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**ECOLOGY AND BREEDING
BIOLOGY OF PAREA
(CHATHAM ISLAND PIGEON)
ON SOUTHERN CHATHAM ISLAND
JULY 1991 -APRIL 1992**

by

**Ralph Powlesland, Andrew Grant, Christine Tisdall,
Peter Dilks and Ian Flux**

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by

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ABSTRACT

This report describes the results from the first year of a three-year research programme on parea (*Hemiphaga novaeseelandiae chathamensis*) at southern Island. It is estimated that the study population increased by 11.5% over the breeding season, and that the total population is about 100 birds. Parea diet was similar to that recorded by previous observers. Although kereru (*H. n. novaeseelandiae*) favour fruit when available (Clout 1990), nesting parea spent much time eating leaves, particularly of pasture species when fruit was scarce, and at least some of these they regurgitated to nestlings and fledglings. During most field-trips, nesting and non-breeding parea occasionally flew from their core ranges in valleys to isolated forest patches and pouteretere-bracken (*Pteridium esculentum*) areas up to a kilometre away to feed on fruit that was not available in the valleys. Parea had an extended nesting season in 1991-92, beginning in August and ending in May, when the last known nestling fledged in May. The 11 nests had a mean height of four metres, and were situated in the shaded canopy and upper understorey. Some nests were readily accessible to rats and cats; however, from 10 nests in which eggs were laid, seven nestlings fledged and no sign of predation was evident at the three unsuccessful nests. Nestlings fledged at about 45 days of age, and became independent when 80-100 days old.

1. INTRODUCTION

The parea or Chatham Island pigeon (*Hemiphaga novaeseelandiae chathamensis*) is a large fruit pigeon (620-960 g), endemic to the Chatham Islands. It is one of two surviving subspecies of the New Zealand pigeon (*H. novaeseelandiae*), a genus with only the one species.

Parea were common on Chatham, Pitt and Mangere Islands when the group was visited by early European naturalists (Travers and Travers 1872). It is also the commonest in subfossil dune deposits and middens of the Chatham Islands (Turbott 1990, P.R. Millener pers. comm.). However, by 1938 very few pigeons occurred north of Waitangi, Chatham Island (Fig. 1), but were moderately plentiful in forested areas to the south (Fleming 1939). By 1975 there were only sporadic sightings of the parea in the northern parts and it was rare in the southern forests of Island and on Pitt Island (Merton and Bell 1975). A survey during the summers of 1988 and 1989 of much of Island indicated a population of about 40 birds, with possibly a further three on Pitt Island and one on South East Island (Grant 1990). The rapid decline of parea following European colonisation has led to the subspecies being critically endangered. The reasons for the decline are considered to be forest clearance for farming, degradation of the remaining forest by browsing of stock (cattle, sheep, pigs) and possums (*Trichosurus vulpecula*), predation by cats and ship rats (*Rattus rattus*), and hunting by people.

Since so few birds were evident during the survey and extinction of parea seemed imminent, a draft recovery plan was prepared listing the actions considered necessary over the 1990-1995 period to reverse the gradual decline of parea in recent years (Grant 1990). One of the objectives of the plan was to gain as much information as possible about the ecology and biology of parea so that the most appropriate management actions can be undertaken. The first field-trip was made in July 1990, when the prospects for the conservation of the parea were assessed and two pigeons were radio-tagged (Clout and Robertson 1991). This report describes the results of the first year of intensive fieldwork to meet this objective, and makes recommendations for future research and management of parea.

2. METHODS

2.1 Study areas

Following our first field-trip in July 1991, when several forest reserves and private forests were visited, the decision was made to initially study parea in the Awatotara and Tuku Valleys. The main reasons for this decision were because the valleys contained much forest, a reasonable number of birds inhabited them (about 30 birds, of which two were already radio-tagged (Clout and Robertson 1991)) and operations were under way to improve the forest for parea (since 1989 cats, possums and rats have been trapped and feral stock shot, while fencing out of stock from the valleys began in 1991).

2.2 Study periods

Field-trips were made to the study areas, southern Chatham Island, during: 23 July - 6 August 1991; 24 September -14 October 1991; 25 November -16 December 1991; 1 -18 January 1992; and 20 March -10 April 1992.

