*, the tettigoniid *Xestophrys horvathi* (both Orthoptera), an undescribed Harpalini species, adult dytiscids (*Hydaticus* cf. *leander* and *Eretus sticticus*) (all Coleoptera), the waterbug *Sphaerodema rusticum*, the leafhopper *Cofana spectra*, Cicadellidae (all Hemiptera), adult *Pelopidas agna agna* (Hesperidae, Lepidoptera), Dermaptera (earwigs), Diptera (flies), Synbranchidae (slit-eels), *Rana limnocharis* (Ranidae, frogs), Annelida (all earthworms), and Mollusca (slugs).

Cattle Egret

In April and May 1986, 26 regurgitations of young Cattle Egrets were collected on one location, containing between 2-149 food items, with an average of 43.0 (Table 1). Main prey species were Orthoptera, Araneae, Blattaria (cockroaches), and "other insects". Within the Orthoptera, Gryllidae (crickets, 47.5%, mainly *Loxoblemmus* spec.) and Gryllotalpidae (molecrickets, 21.2%, mainly *Gryllotalpa* cf. *orientalis*) were more commonly eaten than Tettigoniidae (long-horned grasshoppers, 13.9%, mainly *Conocephalus* spp.), Acridiidae (short-horned grasshoppers, 8.8%), and Tetrigidae (8.6%). Diptera (flies, 37.3%) and Dermaptera (earwigs, 32.7%) were the most important

Javan Pond Heron foraging in young rice (photo R.W.R.J. Dekker).

preys in the group "other insects". Both Orthoptera and Araneae were found in 96.2% of the samples. Odonata and Coleoptera, although eaten in small numbers, occurred both in about a third of the regurgitations. Unlike the Javan Pond Heron, the different prey groups of the Cattle Egret were distributed equally among the samples. The diet of nestling Cattle Egrets included the tettigoniids *Mecopoda elongata* and *Hexacentrus* spec., the acridiids *Acrida willemsei*, *Locusta migratoria*, *Heteropteris obscurella*, *Atractomorpha psitticana psitticana*, *Oxya japonica japonica*, and *Stenocatantops splendens*, the tetrigids *Euparatettix celebesicus*, *Probolotettix* sp. n., *Mazarredia* sp. n. and *Loxilobus insidiosus*, the gryllid *Euscyrtus* cf. *hemelytrus* (all Orthoptera), the carabids *Pherosophus* spec., *Chlaenius bimaculatus*, and some Harpalini spp., *Enochrus* spec., some Scarabaeidae, and Dytiscidae larvae (all Coleoptera), several Hemiptera (*Nezara viridula*, *Sphaerodema rusticum*, Reduviidae, Pentatomidae, Gerridae, and Lygaeidae), Diptera (mainly Tabanidae, horseflies), *Mythimna* spec. (Lepidoptera), Hymenoptera, Mantidae (praying mantids), Synbranchidae (slit-eels), Ranidae (tadpoles), and the skink *Mabuya rudis*.

Table 2. Food of breeding Javan Pond Herons (n= 3) and non-breeding Cattle Egrets (n= 7), based on stomach contents of birds shot by local people or found dead.

	Javan Pond Heron				Cattle Egret			
	n_i	%	oc	$\bar{x}$±s.d.	n_i	%	oc	$\bar{x}$±s.d.
Insects								
Orthoptera	60	11.3	66.7	20.0± 20.5	517	72.2	100.0	73.9±47.2
Coleoptera	18	3.4	66.7	6.0± 7.2	8	1.1	71.4	1.1± 1.1
Odonata	445	83.7	66.7	148.3±256.1	7	1.0	71.4	1.0± 0.8
Blattaria					23	3.2	85.7	3.3± 3.0
Other insects	3	0.6	33.3	1.0± 1.7	60	8.4	100.0	8.6± 5.1
Araneae	2	0.4	33.3	0.7± 1.2	91	12.7	85.7	13.0±10.2
Pisces	3	0.6	66.7	1.0± 1.0				
Other					10	1.4	28.6	1.4± 3.4
Total	531	100.0		177.0±281.7	716	100.0		102.3±55.5

n_i= numbers of preys found; %= percentage of each group of total; oc= occurrence (percentage of samples in which a group is present); $\bar{x}$±s.d.= mean number of group per sample with one standard deviation.

6.3 Food of adults

Javan Pond Heron

Three stomachs of Javan Pond Herons in breeding plumage and with a brood patch contained between 2-502 food items ($\bar{x}$= 177±281.7, Table 2). One adult male found tangled in fishing rope, had only two fishes in its stomach. Another adult, shot by local people, had 502 food items in its stomach, of which 442 were Odonata larvae. Main prey groups in breeding adults were Odonata, Orthoptera, and Coleoptera. The diet of breeding adults seems to resemble that of the nestlings.

Cattle Egret

Seven stomachs of adult Cattle Egrets, all without a brood patch and in white plumage thus lacking the buff feathers often seen in breeding birds, contained between 24-203 items ($\bar{x}$= 102.3±55.5, Table 2). Main prey items were Orthoptera, Araneae, and "other insects". The Orthoptera group can be divided into Tettigoniidae (33.1%), Gryllidae (28.0%), Acridiidae (26.7%), and Tetrigidae (6.8%). The main prey group within the "other insects" were Lepidoptera (46.7%). The stomachs of the adult Cattle Egrets contained relatively more Orthoptera and less Araneae than the nestlings' samples. Within the Orthoptera, less Gryllidae (28.0%, mainly *Euscyrtus* cf. *hemelytrus*), and more Tettigoniidae (33.1%, mainly *Conocephalus* spp.) and Acridiidae (26.7%) were found. No Gryllotalpidae were found. In the stomachs of the adult Cattle Egrets the tettigoniids *Mecopoda elongata* and *Hexacentrus* spec., the acridiids *Oxya japonica japonica*, *Atractomorpha psitticana psitticana*, *Stenocatantops splendens*, *Acrida willemsei*, *Heteropternis obscurella*, and *Locusta migratoria*, the tetrigids *Euparatettix personatus*, *Hedotettix costatus*, *Paratettix tricarinatus*, and *Probolotettix* sp. n., *Loxoblemmus* spec. (Gryllidae), *Melanites* cf. *leda* and *Pelopidas* spec. (both Lepidoptera), *Riptortus linearis* (Alydidae, Hemiptera), *Chlaenius bimaculatus*, some Harpalini spp. (both Carabidae), *Glycyphana* spec. (Cetoniidae) (all Coleoptera), a newly hatched bird (Aves), and the blue-tailed skink *Emoia korduana* were found.

