The Maintenance and Reproductive Behaviour of Black Stilts (*Himantopus novaezealandiae*) in Captivity, and Implications for the Management of this Rare Species.

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of the Requirements for the Degree of

Master of Science in Zoology

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ABSTRACT

In an effort to conserve New Zealand's rarest endemic wading species, the black stilt (Himantopus novaezealandiae), eggs were removed from the wild in October 1979 for establishment of a captive breeding population. Eight chicks fledged following artificial incubation and hand-rearing at the National Wildlife Centre near Masterton. At two years of age, these tentatively sexed stilts were formed into pairs and housed in large outdoor enclosures.

I studied their behaviour from December 1982 until February 1986, aiming to i) collate an ethogram for the species under the restrictions of a captive environment ii) describe and quantify behavioural activity, especially that of reproductive behaviour and breeding biology iii) describe vocalisations and iv) on the basis of observed behaviour, examine captive breeding as a management option for black stilts.

A repertoire of 38 context-specific behavioural patterns were observed throughout the year and a further 15 stereo-typed species-typical nest-building, copulatory, incubation and chick-rearing patterns occurred during the breeding season. Time-budget analysis of a focal pair of stilts showed foraging and immobility to be the predominant daily activities, peaking during the pre-nesting period. A bimodal diurnal distribution of foraging activity was observed, peaking in the early morning and mid-late afternoon. Time allocated to foraging and immobility was inversely related to the time spent in incubation.

While all stilts showed incipient breeding behaviour, only one pair bred. Multiple laying of this focal pair was induced by subsequent clutch removals. This pair produced 10 clutches of eggs over three breeding seasons, with a maximum of five clutches being laid in one season. Laying spanned the period from 18 September to 28 January. The mean clutch size was 3.27 and the mode was 4.0. Fertility was 90.6% in captivity and 95.6% in the wild. Following egg removal, re-laying took place within 8-13 days (mean and mode 9 days).

The male did the most incubating, especially in the first five days after initiation of egg-laying by the female.

Eight chicks were reared successfully by this pair over the three years. Captive chick growth was faster than that of wild chicks and they fledged earlier (at 35-36 days). They exhibited similiar antipredator behavioural patterns to wild chicks and their response depended on age of the chick and type of predator.

Eleven adult and four juvenile vocalisations were structurally described. These categories were both intergraded or discrete and call parameters were variable within and between call types. Variation within one call type (alarm yap) was greater between individuals (wild and captive) than within individuals. Interspecific variation between pied stilt (H. himantopus leucocephalus) and black stilt alarm calls was also greater between species than within them. Hybrids of the two stilt types were intermediate in call structure, but considerable structural overlap with that of pied and black call parameters was evident.

Based on the observed behaviour and breeding biology of captive stilts, I propose a novel management strategy which involves the establishment of a captive breeding facility for this species within their natural range in the Upper Waitaki Basin.

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CHAPTER ONE

INTRODUCTION AND METHODS

1.1 Introduction

1.1.1 Black stilts

The black stilt (Himantopus novaezealandiae) is New Zealand's rarest endemic wader species, existing as a single population of less than forty adult birds (13 pairs) and breeding only on the riverbeds and associated wetlands of the Upper Waitaki Basin, South Canterbury (figure 1.1).

They are considered (Fleming 1962, Pierce 1984a) to be the first of two separate invasions to New Zealand of an Australian form of the genus Himantopus (Order Charadriiformes, Family Recurvirostridae). As has occurred following first invasions of other taxa to New Zealand, the first influx of stilts became melanistic (black stilt) after colonisation (Fleming 1962, Kearton 1976) and morphologically distinct from Australian ancestral stock (Pierce 1982). A second invasion of Himantopus himantopus (the black-winged stilt) possibly in the early nineteenth century, underwent speciation before or during colonisation of New Zealand, giving rise to H. h. leucocephalus-the pied stilt.

The taxonomy of black stilts has been confusing. Full species, subspecies and colour morph status, have all been applied to New Zealand stilts (Pierce 1984b). Hybridisation occurs within the area of range overlap of the two types of New Zealand stilts and this has contributed further to the confusion over nomenclature.

Recently Pierce (1984b) reviewed the historical taxonomy of stilts and concluded that on the basis of;

i) his experimental demonstration of positive assortitive mating in black stilts;

ii) morphological, ecological and behavioural differences between pied and black stilts; and

iii) in view of their present taxonomic position;

they should " retain their full specific status".

In contrast to the highly successful colonisation of New Zealand farmlands and riverine systems by pied stilts in the past century or more, the black stilt has dramatically declined in numbers from its widespread distribution in the nineteenth century (Pierce 1984a).

The reasons for the decline of black stilts include an inability to adapt to man-induced changes (particularly introduction of predators and habitat disruption through wetland drainage, damming, water abstraction, etc.) and reproductive compatability with the pied stilt (Pierce 1982).

Efforts to conserve this endangered species have focussed on the provision of predator-free breeding sites, cross-fostering of eggs to pied and hybrid foster nests and the establishment of a captive population. Progeny from captive birds were to be returned back into the wild population.