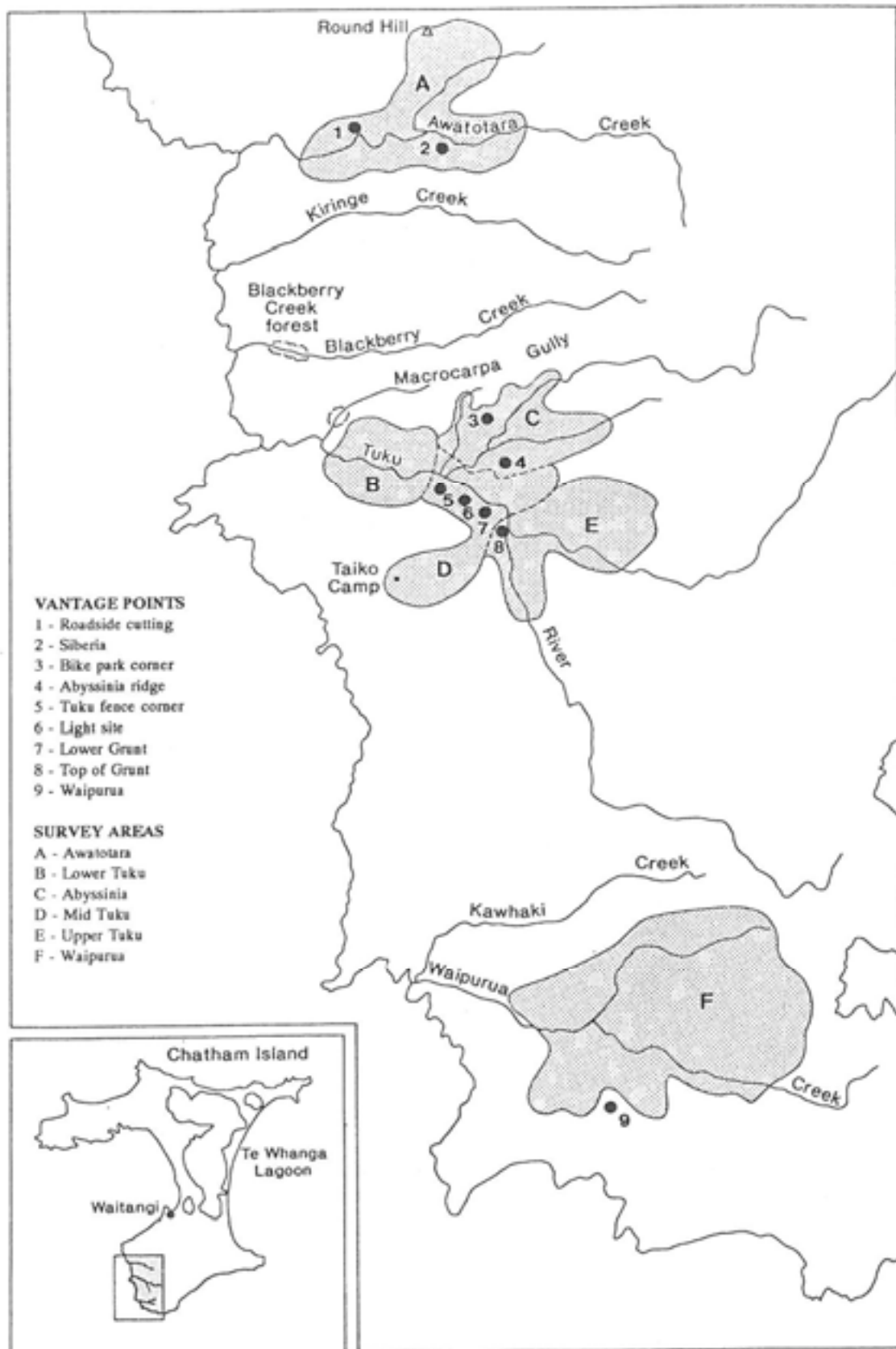


Fig. 1 Chatham Island, showing locations of study areas (Awatotara Valley, Macrocarpa Gully, and Tuku Valley), vantage points used when surveying for parea (1-9), and the boundaries of the survey areas (A-F).

2.3 Identity of parea

By April 1992, coloured jesses had been fitted to the legs of 11 parea so that they could be identified individually. Each jess was a strip, 13 x 120 mm, of coloured cloth impregnated with plastic. It was fastened around the leg by a falconers' knot, with a 50 mm length hanging from the back of the leg. The use of such jesses on kereru over several years indicate they are a safe method for individually identifying pigeons and that they remain intact for at least two years (M.N. Clout pers. comm.) Two of these birds were paired adults with an unmarked mate and were relatively sedentary. Whenever an unjessed bird was seen associating closely and amicably with either of these birds it was assumed to be the mate and was recorded as an 'identifiable' individual during behaviour and habitat-use observations. The other nine jessed birds were two non-breeding adults and seven young of the 1991-92 breeding season. Five jessed birds were also fitted with radio transmitters. The two stage transmitter, 32 g (supplied by Sirtrack Electronics), was attached to the bird's back by a harness with a weak link so that if the bird became entangled, it would be able to free itself from the harness and escape (Karl and Clout 1987). If a bird was not individually identifiable and its behaviour and habitat was recorded, it was listed as unknown and its locality noted.

2.4 Day-periods

When observations were carried out on a bird the data were allocated to a 'day-period'. Mean daylength from sunrise to sunset was calculated for each field trip and then divided into six equal periods. A tally was kept of the number of observations of each bird and locality per day-period to ensure the number of observations for an individual or locality was not biased to a particular portion of the day.

2.5 Behaviour and habitat use records

The habitat use method of O'Donnell and Dilks (1988), with some modifications, was used to quantify the behaviour and habitat utilisation by parea. The method involved recording a pigeon's activity, food type, and precise position in a tree at one minute intervals. The timing of the observations was signalled by an electronic metronome. The observation data were written on to a record sheet (Appendix 1). If more than one bird was in view, the activities and habitat use of only one was recorded. Because of the rarity of parea, transects were not followed to locate a bird (O'Donnell and Dilks 1988). Radio-tagged birds were located by telemetry, and non-tagged birds were found by searching likely habitat and by returning to sites where birds had been located previously. Individuals were followed and their habitat use recorded for as long as possible.

At each minute an 'observation' was made and one criterion from each of 12 categories was recorded. The data were recorded using a three letter code usually derived from the first three letters of an appropriate word. The 12 categories were:

1. Time: of day (24-hour clock)
2. Observation number: the number of the observation for the bird for the sighting

3. Number of birds: that were in view

4. Activity: that the bird was engaged in -

ROO	roost: a stationary posture, often with the head withdrawn onto the body, tail slightly depressed, while standing or sitting, inactive, sleeping.
SEA	search: stationary, standing, neck partially extended and head movements.
ALE	alert: stationary or moving with upright posture, plumage depressed giving slim appearance, neck fully extended, head movements.
FEE	feed: tasting, picking and eating food items, includes drinking.
MOV	move: walk or hop.
FLY	fly: includes flapping, gliding, diving and display flights, the latter consisting of a steep upward flapping flight, stall with wings and tail spread, and a gliding descent.
COM	comfort: includes preening, toe-nibbling, beak-wiping, head scratching, body shaking, bathing, sunbathing and stretching movements.
CAL	call: vocalisations, usually of short duration, that were not associated with intraspecific interactions.
AGG	aggression: almost all such interactions were with conspecifics, involving the aggressor often in erect posture with plumage puffed out, wings held slightly out from and tail fanned while moving towards the other, or following in flight after displacing another from a perch.
COU	courtship: interactions between members of a pair, including one member bouncing on a branch in upright posture with plumage puffed out and calling while next to its partner, beak-fencing, bowing, mating, and nest attraction display.
DEF	defecate (self-explanatory)
MAT	material: includes gathering nest material and nest-building.
INC	incubate (self-explanatory)
BRO	brood (self-explanatory)
YOU	young: interaction with squab or fledgling, which was mainly feeding.
UNK	unknown: when the parea was known to be in a particular tree/shrub, but could not be seen.

5. Plant species: that the bird was using -

AKE	akeake (<i>Olearia traversii</i>)
COP	<i>Coprosma propinqua</i>
GRO	soil or rock
HOH	hoho (<i>Pseudopanax chathamicus</i>)
HOK	hokataka (<i>Corokia macrocarpa</i>)
KAR	karamu (<i>Coprosma chathamica</i>)
KAW	kawakawa
KOP	kopi (<i>Corynocarpus laevigatus</i>)
MAH	mahoe
MAT	matipo (<i>Myrsine chathamica</i>)
PAS	pasture, which includes herbs under a forest canopy and grass-clover pasture at the forest margin

POU	pouteretere (<i>Cyathodes robusta</i>)
STD	standing dead tree
SUP	supplejack (<i>Ripogonum scandens</i>)
TAR	tarahinau (<i>Dracophyllum arboreum</i>)
TRE	treefern (<i>Cyathea</i> and <i>Dicksonia</i> spp.)