Table 3. Contents of pellets from Javan Pond Heron found under nests (UN, n= 39) and at monospecies sleeping sites (AS, n= 7).

	Under nests				At sleeping sites			
	n_i	%	oc	$\bar{x}$±s.d.	n_i	%	oc	$\bar{x}$±s.d.
Insects								
Orthoptera	84	20.5	84.6	2.1±2.2	22	10.7	85.7	3.2±2.4
Coleoptera	202	49.3	89.7	5.2±6.5	90	43.9	100.0	12.9±6.1
Odonata	22	5.4	23.1	0.6±1.7	17	8.3	71.4	2.4±3.1
Blattaria	2	0.5	2.6	0.1±0.3				
Other insects	66	16.1	46.2	1.7±4.5	49	23.9	71.4	7.0±8.0
Araneae	25	6.1	25.6	0.6±1.7	24	11.7	100.0	3.4±2.1
Pisces	3	0.7	7.7	0.1±0.3				
Ranidae	6	1.4	15.4	0.1±0.4	3	1.5	42.9	0.4±0.5
Total	410	100.0		10.5±11.0	205	100.0		29.3±13.7

n_i= numbers of preys found; %= percentage of each group of total; oc= occurrence (percentage of samples in which a group is present); $\bar{x}$±s.d.= mean number of group per sample with one standard deviation.

6.4 Pellet analysis

Javan Pond Heron

Pellets of Javan Pond Heron were collected under nests (UN), at monospecies sleeping sites (AS), and at mixed sleeping sites (MS). To test for heterogeneity between these three sets of samples, the G-test for heterogeneity was applied to the occurrence in numbers for Orthoptera and Odonata (Sokal & Rohlf 1969, Box 16.4). For both groups, the three sets of samples were not homogeneous ($G_{H.Orthoptera}$= 9.942 and $G_{H.Odonata}$= 6.056, both > $X^2$0.5[2]= 5.99). To test if two sets of samples were homogeneous, an a posteriori test by STP of the homogeneity of sets of replicates was applied to all combinations of two sets of occurrences in numbers for Orthoptera and Odonata (Sokal & Rohlf 1969, Box 16.5). For Odonata, the difference between UN and AS samples was heterogeneous ($G_{H:UN-AS.Odonata}$= 6.027 > $X^2$0.5 [2]= 5.99), while for Orthoptera the two sets were homogeneous ($G_{H:UN-AS.Orthoptera}$= 0.01). Although the other combinations were homogeneous, the G_H-values were different for Orthoptera and Odonata ($G_{H:UN-MS.Orthoptera}$= 3.764, $G_{H:UN-MS.Odonata}$= 0.294, $G_{H:AS-MS.Orthoptera}$= 1.260, $G_{H:AS-MS.Odonata}$= 4.626). For this reason, all three sets of samples are given separately in Tables 3 and 4.

Pellets of Javan Pond Heron contained mainly Coleoptera (predominantly waterbeetles, UN= 74.3%, AS= 91.1%, MS= 77.6%), Orthoptera (mainly the molecricket *Gryllotalpa* cf. *orientalis*, UN= 75.0%, AS= 50.0%, MS= 69.8%), "other insects" (Formicidae (ants), UN= 56.1% and Hemiptera, AS= 34.7%, MS= 40.4%), and Araneae (spiders). UN pellets contained also Tettigoniidae (e.g. *Conocephalus maculatus*), Acridiidae (e.g. *Oxya japonica japonica*), Gryllidae (e.g. *Loxoblemmus* spec.), and Tetrigidae (all Orthoptera), *Cybister tripunctatus* larvae, *Hydaticus* cf. *leander*, and *Hyphydrus* spec. (all Dytiscidae), *Hydrophilus bilineatus* larvae (Hydrophilidae), *Onthophagus wallacei* (Scarabaeidae), and Carabidae (all Coleoptera), the waterbug *Sphaerodema rusticum*, the leafhopper *Cofana spectra*, *Enithares* spec., Lygaeidae, and Reduviidae (all Hemiptera), Anisoptera larvae and adults (Odonata), Lepidoptera larvae, Pisces (fishes), and *Rana* spec. (Ranidae, frogs). AS pellets contained also Tettigoniidae, Acridiidae (e.g. *Oxya japonica japonica*), and Gryllidae (all Orthoptera), *Cybister tripunctatus* larvae, *Hydaticus* cf. *leander*, *Eretus sticticus*, and *Laccophilus* spec. (all Dytiscidae), *Hydrophilus bilineatus* larvae, and *Sternolophus* spec. (both Hydrophilidae), an undescribed Harpalini species (Carabidae) (all Coleoptera), the waterbug *Sphaerodema rusticum*, the leafhopper *Cofana spectra*, the pentatomid *Eysarcoris* spec., Lygaeidae, and Reduviidae (all Hemiptera), Anisoptera larvae and adults (Odonata), Lepidoptera larvae,

Table 4. Contents of pellets from Javan Pond Heron (n=35) and Cattle Egret (n=37) from mixed sleeping sites.