1.1.2 Establishment of a captive population

In October 1979, officers of the New Zealand Wildlife Service (Department of Internal Affairs) removed eight fertile black stilt eggs from three nests in the Waitaki Basin. The eggs were transferred to the National Wildlife Centre at Mount Bruce near Masterton (figure 1.1) and "incubator-hatched". Before these clutches were transferred, Mount Bruce staff had successfully experimented with pied stilt eggs to perfect the incubation temperature, humidity and hand-rearing techniques for stilt chicks. All transferred eggs hatched successfully and the eight healthy chicks were initially held in brooders and fed on aquatic invertebrates. A supplementary food supply of chopped oxheart (containing a vitamin/mineral mix) was also provided and the amount progressively increased until it constituted the complete food source for the young chicks.

From fledging until two years of age, the stilts were kept as three separate sibling groups in small concrete-floored aviaries (section 1.3.2). These birds were tentatively sexed at twenty months old. As a result of preliminary sexing (section 1.3.4), three male-female pairs and one female-female pair were moved to outdoor enclosures and housed separately during October 1981.

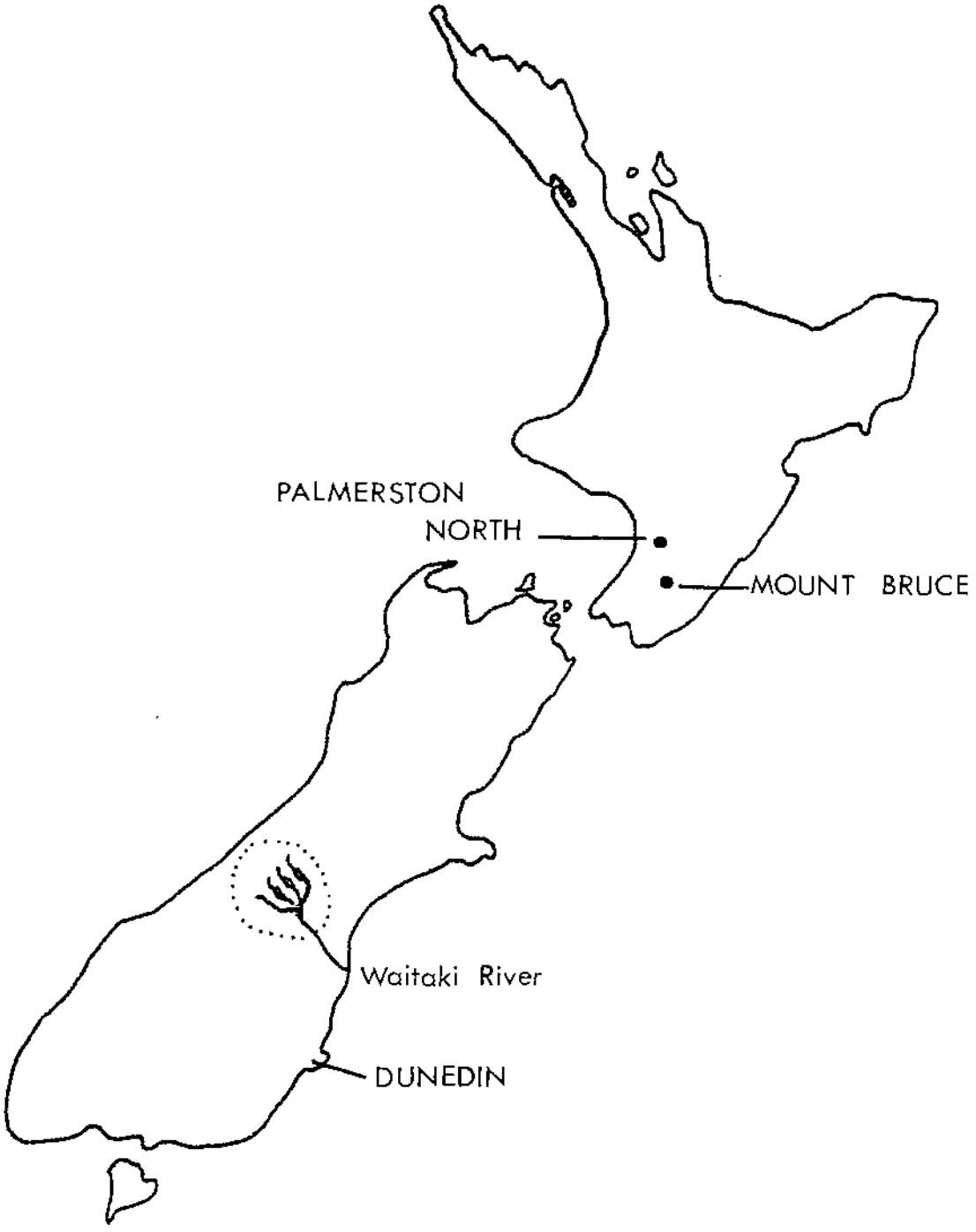

FIGURE 1.1 Breeding range of black stilts

They fed on invertebrates of an artificial stream and this food supply was supplemented by a mixture of chopped oxheart, vitamins and minerals. Incipient breeding patterns were observed by Wildlife Service staff before the initiation of my study, but none of these birds had bred.