6. Food type: category of food being tasted, and/or picked and eaten -

LEB	leaf bud
YLE	young leaf
MLE	mature leaf
MOS	moss
LIC	lichen
PAS	pasture and herbs
FLB	flower bud
FLO	flower
IFR	immature fruit
GFR	green fruit
HFR	half ripe fruit
RFR	ripe fruit
WAT	water
UNK	unknown

7. Stratum: a measure of the level within the forest structure, the height of each stratum varying with the forest type -

FLY	above canopy: in flight
ISO	isolated tree: or two trees isolated from forest by pasture or bracken
EME	emergent: tree growing above the canopy
USC	unshaded canopy: storey of tree crowns unshaded by others
SHC	shaded canopy: upper storey of tree crown shaded by the canopy
UUN	upper understory: region below canopy tree crowns which includes tall shrubs, secondary larger trees, trunks of the canopy trees
LUN	lower understory: vegetation layer immediately above forest floor which includes shrubs, regenerating canopy trees, short tree ferns and lower tree
GRO	ground: bare soil and rocks
PAS	pasture: herbs and pasture species

8. & 9. Bird/canopy height: estimated to nearest metre. Canopy heights of generally less than 10 metres made estimates to within a metre possible.

10. Station: perch type -

TRU	trunk
BRA	branch (> 1 cm diameter)
DEA	dead branch
TWI	twig (< 1 cm diameter)
VIN	vine
FOL	foliage

PAS	pasture
GRO	bare ground, rock

11. Physiography: landform

VAL	valley bottom
FAC	valley side or face
RID	ridge top
FLA	flat

12. Aspect: lie of the land (compass bearing)

NAP	not applicable (flat)
N	north
NE	northeast
NW	northwest
E	east
S	south
SE	southeast
SW	southwest
W	west

2.6 Hilltop watches

Pearson and Climo (1991) considered parea were most conspicuous (flew, gave display flights and roosted on exposed perches) during the evening on fine days but made no quantitative observations to support this statement. However, they and Canterbury Conservancy staff watched from hill and ridge tops for two hours prior to dusk and recorded the number of sightings to determine parea abundance and distribution. Generally, they were able to keep track of individuals and so determined the minimum number of parea present in an area. To test the statement that parea are most conspicuous during evenings, all-day watches of the lower Awatotara Valley were carried out simultaneously from three viewing points in October and December 1991. Each time a bird movement was seen, the time, number of birds involved, locality, and whether it gave a display flight was recorded.

2.7 Nest finding, protection and observations

Nests of parea were found by using one of three methods:

1. When one partner was radio-tagged, this pigeon was regularly located and followed to determine if and where the pair was nesting.
2. Some nests were located when searching for or following a parea and seeing it go to a nest with a twig when nest-building or relieving an incubating partner.
3. Two or three people, each with a two-way radio, were stationed on different viewing points to watch for a bird flying to a likely nest site and then a bird leaving from the same site a minute or two later (a changeover at a nest).

These observations were carried out from 0800 to 1030 and from 1500 to 1800 in October (sunrise 0600, sunset 1845 Standard Time) because observations of incubating

birds indicated they invariably changed over once during each of these periods. This method was used when birds were known to be resident in an area, but no nest had been found.

Once a nest was found an effort was made to minimise the risk of predation. We were able to isolate the nest tree of one pair by cutting off branches of a neighbouring tree and then placing a metal collar of a metre width about two metres up the trunk to prevent rats and possums climbing up. Other nests were not able to be isolated and so six poison tunnels (100 mm diameter containing four to six Talon poison baits) and six Ezeset rat traps baited with cheese, were placed under cover at a 20-50 m radius about the nest trees. In addition, gin traps baited with fish were set near some nests. The traps and poison tunnels were checked daily and when necessary.

Records of parea activities at nests during incubation and nestling rearing were obtained by a person sitting 20-30 m from the nest tree. A hide was not used, but often foliage hid the person to some degree. Most adults proved very tolerant of the presence and movements of an observer; no parea left its nest when approached, or left the observation site, or gave the appearance of being alarmed. Similarly, when people were placing or checking bait stations and traps about nest trees, adult birds remained on their nests.

Nests were inspected only if the adults were absent. On the few occasions when an adult returned to its nest during an inspection, it perched nearby and then moved to the nest soon after the observer departed. Chicks that were easily accessible without risk of damage to their nests or the surrounding vegetation were weighed at about 3-day intervals once they were left unattended (at c. 15 days of age). Chicks were weighed until 35-40 days of age, when their wing-flapping and movements to avoid capture were likely to result in injury to themselves or in their falling from the nest. One or two jesses and a numbered metal band were put on each nestling when it was about 25 days old. Also, at this time some dye was applied to some of the white chest feathers. A transmitter (31.8-33.4 g) and harness of the standard kereru design (Karl and Clout 1987) were attached to three nestlings when two were estimated to be 33 days old (555 g, 570 g) and the third 45 days old (555 g). A feather sample was obtained from each chick during banding or radio-tagging and was stored for later genetic analysis.

When recording observations of a nestling or fledgling being fed, a feeding session was deemed to last from when an adult began regurgitating food to its offspring and until the parent began brooding it, or left the nest/fledgling. Each feeding session consisted of bouts of regurgitations, starting with the chick putting its beak into the adult's mouth and ending when the chick withdrew its beak. During a bout of regurgitations, rhythmic retching movements of the adult's crop, neck and head were obvious as food was forced the crop to the mouth. Each wave of contraction and a bob of the adult's head was counted as a regurgitation.

2.8 Rat index trapping

Index trapping of rats was carried out in April, July and October 1991 and February 1992. Trapping was conducted in Awatotara Valley (22 sites), Macrocarpa Gully (21

sites) and Tuku Valley (50 sites) (Fig. 1), with the sites being 50 m apart. At each trap site one Ezeset rat trap was placed under natural cover or in a tunnel of wire mesh covered with plastic sheet. The traps, baited with cheese, were set for three consecutive nights. They were checked daily and the rats were sexed and weighed. Trapping started in the Tuku Valley and Macrocarpa Gully in April 1991, and in the Awatotara Valley in July 1991.

3. RESULTS

3.1 Numbers of parea

3.1.1 Hill-top watches

Whole-day watches for parea movements in the lower totara Valley on 9 October and 6 December 1991 indicated that parea were most conspicuous during the second to fourth hours after sunrise and the three hours before sunset (Fig. 2). Pigeons were most conspicuous in late afternoon, particularly in October. Overall, 13.0% of movements in October were display flights, and 14.5% in December.