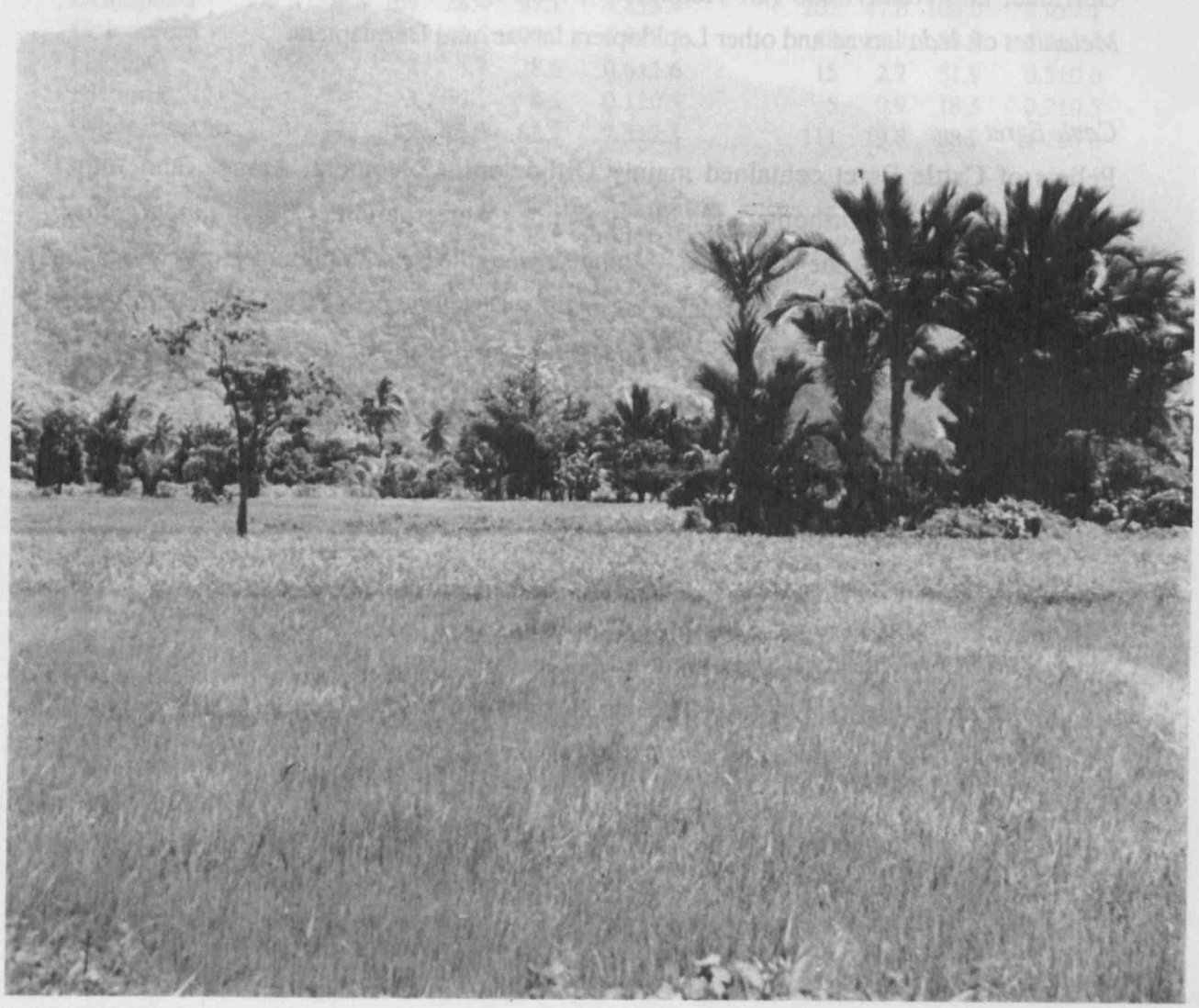
	Javan Pond Heron				Cattle Egret			
	n_i	%	oc	$\bar{x}$±s.d.	n_i	%	oc	$\bar{x}$±s.d.
Insects								
Orthoptera	169	28.4	97.1	4.8±3.4	267	47.6	100.0	9.9±7.1
Coleoptera	241	40.6	100.0	6.9±7.2	88	15.7	88.9	3.3±3.4
Odonata	22	3.7	28.6	0.6±1.6	15	2.7	51.9	0.5±0.6
Blattaria	3	0.5	8.6	0.1±0.3	5	0.9	18.5	0.2±0.5
Other insects	89	15.0	82.9	2.5±2.3	111	19.8	88.9	4.1±5.0
Araneae	68	11.4	71.4	2.0±2.2	75	13.3	88.9	2.8±3.1
Pisces	1	0.2	5.7	0.1±0.2				
Other	1	0.2	2.9					
Total	594	100.0		17.0±10.2	561	100.0		20.8±12.7

n_i= numbers of preys found; %= percentage of each group of total; oc= occurrence (percentage of samples in which a group is present); $\bar{x}$±s.d.= mean number of group per sample with one standard deviation.

and *Rana* spec. (Ranidae, frogs). MS pellets also contained Acridiidae (e.g. *Oxya japonica japonica*, *Stenocatantops splendens*, and *Atractomorpha psitticana psitticana*), Gryllidae (e.g. *Loxoblemmus* spec.), and Tetrigidae (all Orthoptera), *Cybister tripunctatus* larvae, *Hydaticus* cf. *leander*, and *Eretus sticticus* (all Dytiscidae), *Hydrophilus bilineatus* larvae, *Enochrus* spec. and *Berosus indicus* (Hydrophilidae), *Charitovalgus vermeulenae* (Cetoniidae), *Onthophagus wallacei* (Scarabaeidae), and *Pherosophus* spec., *Chlaenius bimaculatus*, and *Stenolophus quinquepustulatus* (Carabidae) (all Coleoptera), the waterbug *Sphaerodema rusticum*, the leafhopper *Cofana spectra*, *Enithares* spec., Gerridae, and Reduviidae (all Hemiptera), Anisoptera larvae and adults (Odonata), *Melanites* cf. *leda* larvae and other Lepidoptera larvae, and Dermaptera.