1.1.3 Other Recurvirostridae in captivity

The Family Recurvirostridae contains about 14 forms of avocet and stilt (Gruson 1976) distributed widely across the world (figure 1.2). Nomenclature of the Recurvirostridae has been treated in different ways by taxonomists (appendix one) but I shall refer to each of the 14 types as forms and not individual species of one of the three widely recognized (Kinsky 1970, Clements 1974, Condon 1975, Gruson 1976) genera occuring in this family; Himantopus (stilts), Recurvirosta (avocets) or Cladorhynchus (banded stilt). The genus Ibididorhyncha has been excluded (appendix one).

The International Zoological Yearbook (1975-1982) lists 28 institutions throughout the world which have bred and/or maintained recurvirostrids in captivity. Questionnaires (exemplified in appendix two) were sent to 24 of these institutions, to investigate the captive management of recurvirostrids other than H. novaezealandiae. Two New Zealand centres maintaining stilts but not listed in the yearbook, were also sent questionnaires. Fifteen of the 26 questionnaires were answered and returned.

A complete list of the 15 institutions (plus Mount Bruce; Bryant, pers comm.) is presented in table 1.1 and appendix three. Additional information from the questionnaires will be referred to in chapter six.

1.1.4 Studies of stilt/avocet behaviour

Since the late nineteenth century, general observations have been made on the distribution of black stilts and aspects of their breeding biology (Stead 1932, Oliver 1955, Soper 1967).

It was not until the late 1970's however, when black stilt numbers had decreased to less than 100 (Budgeon 1977), that ecological studies on this species began. Pilot studies of their feeding habitats (Merton

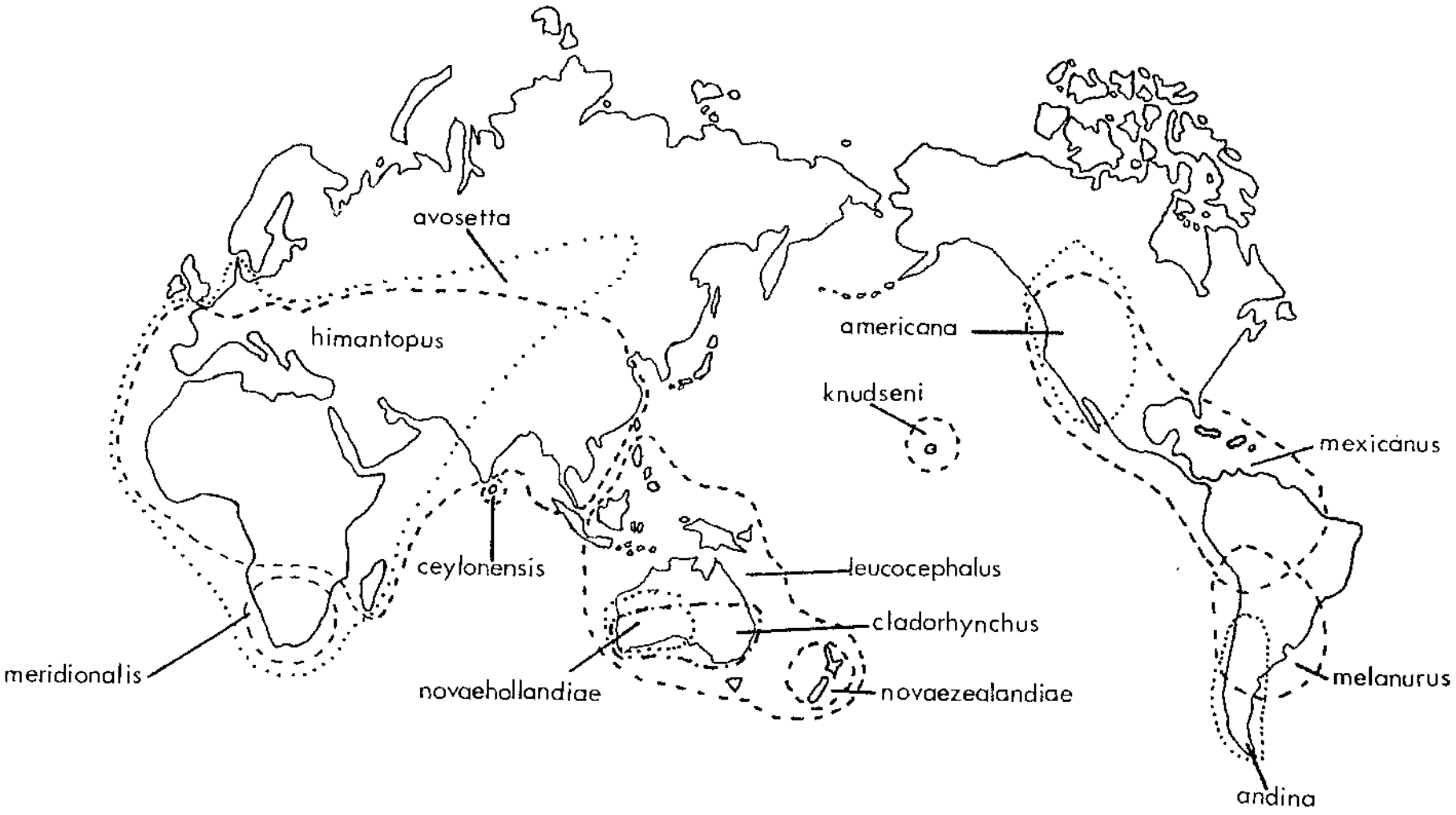

FIGURE 1.2 World distribution of the Recurvirostridae (from Pierce 1982)

Table 1.1 Recurvirostridae in captivity.