3.1.2 Adult survival

All four individually marked adults were still present in April 1992. No evidence was found that any unmarked adults had died (no abandoned nests were found, nor malnourished nestlings suggesting only one parent was attending them). No dead birds were found, nor aggregations of feathers indicating predation or scavenging. Two adults (K-8152, K-8153) radio-tagged in July 1990 were still alive in April 1992. A third bird (K-8151) fitted with jesses in July 1990, whose core home range was probably beyond the areas regularly searched for parea, was seen irregularly, the last time in March 1992. A fourth adult (K-8161), fitted with a jess in December 1991, was last seen in March 1992.

3.1.3 Census

On 2 February 1992 a census of parea in the Tuku study area was undertaken. Between 1730 and 2000 hours, six people recorded parea movements and made estimates of the number of parea in the Tuku catchment in each of their fields of view. A person was stationed at each of the following vantage points: bike park corner, Abyssinia ridge, Tuku fence corner, light site, lower Grunt on the western side looking NW to SW, and top of the Grunt looking NE to SE (Fig. 1). Observers noted the time of each parea sighting and the bird's location so that when estimating the number of birds seen in a particular area it was possible to determine if a bird was seen by more than one observer. Similarly, on 16 February 1992 a census of parea in the Awatotara Valley was made from 1730 to 2000 hours from 'roadside cutting' and 'Siberia' vantage points (Fig. 1). From these observations it was estimated that at least 40 adults and 10 fledglings occupied the Awatotara and Tuku catchments (Table 1). Maximum numbers may have been as high as 46 adults and 12 fledglings. The estimate of eight parea in the Awatotara Valley agrees with the number determined from locating and following birds during December 1991 and January 1992.

3.2 Diet

Although a wide variety of plant species and food types were available to parea, during each three-week trip most of their diet usually consisted of five or less food-types from

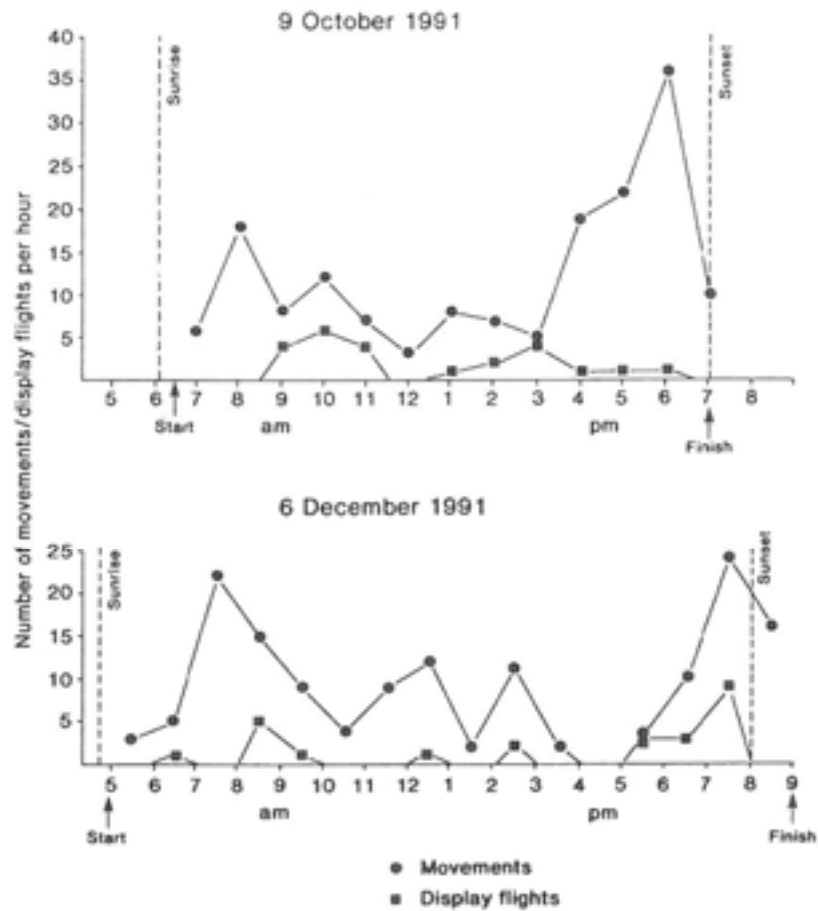


Fig. 2 Number of movements and display flights by parea at hourly intervals between sunrise and sunset on 9 October and 6 December 1991 in the Awatotara Valley, southern Chatham Island.

Table 1 Estimated minimum number of parea in the Tuku and Awatotara Valleys in February 1992 as determined by hill-top watches. For boundaries of areas, see Figure 1.

Area	Adult	Juvenile	Total
TUKU VALLEY			
Abyssinia	8	2	10
Taiko camp & mid Tuku	12	2	14
Upper Tuku	3	-	3
Lower Tuku	10	5	15
AWATOTARA VALLEY			
TOTAL	40	10	50