Cattle Egret

Pellets of Cattle Egret contained mainly Orthoptera, Coleoptera, Aranea, and "other insects". Within the Orthoptera mainly Acridiidae were found (31.8% *Stenocatantops splendens* and 43.1% other acridiids). Carabidae were the most important group within the Coleoptera (43.2%). "Other insects" were mainly Dermaptera (43.2%). Pellets of Cattle Egret contained also the acridiid *Oxya japonica japonica*, *Atractomorpha psitticana psitticana*, *Heteropternis obscurella*, and *Locusta migratoria*, the tettigoniid *Conocephalus maculatus*, tetrigids, the gryllids *Loxoblemmus* spec. and *Euscyrtus* cf. *hemelytrus*, *Gryllotalpa* cf. *orientalis* (Gryllotalpidae) (all Orthoptera), *Chlaenius bimaculatus*, *Pherosophus* spec., *Cicindela* spec., and a new Harpalini species (Carabidae), *Onthophagus wallacei* and *O. rectecornutus* (Scarabaeidae), *Hydaticus* cf. *leander* and *Eretus sticticus* (Dytiscidae), *Hydrophilus bilineatus* larvae, *Enochrus* spec., *Sternolophus* spec., and *Berosus indicus* (Hydrophilidae) (all Coleoptera), Reduviidae, the waterbug *Sphaerodema rusticum*, Hydrometridae and *Riptortus linearis* (Alydidae) (all Hemiptera), *Melanites* cf. *leda* and other Lepidoptera larvae.



The tropical rainforest of the Dumoga-Bone National Park acts as a watercatchment area for rice cultivation in the Dumoga Valley (photo R.W.R.J. Dekker).

7 DISCUSSION

7.1 Feeding ecology

Feeding habitat preference and food choice of the Javan Pond Heron in North Sulawesi resemble that of its congeners in other parts of the world (Squacco Heron *A. ralloides*, Indian Pond Heron *A. grayii*, and Chinese Pond Heron *A. bacchus*). The Javan Pond Heron prefers recently ploughed or harrowed, submerged muddy ricefields as foraging habitat. Apart from the more adaptable Chinese Pond Heron, pond herons forage mainly along muddy margins of ponds and rivers, in mangrove swamps, and on irrigated ricefields (Cramp & Simmons 1977, Hancock & Elliott 1978, Hancock & Kushlan 1984). In ricefields which have been recently planted, the Javan Pond Heron is a solitary feeder, like the Squacco Heron (Hancock & Kushlan 1984). On ploughed fields, however, it forages in large, loose flocks. Like the Squacco and Indian Pond Heron (Hancock & Kushlan 1984), the Javan Pond Heron uses mainly the 'Standing and Walking Slowly' feeding technique. The prey of the Javan Pond Heron consists mainly of dragonfly larvae, waterbeetle larvae, molecrickets, spiders, and some fishes. This diet closely resembles that of Squacco, Indian, and Chinese Pond Heron (Cramp & Simmons 1977).

The Indian subspecies of the Cattle Egret *B. ibis coromandus* forages in the study area mainly on wet ricefields which are being ploughed, and on dry, harvested fields. In Japan, this subspecies also forages in ricefields (Ikeda 1956), while in Australia it prefers moist pastures (McKilligan 1984). Elsewhere, the habits of the Cattle Egret are heterogeneous (Hancock & Elliott 1978). The species can feed both in dry and wet habitats (Cramp & Simmons 1977). In some areas it prefers dry feeding habitats (Lowe-McConnel 1967, Hafner 1978), while at other places it feeds in deeply flooded grasslands (Hancock & Elliott 1978). The diet of the Cattle Egret in the study area consists mainly of grasshoppers, crickets, molecrickets, spiders, caterpillars, earwigs, and cockroaches. No earthworms were found. In Australia and in Java, Indonesia, Orthoptera are the main prey (McKilligan 1984, Hoogerwerf 1950). In Japan it feeds predominantly on waterbeetle larvae (Ikeda 1956). On a worldwide scale, the nominate subspecies of the Cattle Egret preys mainly upon Orthoptera (Kirkpatrick 1925, Siegfried 1966, 1971, Cramp & Simmons 1977, Hafner 1978, Hancock & Elliott 1978, Dean & MacDonald 1981, Telfair 1981, Bredin 1983, Hancock & Kushlan 1984). The diet of young and non-breeding adults of the Cattle Egret in the study area is generally the same, although adults seem to eat more Orthoptera and Lepidoptera. In Australia a close similarity between the composition of regurgitations of young and of stomachs of adult Cattle Egrets was found (McKilligan 1984). The diet of nestlings of the nominate subspecies also resembles that of non-breeding adults, but includes a higher proportion of grasshoppers (Siegfried 1971).

Some authors studied the seasonal variation of the diet of the nominate subspecies and concluded that it eats Orthoptera only during certain periods of the year (Siegfried 1971, Bredin 1983, Ruiz 1985). In the study area rice is cultivated asynchronously. The tropical climate and the irrigation system in use enable farmers to grow 2-3 ricecrops a year. This means that good foraging habitats for the herons are available throughout the year. In Spain, ricefields are not suitable for herons in May, forcing a large proportion of Cattle Egrets to migrate to the Camargue, France, at the onset of the breeding season. Cattle Egrets and Little Egrets *Egretta garzetta* in the Camargue use ricefields only as a foraging habitat following flooding of the fields (Hafner et al. 1982, Bredin 1983).