GENUS	FORM	COUNTRY	INSTITUTION *1
Recurvirostra	americana	U.S.A	6,7 *2
	avosetta	U.S.A	8
		Germany	12,11,9,10
		Holland	14,13
		Switzerland	15
		Hungary	16
	novaehollandiae	Australia	4*3
Himantopus	leucocephalus	New Zealand	2,3,1
		Australia	5
	himantopus	Australia	4
		Germany	12,11,9
		Switzerland	15
	mexicanus	U.S.A	6,7,8
Cladorhynchus	leucocephalus	Australia	4

*1 KEY TO INSTITUTIONS: (see Appendix three for full address)

1 = Auckland	6 = Dallas	11 = Rheine
2 = Mount Bruce	7 = Los Angeles	12 = Wuppertal
3 = Otorohanga	8 = New York Bronx	13 = Emmen
4 = Perth	9 = Bochum	14 = Amsterdam
5 = Taronga	10 = Koln	15 = Bern
		16 = Budapest

*2 Breeding has occurred in underlined institutions only (number)

*3 Fertile eggs laid but did not hatch

1977), breeding areas and general behaviour (Budgeon 1977) were carried out.

A comprehensive ecological and morphological study of black and pied stilts in South Canterbury has recently been completed (Pierce 1982). Pierce examined the general biology of the two species, seasonal movements, habitat choice, feeding behaviour, breeding biology, nesting success, hybridisation and taxonomy. These comprehensive ecological studies have provided valuable information for managing black stilts in the wild. However, except for feeding behaviour (Budgeon 1977, Pierce 1982), the species has been little studied behaviourally.

Studies on the behaviour of closely related species have been relatively comprehensive and quantitative. Breeding behaviour of pied stilts was studied in the Manawatu area of the North Island (McConkey 1971). Makkink (1936) attempted an early ethogram of the European avocet (R. avosetta). Hamilton (1975) published a quantitative behavioural comparison of the American avocet (R. americana) and black-necked stilt (H. himantopus mexicanus), relating behavioural differences to generic taxonomy. Since this publication, an increasing amount of work has been completed on the Recurvirostridae. Quantitative descriptions of juvenile behaviour have been highlighted in studies of antipredator behaviour (Sordahl 1982) and the ontogeny of feeding behaviour (Espin et. al., 1983). Time budgets of adults have been analysed for the American avocet (Gibson 1978), and Sordahl (1980) extensively studied adult antipredator behaviour in the American avocet and black-necked stilt.

Descriptive observation of the breeding behaviour of stilts (Goriup 1982) and avocets (Cooke 1977) continue to be the focus of some studies.

1.2 Objectives

Although black stilt ecology has been comprehensively studied (Pierce 1982), no complete ethogram for this species has yet been assembled. Vocal behaviour has also been ignored, with only a few calls anecdotally described (Stonehouse 1968, Pierce 1982, Falla et. al., 1982).

Behavioural studies of endangered New Zealand species held in captivity, have in the past been limited to general observations of kakapo (Strigops habroptilus) (Reid 1969) and takahe (Notornis mantelli) (Reid 1977). The role of captive breeding in management of rare species has not been examined fully for any of the New Zealand birds.

The main aims of the present study were;

i) to collate an ethogram of all observed behavioural patterns used by captive black stilts;

ii) to describe and quantify daily and seasonal activity, aggressive, breeding and parental behaviour of successful breeders and the physical and behavioural development of their progeny;

iii) to sample and describe vocalisations of captive stilts and investigate alarm calls of wild pied, black and hybrid stilts, testing for a) individual and b) species differences; and

iv) on the basis of described behaviour, to examine captive breeding as a management option for black stilts.

One assumption made throughout this study was that management of black stilts for conservation is an appropriate objective for the species.

1.3 Methods

1.3.1 Study area

All observations on captive birds were made at the National Wildlife Centre near Mount Bruce in the Wairarapa. Mount Bruce is located on State Highway 2, 25 km north of Masterton. Since 1962, this area has been administered by the New Zealand Wildlife Service as a wildlife reserve.

The reserve covers 56 ha in area, of which all but a few hectares are native podocarp/hardwood forest beginning at 305 m above sea-level and ascending to 716 m (top of Bruce Hill).