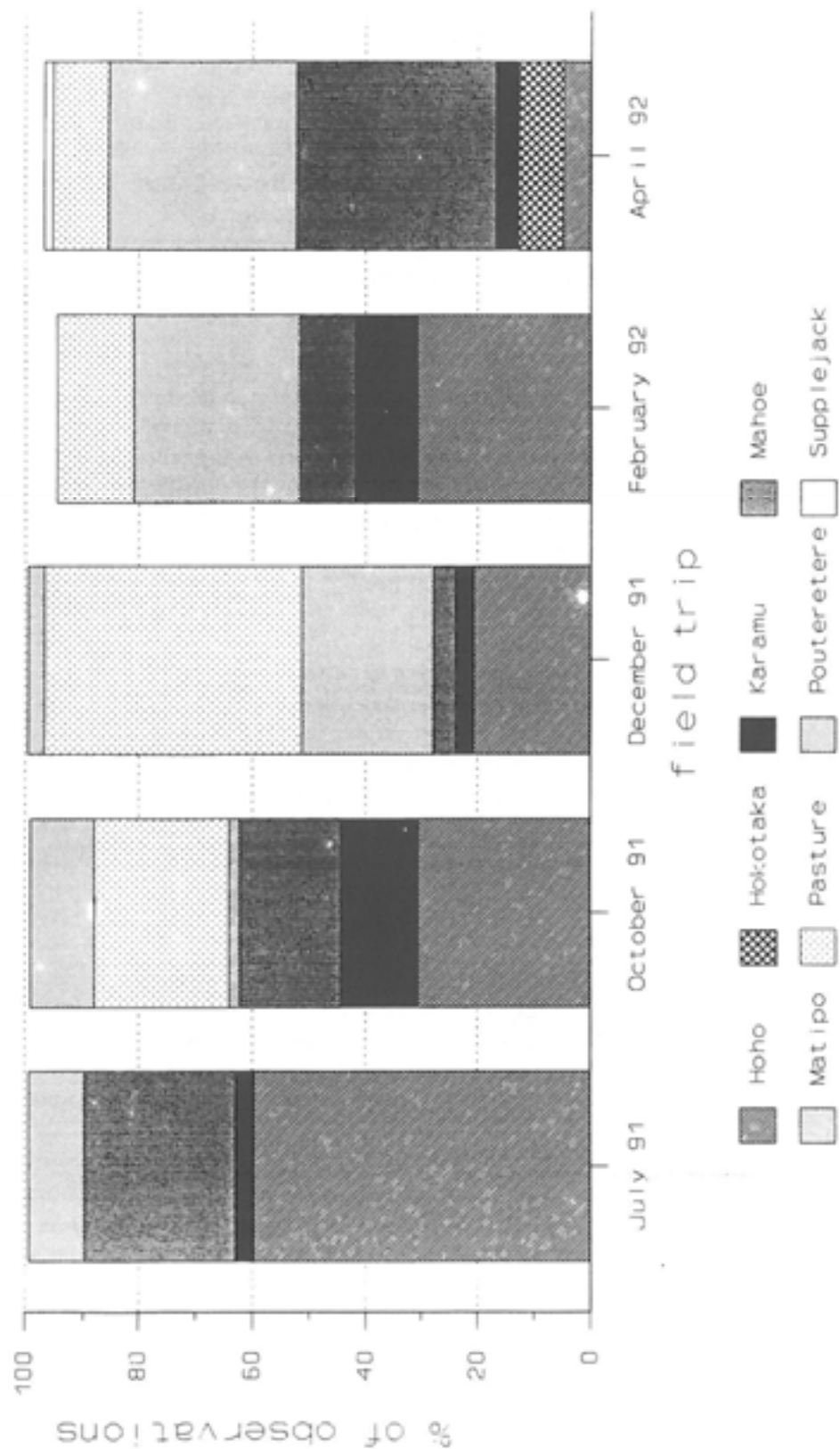


Fig. 3 Percentages of feeding observations (>1%) of parea in the Awatotara and Tuku Valleys feeding on seven species and 'pasture', which was mainly pennywort, chickweed, white clover, and grasses.

eight or fewer species (Table 2). When parea fed on 'pasture' species we could rarely determine the food species. The main species eaten seemed to be pennywort (*Hydrocotyle heteromeria*), chickweed (*Stellaria decipiens*), white clover (*Trifolium repens*) and grasses. Over the first year of study only 12 species (seven tree/shrubs, one liane and four pasture species) were prominent in the parea diet (Fig. 3). Eight of these species were represented in the diet in four or all five of the field trips. Leaves and fruit were eaten each field-trip and made up the hulk of parea diet (69.2-97.3% per trip) (Fig. 4). Flower buds and flowers occasionally formed an appreciable component of the diet, such as in July 1991 when mahoe flower buds were eaten.

3.3 Movements

Each of two radio-tagged and paired parea (caught in July 1990), one in the Awatotara Valley and the other in the Tuku Valley, restricted their movements to a home range of about 20 hectares, particularly during the July and October 1991, and April 1992 field trips. However, during the summer months they were often found outside their core ranges, which occasionally involved them flying over unsuitable habitat (extensive pasture-bracken). In summer and autumn other parea were also often seen flying long distances, and were found in isolated forest or scrub patches where parea had not been seen during previous trips. When a bird in an isolated patch was it was invariably last seen in flight beyond the patch and over habitat unsuitable for parea. Long-distance flights seemed to involve birds moving to or from habitats or patches of isolated forest where particular foods were available that were not present in their core ranges, such foods being fruit of matipo, mahoe, pouteretere and supplejack. For example, nesting parea and fledglings flew up to a kilometre from their core ranges in valleys which contained very few fruiting matipo to patches of mixed broadleaf forest beyond the valleys (e.g. Blackberry Creek and Round Hill, Fig. 1). In these patches some matipo trees fruited heavily in December 1991, about two months before matipo in the *Dracophyllum* forest on the adjacent tablelands had ripe fruit.

3.4 Breeding

3.4.1 Extent of breeding season

In July 1991 pairs were infrequently seen involved in courtship, and occasionally one member tried to attract its mate to a prospective site or presented it with a twig. The earliest evidence of nesting was on 20 August when a pair was seen nest building. Of the 11 nests found, the date of egg-laying could be determined for nine (Table 3). Six eggs were laid in September, two in October and one in February. The laying date for Nest 1 was probably during late August, and Nest 11 was completed in late February but apparently an egg was not laid. Nestlings from Nests 2 to 9 fledged in November-December, and the one from Nest 10 in May. Thus, there were two separate nesting periods, an early one in August-December and a late period in February-May.

3.4.2 Nests

Of the 11 nests found, seven were in the shaded canopy and the rest in the upper understorey. All but one nest (Nest 7, which failed in early incubation) had sufficient foliage about them to provide incubating birds and nestlings with some shelter from weather and to hide them from harriers (*Circus approximans*) flying overhead.

Table 2 Percentage of feeding observations (>5%) of parea in the Awatotara and Tuku Valleys feeding on various food-types.

Field-trip	N ¹	Food species and types																
		Hobo		Hokotaka		Karamu		Mahoe		Matipo		Pasture ²		Pouteretere		Other		
		LEA ³	FLB	FRU	FRU	FRU	LEA	FLO	FRU	FLB	FLO	FRU	FRU	PAS	PAS	FRU	FRU	Other
1991																		
July	534	9.9	-	48.5	-	-	-	-	22.1	-	-	-	-	-	-	9.7	9.8	
October	1480	16.3	-	14.1	-	5.1	8.5	-	-	12.2	-	-	-	23.9	11.2	8.7		
December	1785	13.1	-	6.5	-	-	-	-	-	-	-	23.5	45.4	-	-	11.5		
1992																		
February	1050	-	27.8	-	-	-	-	9.7	-	-	9.1	27.3	13.5	-	-	12.6		
April	754	-	-	-	8.1	-	-	-	-	-	34.0	32.2	9.8	-	-	15.9		

¹ N = number of feeding observations.

² Pasture foods were mainly peasaywort, chickweed, white clover and grasses.

³ LEA = leaf, FLB = flower bud, FLO = flower, FRU = fruit, PAS = pasture.