On Sulawesi, both Javan Pond Herons and Cattle Egrets forage on wetland ricefields. However, they differ in foraging habitat preference, feeding technique, and diet. This explains why both species can coexist in the same area in such large numbers.

7.2 Comparison of sampling methods

Collecting of stomachs, for instance by shooting as done by several authors (e.g. Kirkpatrick 1925, Siegfried 1971, McKilligan 1984, Ruiz 1985), seems to be the best way to study a heron's diet. Preys out of stomachs, often entire animals, are relatively easy to identify. However, it was considered not to be wise to shoot herons in the study area. They are not only protected by law in Indonesia, it would also give the local people a wrong opinion of what we consider a conservation study. Stomachs of Cattle Egrets collected in this study were not a random sample, because most herons collected were traffic casualties.

Another method to study the food of herons is by collecting regurgitations of nestlings (Siegfried 1971, Bredin 1983, McKilligan 1984). Regurgitations often also contain easily identifiable whole prey items. They can, of course, only be collected during the breeding season, which could bias the results because of seasonal aspects and differences in the food of young and adult birds. Some preys can be regurgitated more easily than others. Javan Pond Herons more often refused to regurgitate than Cattle Egrets. If we compare regurgitations of nestling Javan Pond Herons (Table 1) with the stomach contents of breeding adults (Table 2), some prey types (e.g. Ranidae, frogs) seem to be regurgitated more easily than others.

The undigested remains of prey in pellets consist often of fragments that are not easy to identify. Pellets, collected at mixed sleeping sites in the study area, could not be attributed to a certain species with 100% certainty. Atypical heron pellets could not be attributed to any species at all. An example of these atypical pellets are the patches of gelatinous matter, probably resulting from the predation of fish (Hibbert-Ware1940). Bredin (1983) found that, when fishes, frogs, and earthworms are eaten by Cattle Egrets,

this does not lead to pellet formation and that even bones and small teeth are digested. An experiment showed that sheep teeth, when sewed in mice and fed to a Cattle Egret, lost some 60% of their weight while in the stomach (Bredin 1983). These differences in digestibility of prey may explain the differences in the composition of pellets found by us under nests of Javan Pond Heron, compared to the regurgitations of nestlings and the stomachs of breeding adults. Thus, the pellets contained less remnants of relatively soft-bodied dragonfly larvae and fishes. An advantage of pellets is that in the Cattle Egret they, contrarily to regurgitations, were available throughout the year. Cage experiments in the Camargue, France, showed that Cattle Egrets reject one pellet a day, a few hours before sunrise. A pellet thus gives a good indication of the food collected by an individual Cattle Egret during one day (Bredin 1983).

All three methods of sampling have their advantages and disadvantages. If these are kept in mind, they can be used complementarily.

7.3 Economic importance

The Cattle Egret is an opportunistic feeder, considered on balance beneficial by Hancock & Elliott (1978). It feeds mainly on Orthoptera, which are often damaging to crops or compete with cattle for food. Cattle Egrets in South Africa, Texas, and Australia reduce the level of grass-eating insects to the benefit of grazing cattle (Siegfried 1971, McKilligan 1984, Telfair & Marcy 1984). Hoogerwerf (1950) considered Cattle Egrets beneficial, because in Java they raise their young on grasshoppers. In Egypt, they destroyed large numbers of the regular pest *Gryllotalpa vulgaris* (Kirkpatrick 1925), while cattle living close to a new heronry in Australia had markedly fewer ticks since the arrival of the herons (McKilligan 1984). Telfair & Marcy (1984) consider the presence of the Cattle Egret in Texas beneficial to cattle, because the birds not only prey upon competing herbivorous insects, but also on biting pests like horseflies; they may even help to control bovine anaplasmosis by eating tabanid flies. According to Blaker (1965) Cattle Egrets can control dipterous pests. Cattle Egrets in ricefields in Japan, however, were not believed to play a role of economic importance (Ikeda 1956).

Cattle Egret and Javan Pond Heron in Sulawesi forage mainly on insects, including orthopteran ricepests like the short-horned grasshopper *Oxya japonica japonica*. *Oxya* species are destructive leaf feeders. Their main damage occurs in rice, where they cause the ripening ears to wither. They reproduce more or less continuously and are able to swim in irrigated ricefields (Willemse 1955 and PANS-Manual 3 1976). The short-horned grasshopper *Stenocatantops splendens*, commonly found in the food of the Cattle Egret, is also known as a pest species (R. Butlin). The locust *Locusta migratoria*, which was found by us in the diet of the Cattle Egret in small numbers, can form destructive swarms, which

Nestling of Javan Pond Heron with bulging stomach (photo R.W.R.J. Dekker).

attack mainly monocotyledons, including rice (Kalshoven 1981). Outbreaks of this locust species have been reported for Sulawesi (Kalshoven 1981). The long-horned grasshoppers of the *Conocephalus* group are often 'predacious and herbivorous' (Pitkin 1980). Van Halteren (1979), who studied rice cultivation in South Sulawesi, considered them especially harmful in rice when they occur in high density on fields surrounded by recently harvested ricefields. We found this latter case also in North Sulawesi. They nibble on developing grains, resulting in shrivelled endosperm. Although some *Conocephalus* species are considered real ricepests, others, as for instance species from Papua New Guinea and Sarawak, are considered beneficial, because they are predators of eggs and nymphs of the stinkbug *Leptocorisa oratorius* (Pitkin 1980), which also occurs in the study area. The role of *Conocephalus* species in the sawah ecosystem of Sulawesi needs therefore further research. Another harmful insect, especially abundant in the diet of the Javan Pond Heron on North Sulawesi, is the molecricket *Gryllotalpa* cf. *orientalis*, which was previously lumped with most African, Asian, and Australian *Gryllotalpa* species under the name *Gryllotalpa africana* (Townsend 1983). In Indonesia, *Gryllotalpa* species burrow in wet and moist soils, where they damage roots and loosen the soil structure, causing seedlings to wilt (Kalshoven 1981). Molecrickets attack also stems of riceplants below the surface, close to the roots. During one night a large number of riceplants can be destroyed in this way (PANS-Manual 3 1976).