The average annual rainfall for the area is 2350 mm, with temperatures ranging from $-5.0^{\circ}C$ (extreme minimum June 1983) to $28.3^{\circ}C$ (extreme maximum January 1983) during this study. Monthly rainfall and air

temperatures recorded at Mount Bruce weather station (305 m above sea level) during this study, are presented in figures 1.3 and 1.4.

1.3.2 Aviaries

The study birds were kept in two outdoor enclosures (plate 1.1) at the initiation of this study in July 1982. The two enclosures covered an area of approximately 700 m^2 and 445 m^2 respectively, with an arched external frame reaching to a maximum height of 5-6 m. Each aviary was subdivided into two adjoining sections by a 12 mm mesh wire fence (plate 1.2) which could be raised if neccessary.

Water flow from the nearby Mount Bruce stream was diverted along a concrete channel to grills and a weir (plate 1.3). Flow into the two aviaries was controlled by removing or adding wooden boards to the weir, thereby lowering or raising the water levels. From the intake (plate 1.4), water moved slowly down a curved silt-covered gravel bed and exited through an outlet at the far end of the aviary. Figure 1.5 shows the depths of silt and the approximate dimensions of the stream and aviary banks.

Permanent vegetation was sparse along the gravel banks and consisted mainly of tussock and flax and Hebe shrubs.

Small (0.5 m x 0.5 m) and large islands (1-3 m x 0.5-1 m) were created mid-stream in each aviary, to provide nesting areas for the stilts. Smaller concrete-floored aviaries (plates 1.5 a,b) were used to house stilts later in the study. These rectangular aviaries (referred to below as "security aviaries") were 3 m high, 3 m wide, and 6 m long. They had an inside covered area (2.3 m x 3.0 m x 3.0 m) for shelter.

A mixture of minced oxheart, vitamins and minerals was the only food available to birds held within these aviaries.

1.3.3 Hides

A hide was erected near each of the two large outdoor enclosures, at a floor level of 1.1 m (aviary 1-2) and 1.9 m (aviary 3-4) above ground. Access to these hides was by way of a ladder to a rear entrance. The hides were placed 3.6 m and 8.3 m from the enclosures, permitting views