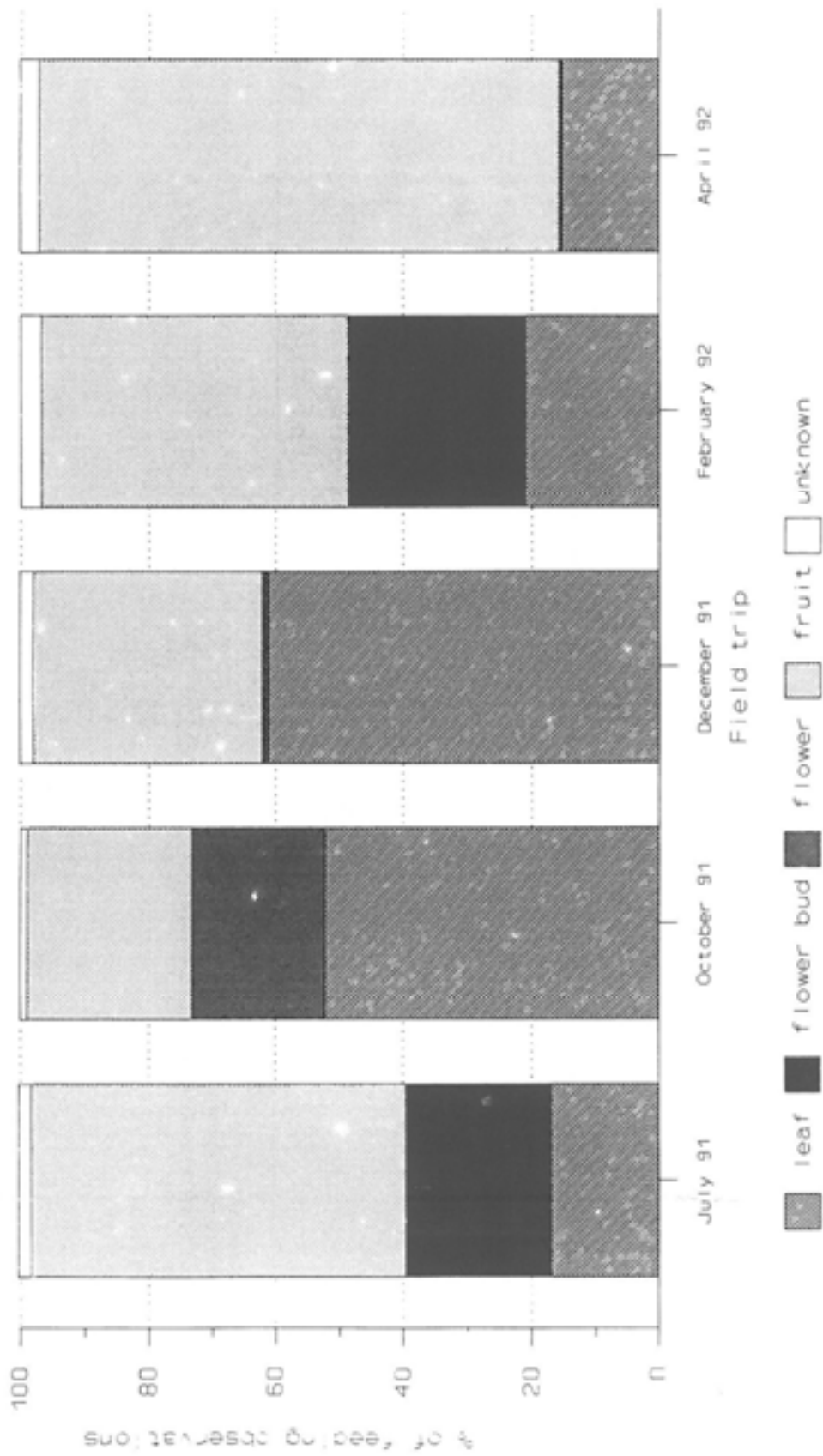


Fig. 4 Percentage of feeding observations of parae in the Awatotara and Tuku Valleys feeding on various food-types.

Table 3 Dates of various nesting activities in relation to each parent nest found during the 1991-92 breeding season in the Awatotara and Tuku Valleys. Known dates are in bold; others have been estimated.

Nest number	Nest found	Nest building ¹	Egg laid	Nestling hatched	Nestling unattended	Nestling out of nest ²	Nestling fledged ³	Fledgling independent ⁴
1	15/10	20/8	?	(some shell and yolk in nest when it was found)				
2	8/10	-	4/9	1/10	15/10	-	8/11	Between 20/21 & 13/1
3	4/9	-	4/9	1/10	7/10	6/11	19/11	Between 18/12 & 13/1
4	8/9	30/8	6/9	4/10	14/10	15/11	19/11	Between 19/12 & 13/1
5	13/10	-	11/9	8/10	27/10	15/11	17/11	After 20/12
6	19/9	19-20/9	26/9	23/10	7/11	(nestling fatally injured during handling)		
7	12/9	12-13/9	27/9	(cracked egg found under abandoned nest)				
8	25/9	25-27/9	1/10	28/10	17/11	11/12	19/12	Between 19/12 & 21/1
9	6/10	-	5/10	1/11	10/11	7/12	14-19/12	?
10	8/3	8/2	18/2	by 16/3	30/3	-	2-4/5	?
11	21/3	(6-19/2 pair seen prospecting and copulating in vicinity; nest tilted when found; no egg found on ground)						

¹ Period of intense building with one bird taking twigs to nest and mate at nest incorporating material.

² Nestling out of nest but perching in nest tree.

³ Nestling seen in flight or roosting in a tree it had had to fly to.

⁴ Fledgling found alone and outside natal home range, or feeding competently and not fed by parents.

Eight nests were supported by forking branches, two by tree fern (*Cyathea* and *Dicksonia* spp.) fronds and one by an almost horizontal tree fern trunk and supplejack vines. Mean nest height was 4.03 m (range = 1.7-7.0, s.d. = 1.77) and mean canopy height directly above the nests was 6.17 m (range = 3.3-8.5, s.d. = 1.62). Some of the nests were readily accessible to cats and rats, being low to the ground (five nests < 3 m high), and being on tree ferns (n = 3) or in trees with short sloping trunks growing out of banks (n = 2).

Nests were constructed mainly of dead tarahinai twigs broken from trees within 50 m of the nest. Much of a nest was built within two days during periods of intense activity (n = 3), when one bird flew to the nest site every minute or two with a twig, while the partner remained at the site much of the time, accepting the material and adding it to the nest. Further twigs were incorporated irregularly up until egg-laying. At a changeover of an incubating pair, the incoming bird sometimes brought a twig to the nest. Eight of the nests were typical of pigeons, being platforms of twigs with a slight depression at their centres. Three nests were quite bulky, and may have been built in a previous season and refurbished in 1991, as the kereru is occasionally known to do (RGP pers. obs.). Of the seven nests that chicks fledged from, two had disintegrated before the chicks fledged, little material remained at one, and the rest remained reasonably intact.