In the Dumoga Valley, few pests damage ricecrops above the economic threshold level. Since the valley was lowland rain forest until recently and crops are only grown since the last 1-2 decades, pest densities are fairly low. Moreover, rice is cultivated there asynchronously, which prevents fast spreading of pests over a large area. Hemipteran ricepests (e.g. *Leptocorisa* spp., *Nephotettix* spp., *Nezara viridula*) and lepidopteran ricepests (e.g. the rice case-worm *Nymphula* spec. and Noctuidae, especially armyworms) are the main problems in the area (P.A.C. Ooi, pers. obs.). In other parts of Sulawesi, short- and long-horned grasshoppers are considered as minor pests of rice (Van Halteren 1979).

Apart from orthopteran and lepidopteran pest species the herons eat also predatory species like spiders, which are commonly considered beneficial. To ascertain the economic importance of herons with certainty, the food chain in the Dumoga Valley needs to be examined. However, preliminary calculations show that the two heron species eat an estimated amount of 300,000 Orthoptera daily in an area of 20x6 km in the study area (Appendix II). Conservation of the herons in North Sulawesi by protecting their sleeping and nesting sites in marginal marshy areas might prevent future orthopteran pest outbreaks. This can reduce the future level of pesticides use in the area with all positive side-effects for the sawah ecosystem, including human beings.

Nestling of Javan Pond Heron during collection of regurgitations for food analysis (photo R.W.R.J. Dekker).

8 ACKNOWLEDGEMENTS

We would like to thank the governmental and local authorities in Indonesia: Lembaga Ilmu Pengetahuan Indonesia (LIPI)= Indonesian Institute of Sciences, Jakarta, and Universitas Sam Ratulangi (UNSRAT), Manado, especially counterparting Dr. D Sembel, and Direktorat Jenderal Perlindungan Hutan dan Pelestarian Alam (PHPA)= Directorate General of Forest Protection and Nature Conservation, Bogor, PHPA-Manado, and PHPA-Dumoga-Bone for their support. The Institute of Taxonomic Zoology (Zoölogisch Museum, ITZ) of the University of Amsterdam, the Department of Animal Ecology of the Free University, Amsterdam, and the Institute for Environmental Problems (IVM), Amsterdam, are thanked for facilities. We thank Dr J.P. Duffels, Dr J. Wattel, Dr P.J.H. van Bree, and Prof. Dr L. Vlijm for their advice, and Ir J. Wind for his help to start this project and for making the Indonesian summary. For the identification of specimens we want to thank the participants of Project Wallace: Dr R. Blackith, University of Dublin (Tetrigidae), Dr R.K. Butlin, University of East Anglia (Acridiidae), Drs H. Huijbregts, Rijksmuseum van Natuurlijke Historie (RMNH), Leiden (Coleoptera), Dr R. de Jong, RMNH, Leiden (Lepidoptera), Dr W.J. Knight, British Museum (Natural History) (BMNH), London (Hemiptera), Dr J. Krikken, RMNH, Leiden, (Cetoniidae), Dr P.A.C. Ooi, Commonwealth Institute of Biological Control, Selangor, Malaysia (ricepests), Dr B. Orr, Griffith University, Nathan (Lepidoptera), Dr G. Robinson, BMNH, London (Lepidoptera and Diptera), and Dr N.E. Stork, BMNH, London (Carabidae). We thank also Dr I.J.H. Isbrücker, ITZ, Amsterdam (Pisces), Dr Kiew Bong Heang, University of Malaya, Kuala Lumpur and Dr R. Stuebing, National University of Malaysia, Sabah (Ranidae), Mrs J. Marshall, BMNH, London (Orthoptera), and Drs P. Mudde, ITZ, Amsterdam (Scincidae), for their identifications. Ir D.E.J. Vermeulen, and Mr J.W. and Mrs S.J. Vermeulen are thanked for their logistic support. The first author wishes to thank Drs R.W.R.J. Dekker for his support throughout the project.

Financial support was given by the World-Wildlife-Fund-Holland (AVGN-WNF), Uyttenboogaart-Eliasen Stichting, Haak Bastiaanse Kuneman Stichting, Van Tienhoven Stichting, and Greshoff's Rumphius Fonds, 1913.

9 REFERENCES

Blaker, D. 1965. Flies in the Cattle Egret diet. Ostrich 36:147.

Bredin, D. 1983. Contribution à l'étude écologique d'*Ardeola ibis* (L.): héron gardeboeufs de Camargue. (Ph. D. thesis), University Paul Sabatier, Toulouse, France.

Cramp, S. & K.E.L. Simmons 1977. The birds of the western Palearctic. Oxford University Press, Oxford.

Dean, W.R.J. & I.A.W. MacDonald 1981. A review of African birds feeding in association with mammals. Ostrich 52:135-155.

Fasola, M. 1983. Nesting populations of herons in Italy depending on feeding habitats. Boll. Zool. 50: 21-24.

Hafner, H. 1978. Comparative biology of treenesting herons in the Camargue, France. Symposium on Conservation of colonially nesting waterfowl, Carthage, Tunesia 24-25 November 1978 S3:1-4.

Hafner, H., V. Boy & G. Gory 1982. Feeding methods, flock size and feeding success in the Little Egret *Egretta garzetta* and the Squacco Heron *Ardeola ralloides* in Camargue, Southern France. Ardea 70: 45-54.

Halteren, P. van 1979. The insect pest complex and related problems of lowland rice cultivation in South Sulawesi, Indonesia. (Ph. D. thesis), Landbouwhogeschool Wageningen, Wageningen.