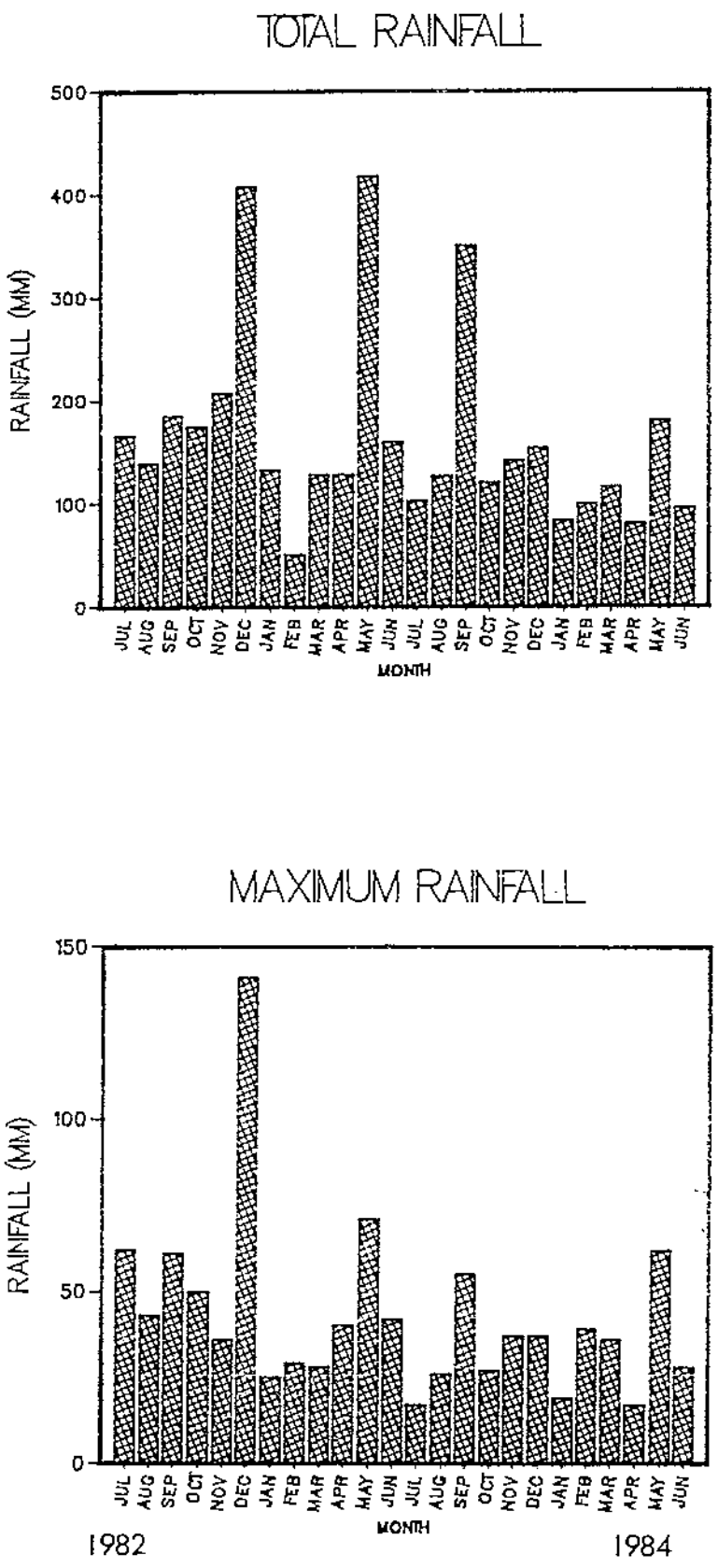

FIGURE 1.3 Monthly rainfall at Mount Bruce

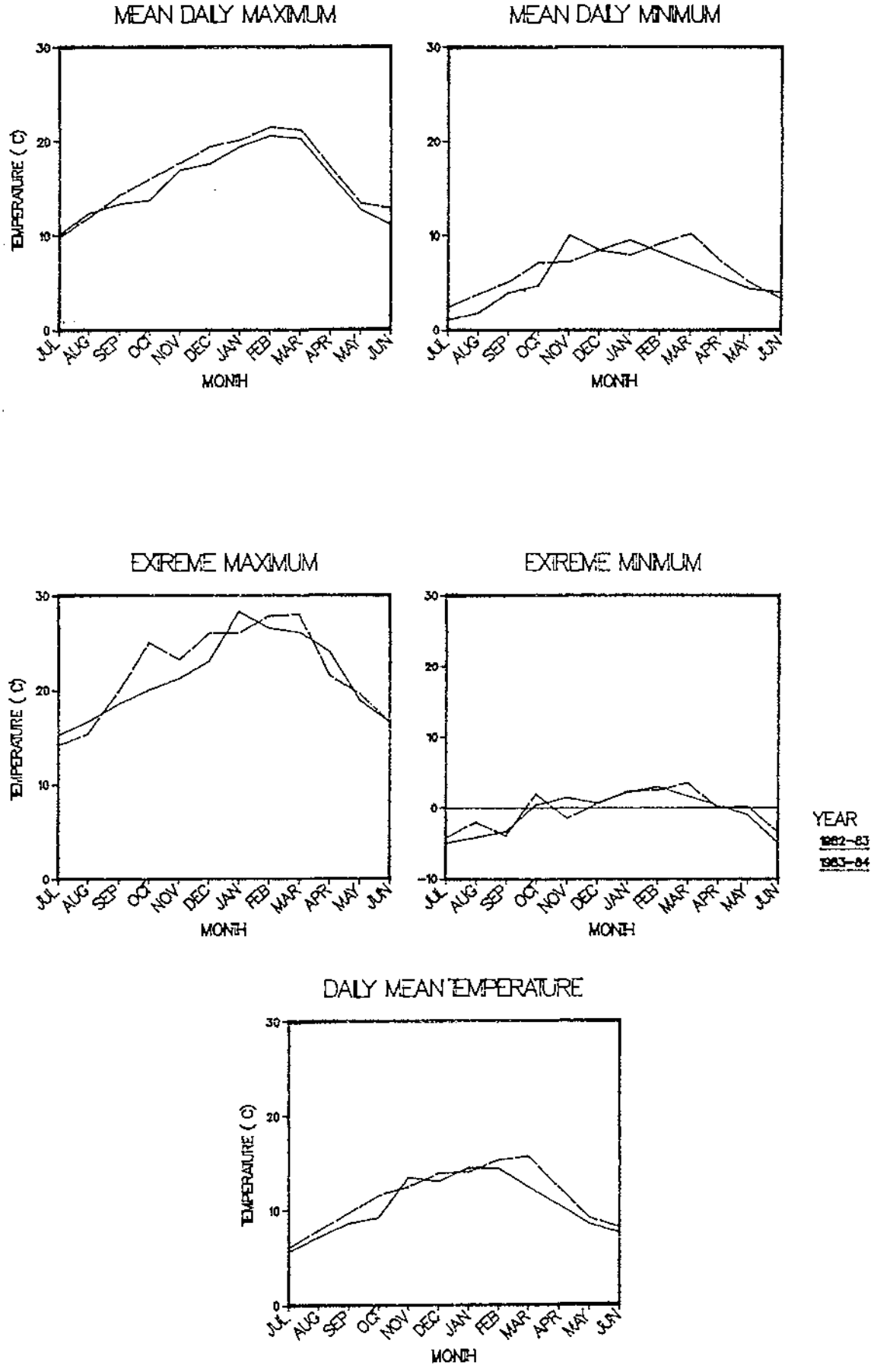

FIGURE 1.4 Monthly temperatures at Mount Bruce

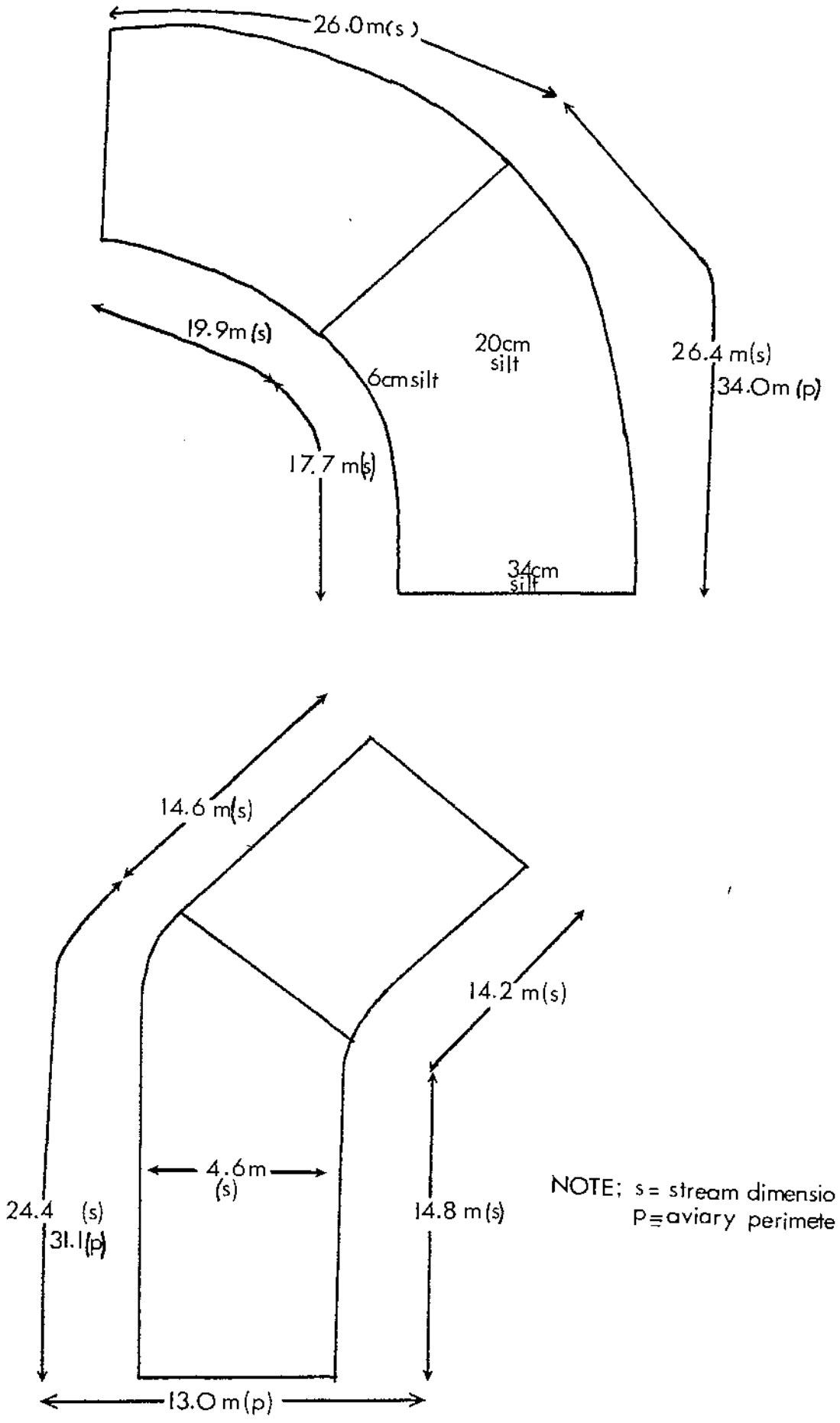

FIGURE 1.5 Dimensions of the two outdoor enclosures

PLATE 1.1 L-shaped outdoor enclosure (foreground)
Second enclosure in the background.

PLATE 1.2 Internal view of enclosure. Note median fence between aviaries.

PLATE 1.3 Grill and weir controlling water flow into enclosures.

PLATE 1.4 Water inflow pipe to an enclosure.

PLATE 1.5a "Security" aviaries
External view

PLATE 1.5b Internal view

of all but a small bank area in one enclosure.

Some observations and vocal recordings were made from inside a parked car, situated on a slightly elevated roadside, 4 m from the aviaries.

No hides were used during observations of the security aviaries, as there was too small an area in which to place them. The study birds held within these aviaries were frequently approached by visitors to the reserve and as a result, the birds were tolerant of my presence.

1.3.4 Sexing

1.3.4.1 Methods

A combination of sexing techniques was used in an attempt to establish the sex of individuals.

The five techniques yielding results were;

i) hormonal analysis of faeces,
ii) behavioural observation,
iii) tactile examination of the width between pubic bones,
iv) discriminant function analysis of morphometric measurements,
and v) autopsy.

These methods are elaborated upon below;

Hormonal analysis of faeces: Faecal samples were taken from each of the eight adult birds during August 1981. The samples were analysed by Professor G.C. Liggins (Postgraduate School of Ostetrics and Gynaecology, Auckland) for oestrogen and progesterone content. The procedure was repeated in September 1984 for four of these birds and again in October 1984 for eight adults and six sub-adults held at that time. The hormone ratios are presented in appendix four.