3.4.3 Pre-lay

The duration of the pre-lay period (number of days between intensive nest-building and egg-laying) was six and 14 days for Nests 6 and 7 respectively. During this period twigs were brought irregularly to the nest and occasionally a bird was found sitting on a nest, as though incubating. At Nest 6 the pair was even seen to changeover at the nest although the egg was not laid until four days later.

3.4.4 Eggs

Parea eggs were smooth, white and oval. As for kereru, the clutch size was one. The only one measured was from Nest 7; 33.6 x 50.6 mm, 31 g. It had been incubated for about six days and was found on the ground below the nest. Its measurements are similar to those of two other parea eggs; 35.4 x 49.0 (no date, Canterbury Museum), and 35.5 x 49.6 mm (October 1985, Museum of New Zealand).

3.4.5 Incubation

Incubation began on the day the egg was laid, but during the first few days the egg was occasionally left unattended. For example, the egg at Nest 6 was unattended for 20 minutes on Day 2 from 0953 hours, and for 12 minutes on Day 3 from 0931. Similarly, on Day 6 at the same nest the incubating bird left the egg unattended three times between dawn and 1000 hours for periods of three to 13 minutes. However, at most nests by Day 4, a bird was present when each nest was checked. Also, by then most changeovers involved eggs being exposed for less than a minute because the incubating bird did not leave the nest until its partner landed in the nest tree. It was not unusual for the incoming bird to bring a twig to the nest at changeover.

Changeovers occurred twice each day. During September and October, 12 morning changeovers were observed between 0852 and 1105 hours, with a mean time of 0944 (36.4). The 16 afternoon changeovers observed occurred between 1559 and 1808 hours, with a mean of 1655 (s.d. = 36.8). From observations of the one nesting pair with an

identifiable member (radio-tagged), it was evident that the male (determined during copulation) incubated from mid-morning to late afternoon. The incubation period was determined for Nest 6 only and was 27 days.

3.4.6 Nestlings

Plumage development of nestlings was rapid. When about 14 days old, the nestlings' plumage was well developed, except for the remiges, rectrices and head feathers. At Nests 4 and 6 the nestlings were first found unattended on Day 10 and 15 respectively, and at Nest 10 the nestling was at least 15 days old when first seen unattended. Nestlings were about 40 days old (n= 5) when first seen perching in their nest trees beyond the nest. They gradually spent more time roosting away from the nest until at about Day 45 they made their first flights. Two of the three radio-tagged fledglings were found back in their nest trees one to three days after having flown from them. Thus, other nestlings may have fledged earlier. Only one of six fledglings was found on the ground at fledging. It was radio-tagged on 2 November 1991 at an estimated age of 33 days old. It was found on the ground twice on 8 and once on 9 November. On each occasion it was captured, checked and put up into a tree. Subsequently, it was always found roosting above ground.

Nestlings were fed infrequently by day (Table 4). However, the mean number of bouts of regurgitations per feeding session and the mean number of regurgitations per bout (Table 4), suggest a considerable amount of food was given to a chick each session. After being fed, the crops of chicks were quite swollen. Figure 5 shows the weights of seven nestlings at intervals from soon after being left unattended (about 15 days old) to late in the nestling period.

Table 4 The number of feeding sessions per day, mean number of regurgitation bouts per session, and mean number of regurgitations per bout received by parea nestlings and fledglings of various ages (day of hatching being Day 1) in 1991–1992.

Nestling number	Nestling age (days)	Date	Sessions per day	Bouts per session (n, range)	Regurgitations per bout (n, range)
1	7	22 Mar 1992	1	21.0 (1,-)	11.1 (21, 7–15)
2	12	12 Oct 1991	2	16.5 (2, 10–23)	10.9 (33, 5–16)
1	15	30 Mar 1992	2	17.0 (2, 12–22)	9.0 (34, 2–15)
3	36	27 Nov 1991	3	13.0 (3, 11–14)	10.0 (31, 4–16)
4	37	7 Dec 1991	5	10.7 (3, 7–15)	13.5 (38, 8–21)
<hr/>					
Fledgling number					
1	57	29 Nov 1991	12	6.8 (12, 4–10)	8.4 (77, 2–16)
2	61	1 Dec 1991	10	6.2 (9, 3–9)	10.8 (54, 1–25)

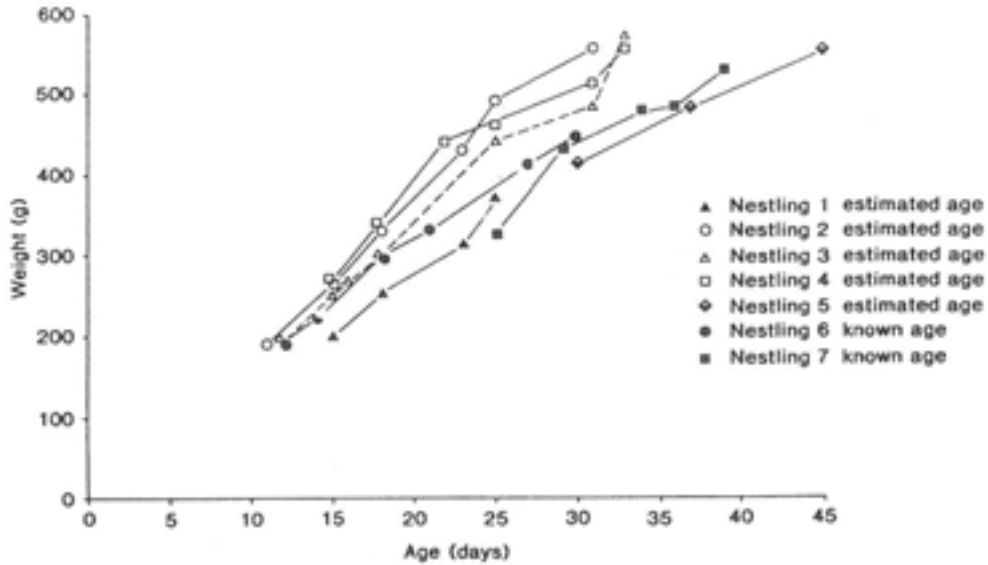


Fig. 5 Weights (g) of parea nestlings at various ages, from nests in the Awatotara and Tuku Valleys, southern Chatham Island, during 1991-92.