Hancock, J. & H. Elliott 1978. The herons of the world. London Editions, London.

Hancock, J. & J. Kushlan 1984. The herons handbook. Croom Helm, London & Sydney.

Heather, B.D. 1978. The Cattle Egret in New Zealand in 1977. Notornis 25: 218-234.

Hibbert-Ware, A. 1940. An investigation of the pellets of the Common Heron *A. cinerea*. Ibis Series 14 vol IV: 433-450.

Hoogerwerf, A. 1950. Over de "schadelijkheid" van Reigers. Ardea 38: 94-95.

Ikeda, S. 1956. On the habits of the Indian Cattle Egret. Jap. J. appl. Zool. 21: 83-86.

Kalshoven, L.G.E. 1981. The pests of crops in Indonesia. Ichtiar Baru-Van Hoeve, Jakarta.

Kirkpatrick, T.W. 1925. The Buff-Backed Egret (*Ardea ibis*, L. Arabic: Abu-Querdan) as a factor in Egyptian agriculture. Min. Agr.Egypt.Tech. and Sci. Ser. Bull. 56: 1-28.

Kushlan, J.A. & M.S. Kushlan 1975. Food of the White Ibis in Southern Florida. Florida Field Naturalist 3: 31-38.

Lowe-McConnel, R.H. 1967. Biology of the immigrant Cattle Egret *Ardeola ibis* in Guyana, South America. Ibis 109:168-179.

McKilligan, N.G. 1984. The food and feeding ecology of the Cattle Egret, *Ardeola ibis*, when nesting in South-East Queensland. Austr. Wildl. Res. 11: 133-144.

PANS-Manual 3 1976. Pest control in rice. 2nd edition. Centre for Overseas Pest Research, London.

Pitkin, L.M. 1980. A revision of the Pacific species of *Conocephalus* Thunberg (Orthoptera: Tettigoniidae). Bull. Br. Mus. Nat. Hist. (Ent.) 41: 315-355.

Ruiz, X. 1985. An analysis of the diet of Cattle Egrets in the Ebro Delta, Spain. Ardea 73: 49-60.

Siegfried, W.R. 1966. On the food of nestling Cattle Egrets. Ostrich 37: 219-220.

Siegfried, W.R. 1971. The food of the Cattle Egret. J. appl. Ecol. 8: 447-468.

Sokal, R.R. & F.J. Rohlf 1969. Biometry. Freeman, San Francisco.

Telfair, R.C. II 1981. Cattle Egrets, inland heronries and the availability of fish. Southwestern Nat. 26: 37-41.

Telfair, R.C. II & L.E. Marcy 1984. Cattle Egrets (*Ardeola ibis* = *Bubulcus ibis*) in Texas. Texas J. Sci. 35: 303-314.

Townsend, B.C. 1983. A revision of the afrotropical Molecrickets (Orthoptera: Gryllotalpidae). Bull. Br. Mus. Nat. Hist. (Ent.) 46:175-203.

Uttley, J. 1987. Survey of Sulawesi Selatan to assess the status of wetlands and to identify key sites for breeding and migratory waterbirds. (Interwader/PHPA Report 2) Interwader Publications 11.

White, C.M.N. & M.D. Bruce 1986. The birds of Wallacea. British Ornithological Union Checklist 7.

Willemse, C. 1955. Synopsis of the Acridoidea of the Indo-Malayan and adjacent regions, 1. Public. natuurh. Gen. Limburg 8: 1-225.

Appendix Ia. Numbers of Javan Pond Herons per hectare in ricefields in different stages of development (transect counts). The relative area of each field type is given as a percentage of the total.

Field type:	A	B	C	D	E	Total area	N_{JPH}
24-06-1985	7.3 (16)	0.6 (44)	0.2 (8)	0.2 (22)	0.0 (10)	86 ha	126
04-09-1985	48.9 (5)	1.6 (22)	0.0 (36)	0.4 (15)	0.2 (22)	59 ha	181
16-10-1985	11.7 (16)	2.4 (14)	0.0 (11)	0.2 (21)	0.3 (38)	47 ha	96
25-11-1985	8.1 (25)	2.3 (30)	0.0 (13)	0.0 (1)	0.1 (31)	54 ha	140
14-01-1986	27.1 (8)	1.1 (23)	0.1 (47)	0.6 (5)	0.3 (17)	37 ha	101
03-03-1986	16.3 (9)	1.1 (23)	0.7 (11)	0.2 (36)	0.8 (21)	38 ha	74
14-05-1986	12.2 (19)	0.8 (15)	0.0 (26)	0.0 (1)	0.1 (39)	43 ha	105
$\bar{x}$ s.d.	18.8 14.86	1.4 0.73	0.1 0.26	0.2 0.20	0.2 0.26		

Field types: A= ploughed ricefields, B= fields with young riceplants, up to 6 weeks after planting, C= fields with rice older than 6 weeks, D= harvested ricefields, E= fallow lands. N_{JPH}= numbers of Javan Pond Herons counted in A-E.

Appendix Ib. Numbers of Cattle Egrets per hectare in ricefields in different stages of development (transect counts). The relative area of each field type is given as a percentage of the total.