This method posed several problems;

i) repeated analysis of the same individual was not always consistent eg., 2608 (appendix four);
ii) there were problems assigning a cutoff limit to the oestrogen/progesterone ratio between males and females. G.C. Liggins considered this value to be 0.45, but

individuals which scored between 0.35 and 0.60 were unable to be reliably sexed; and

iii) hormonal levels varied with time of the year.

Behavioural observation: Individuals (recognised by metal and colour-bands) were appointed female status if they were observed adopting the pre-copulatory posture described in section 3.3.1.1. Confirmation of female sex was made through observation of egg-laying. Stilts were classed as behaviourally male, if they performed the pre-copulatory walk (section 3.3.1.1) around another stilt or if they imitated the male copulatory posture (section 3.3.1.2).

Tactile examination of pubic bone width: Tactile examination of the width between the pubic bones of each stilt, was carried out by I. J. Bryant (Senior Wildlife Officer at Mount Bruce). This method was relatively consistent with other results in table 1.2.

Sexing based on morphology : Although sexual dimorphism in plumage occurs in other Recurvirostridae, (eg.,H. himantopus; black-necked stilt and black-winged stilt), both sexes of the study species are entirely black except for crimson legs and irises. Pierce (1982) described a greenish gloss to be more prominent on the back of the male, but this was not a reliable feature for sexing captive birds. Of the standard body measurements, sexual dimorphism is significant only in the length of the tarsus (Pierce 1982), males having longer tarsi than females (but with much overlap).

Two sets of four measurements equivalent to those made by Pierce, were taken in captivity from each of the eight adult birds and four juveniles (hatched in captivity later in the study), as an aid to preliminary sexing. The exact method of measurement and one set of results, are given in appendix five.

Four parameters were measured;

i) tarsal length ii) wing length

iii) bill length and iv) weight.

A discriminant function analysis was performed on each set of measurements, using the tarsal length of three birds of known sex (2605, 2611 and 2612) as a basis for grouping birds of unknown sex.

Each analysis yielded the same result for each of the eight adult birds (table 1.2).

Autopsy: Two sub-adults and one five year old adult were reliably sexed by autopsy, after being humanely killed following injury. The stilts were sexed by M.C. Vickers (M.V.Sc), veterinarian with the Ministry of Agriculture and Fisheries (Palmerston North).

1.3.4.2 Synthesis of sexing results

The most consistent results for each individual were provided by a combination of behavioural observation, tactile examination of pubic bone width and faecal steroid analysis (table 1.2). Except for known breeders or autopsied birds, sexes of all other individuals can only be classified as "probable" or "unknown".

The least consistent method of sexing in relation to results obtained from all other techniques, was discriminant function analysis of morphometric measurements. The three birds constituting a reference set for this analysis were a very small sample size. The two discriminant function analyses themselves were consistent for each unclassed individual, but in some cases (eg., 2606 and 2609), the results did not agree with other methods.

1.3.5 Equipment

Observations were made from hides through Zeiss 8 x 30 mm binoculars. A 60 mm spotting scope was used for observing young chicks and the foraging and incubation behaviour of captive adults. All observations in the wild were made through a telescope.

Vocalisations were recorded onto a Nagra IV-D tape recorder through a Sennheiser transistorized condenser, directional microphone. The recordings were run at a 19.05 cm/sec tape speed, on low noise setting. Tapes were played through a Kay Electric Co. spectrographic vibralizer model no.7030, on a wide band setting at 80-80,000 Hz.

Photographs were taken with a Pentax K1000 camera, using 50 mm and 350 mm lenses in captivity and a 500 mm lens (courtesy R. Pierce) in the wild population.

Table 1.2 Methods of sexing *1

	1	2	3	4	5	6	7	8	Probable sex
Individual									
2605	m	nr	m	m	m	m	m	-	male
2606	f	m	f	f	f	m	m	-	female
2607	f	-	f	f	m	f	f	fA	female
2608	f	-	m	f	f	f	f	-	female
2609	f	-	f	f	f	m	m	-	female
2610	m	-	m	m	m	m	m	-	male
2611	m	m	m	m	m	m	m	mB	male
2612	f	f	f	f	f	f	f	fB	female
5107	-	-	-	f	-	-	-	fA	female
5108	-	-	nr	f	m	-	f	-	unknown*2
5109	-	-	m	nr	m	-	f	-	unknown*2
5110	-	-	m	m	m	-	m	-	male
5111	-	-	-	m	-	-	-	mA	male
5112	-	f	f	f	f	-	f	-	female
5113	-	m	m	f	f	-	f	-	unknown*2
5114	-	nr	m	m	m	-	f	-	male
2632	-	-	-	-	m	-	-	-	unknown*2

*1 KEY: 1 = hormonal analysis (1)
2 = hormonal analysis (2)
3 = hormonal analysis (3)
4 = behavioural observation
5 = pubic bone width
6 = discriminant analysis (1)
7 = discriminant analysis (2)
8 = actual sex

m = male f = female nr = no result
A = autopsy B = breeder - = not tested

*2 = sex unknown; insufficient or conflicting results.