Field type:	A	B	C	D	E	Total area	N_{CE}
24-06-1985	2.0 (16)	1.1 (44)	0.0 (8)	1.6 (22)	5.6 (10)	86 ha	146
04-09-1985	8.8 (5)	2.0 (22)	0.0 (36)	0.9 (15)	2.5 (22)	59 ha	94
16-10-1985	10.8 (16)	0.0 (14)	0.0 (11)	1.3 (21)	5.8 (38)	47 ha	184
25-11-1985	13.4 (25)	1.3 (30)	0.0 (13)	0.0 (1)	4.0 (31)	54 ha	265
14-01-1986	3.7 (8)	0.4 (23)	0.0 (47)	21.6 (5)	5.0 (17)	37 ha	85
03-03-1986	7.2 (9)	0.7 (23)	0.2 (11)	0.9 (36)	0.3 (21)	38 ha	45
14-05-1986	14.3 (19)	0.0 (15)	0.0 (26)	0.0 (1)	0.9 (39)	43 ha	132
x̄ s.d	8.6 4.63	0.8 0.74	0.0 0.09	3.8 7.87	3.4 2.25		

Field types: A= ploughed ricefields, B= fields with young riceplants, up to 6 weeks after planting, C= fields with rice older than 6 weeks, D= harvested ricefields, E= fallow lands. N_{CE}= numbers of Cattle Egrets counted in A-E.

Appendix II. Daily amount of Orthoptera eaten by Javan Pond Herons and Cattle Egrets in the western part of the Dumoga Valley (20 x 6 km), North Sulawesi.

- estimated number of Javan Pond Herons: 2500
- estimated number of Cattle Egrets: 3000
- daily consumption: 150 prey items per individual (from Tables 1 and 2)
- percentage Orthoptera in diet Javan Pond Heron: 15 % (from Tables 1-4)
- percentage Orthoptera in diet Cattle Egret: 55 % (from Tables 1-3)
- daily Orthoptera consumption=
  number of birds x daily consumption x % Orthoptera in diet

  daily Orthoptera consumption of Javan Pond Heron=
  2500 x 150 x 15/100= 56,250

  daily Orthoptera consumption of Cattle Egret=
  3000 x 150 x 55/100= 247,500

NB. These are rough calculations that should be considered as a minimum, because the daily consumption of an adult during the breeding season will be higher. E.g. one stomach of a breeding Javan Pond Heron contained no less than 502 prey items.

Appendix III. Notes on the occurrence of herons in North Sulawesi

Data on the herons of Sulawesi are scarce and incomplete (Hancock & Kushlan 1984, White & Bruce 1986, Uttley 1987). Hardly any research has been conducted on the Javan Pond Heron (Hancock & Kushlan 1984). This appendix will give general remarks on the status of herons in North Sulawesi as observed during the fieldwork in 1985 and 1986. Observations on the Javan Pond Heron will be given in some detail.

Ardea sumatrana Sumatran Heron
One observation of two individuals near Molibagu, south coast, 19-21 November 1985 (R.W.R.J. Dekker).

Ardea purpurea Purple Heron
Breeding in several pairs in the Dumoga Valley. One observation of three nestlings in a nest in a reed-bed in a mixed heronry with Cattle Egrets in the Kosingolan swamps on 7 May 1985. This breeding record is later in the season than given in White & Bruce (1986).

Egretta alba Great White Egret
Present in the Dumoga Valley in small numbers.

Egretta intermedia Intermediate Egret
Present in the Dumoga Valley in small numbers. Hancock & Kushlan (1984) do not mention this species for Sulawesi.

Egretta garzetta Little Egret
Fairly common in the Dumoga Valley. Adults breeding in a mixed heronry with Cattle Egrets and Javan Pond Herons (March 1986). Hancock & Kushlan (1984) and White & Bruce (1986) do not mention this species as a breeding bird for Sulawesi. Uttley (1987) confirms its presence and breeding in South Sulawesi.

Bubulcus ibis Cattle Egret
Very common in the Dumoga Valley, birds present throughout the year (contrarily to White & Bruce 1986). April/May 1985 breeding in small numbers in a mixed heronry with Purple Herons. Also breeding in small numbers in a mixed heronry with Javan Pond Herons and Little Egrets in the Dumoga Valley in March-April 1986. Hancock & Kushlan (1984) and White & Bruce (1986) do not mention this species as a breeding bird for Sulawesi. In South Sulawesi, Uttley (1987) observed this species flying with nesting

material. Some adults in breeding plumage with red lores, bill, and legs.

Ardeola speciosa Javan Pond Heron

Common in the Dumoga Valley (contrarily to Hancock & Kushlan 1984). Breeding (contrarily to White & Bruce 1986) throughout the year, solitarily, in monospecies colonies, or in a mixed heronry together with Cattle Egrets and Little Egrets. Nesting, often near human settlements, in bambu, on top of Pandan trees, in shrubby vegetation, as well as in tree species planted by man (clove, cinnamon, belimbing, rambutan). Most breeding Javan Pond Herons were found in March-April and in September. Eggs, young, adults in breeding plumage, and moulting adults were observed throughout the year. This species occurs also in large numbers in South Sulawesi, where it is widespread and possibly breeds (Uttley 1987). Adults in breeding plumage had sometimes rosy legs. The upper mandible of the bill of breeding adults is, apart from the black tip, entirely blue, which means that it has more than 'a touch of blue near the base' as mentioned by Hancock & Kushlan (1984). Nestlings have a black-tipped flesh coloured bill, which changes into brownish red after a few days. When disturbed the call is a nasal "coaa".

Egg measurements: 34.0 - 39.5 x 25.5 - 29.9 ($\bar{x}$= 37.0 x 28.1) mm (n=29). Clutch size between two and five, usually two or three eggs.

Butorides striatus Green-backed Heron

Present in the Dumoga Valley in small numbers. Also observed along the coast.

Nycticorax caledonicus Nankeen Night Heron

Several pairs in the Dumoga Valley. One downy young was collected by local people at the end of April 1986. Contrarily to Hancock & Kushlan (1984) this species breeds in Sulawesi. In South Sulawesi, Uttley (1987) observed this species flying with nesting material.

Ixobrychus sinensis Yellow Bittern

Present in small numbers in the Dumoga Valley between October and March, contrarily to Hancock & Kushlan (1984). Uttley (1987) confirms its presence and presumes its breeding in South Sulawesi.

Ixobrychus cinnamomeus Cinnamon Bittern

Common resident in the Dumoga Valley.