3.4.7 Fledglings

Fledglings first flew at about 40 to 50 days of age (mean = 45.4, $n = 5$) (Table 3). For the next 20 days or so they remained within 50 to 100 m of their nest trees, mainly roosting in the shaded canopy. Flights during this period tended to be brief, with the fledglings quickly returning to roost. During this period it seems that fledglings were fed more frequently than nestlings (Table 4). Although fledglings nibbled at and broke off foliage and twigs, they ate few, if any, items until they were about 70 days old. At this age they began to follow their parents about, which included accompanying them to the ground while the parents fed on pasture species.

The radio-tagged fledglings from Nests 2 and 3 became independent during the Christmas-New Year period when 80 to 100 days old. At independence they fed fairly competently, although they tried to eat several foods rarely, if ever, eaten by adults (lichen, moss, twigs, fern frond, immature green fruit of hoho) and were not so adept at breaking off and manipulating items. Having left the natal range, each fledgling initially made occasional brief visits to the vicinity of its nest. By March they had become fairly sedentary at locations about a kilometre from their nests. The third radio-tagged fledgling (Nest 8) was not seen being fed by a parent after it was about 90 days old (begged unsuccessfully when 113 days old), but it often accompanied an adult and returned daily to within 100 m of the nest until the end of March (177 days old). Similarly, the fledgling from Nest 4 was not seen to be fed by its parents in January (c. 100 days old), but remained in the natal range and invariably accompanied at least one adult until late March (c. 180 days old), after which it was not seen.

Once independent all three radio-tagged juveniles established themselves in tarahinau dominated forest on terraces above the mixed broad-leaf forest in the valleys. We assume the mixed broad-leaf forest is the optimum habitat at present because most nesting pairs occupied this habitat type. If that is the case it will be important to

determine whether the juveniles survive and remain in the tarahinau forest as such results would have implications for the maximum number of parea that can inhabit the study areas.

3.4.8 Nesting success

At least one pair did not nest; one of two pairs of which one member was radio-tagged. The unsuccessful attempts by the female to build a nest after several attempts, even though her mate was seen to offer her twigs irregularly over seven months, suggests she was a young bird. Having three radio-tagged juveniles should enable us to determine the age and competence at first breeding.

From the 10 nests that each contained an egg, six nestlings fledged and reached independence. In addition, a seventh nestling (Nest 10) probably fledged successfully as it disappeared from the nest when 48-50 days old, an age when the other nestlings fledged. As well as the six early fledglings, at least five other unmarked fledglings were seen in January 1992.

3.5 Rat index trapping

Results of the index trapping indicate ship rats were most abundant in autumn (April 1991 and 1992) and winter (July 1991) (Table 5). They remained reasonably numerous in the Tuku Valley in spring (October 1991) and summer (February) to low numbers in the other two areas during these seasons. Mice (*Mus musculus*) also caught in the traps. Wekas (*Gallirallus australis*) occasionally sprung traps, more so during the April and July 1991 trapping sessions than during later ones.

3.6 Genetics and morphology

The allele frequencies in tissue samples from the parea nestling of Nest 6 (Table 3) were compared with those in samples from 10 kereru and a rock pigeon (*Columba livia*) by starch gel electrophoresis (Appendix 2). Dr S. Triggs determined that the parea is not

Table 5 Results of seasonal rat index trapping (captures per 100 trap nights) during 1991-1992 in the Awatotara Valley, Tuku Valley and Macrocarpa Gully, southern Chatham Island.

Date	Awatotara Valley	Tuku Valley	Macrocarpa Gully
9-11 Apr 1991	-	14.6	19.6
29 Jul-5 Aug 1991	14.0	18.0	5.3
26 Sep-7 Oct 1991	1.6	13.5	11.4
3-8 Feb 1992	6.8	13.5	1.8
2-5 Apr 1992	7.1	22.0	25.2

very distinct from the kereru but this conclusion must be considered very tentative until more parea samples are obtained and more discriminating techniques (i.e. DNA analysis) used.

Measurements of study skins by RGP and subfossil bones by Dr P. Millener, Museum of New Zealand, that there are significant differences between parea and kereru in beak morphology, the skull and pelvis structure, and lengths (both absolute and relative) of leg and wing bones.

4. DISCUSSION

4.1 Numbers of parea

4.1.1 Hilltop watches

Results indicate that in October and December, when some pairs were breeding, parea were most conspicuous from two hours after sunrise for about two hours and during the three hours prior to sunset, particularly so in the latter period. Thus, if teams were in the field to determine parea distribution and numbers, observations could productively be carried out in the morning period as well as the afternoon one. Observations in the Awatotara Valley, where the number and home ranges of resident birds were known, indicated that single birds were more likely to go undetected than were pairs, especially in the morning. This probably occurred because three pairs defended much of the valley, and the two single birds when present confined their activities to small areas of forest and either rarely flew above the canopy or roosted conspicuously. In contrast, members of a pair occasionally gave display flights when flying between feeding sites or going to the nest, invariably roosted conspicuously, and usually chased any intruders from their range giving a display flight when returning to roost. Our observations indicate that parea perform display flights year-round, but we have yet to quantify the frequency outside the breeding season. This finding is in contrast to that for kereru, which perform display flights only just before and during the breeding season (Clout 1990, Langham 1991).

4.1.2 Adult survival

Although there were only three parea individually marked prior to December 1991, all survived the eighteen months that have elapsed since banding. It is known from sign found in the 1980s near Taiko (Figure 1) that cats kill adult parea (D. Crockett pers. comm.). B. and L. Tuanui (pers. comm.) commented that prior to the cat control programme conducted over the past three years, they regularly saw wild cats in and about the Awatotara Valley. This control programme has reduced the cat population to low levels; during our field trips no wild cats and very few cat scats were seen in the study areas. While feeding on the ground parea are to being caught by cats. When feeding among herbs under forest or on pasture at the forest edge, parea were often observed in a situation where a stalking cat could have remained concealed until within a metre or two of the bird.

4.1.3 Census results

Parea of the Tuku and Awatotara Valleys have been observed for many years. E. Tuanui (pers. comm.), whose home overlooks the Awatotara Valley, considered that prior to 1990 about three parea lived in this valley. Casual observations by ornithologists involved in the taiko (*Pterodroma magentae*) project since 1969 suggested there were

about six parea in the Tuku Valley. These figures were consistent with the estimates obtained during a survey of the valleys in 1988 (Grant 1989).

The hill-top censuses, begun in October 1990 (Pearson and Climo 1991), indicated greater numbers of parea in both valleys than previously thought. About the same time Tuanui family members commented that they were seeing more parea than previously. Whether this apparent increase in parea numbers in the valleys was due to people being more aware of parea, the use of a better method to detect parea (hill-top observations, Pearson and Climo 1991), or an actual increase in numbers is unknown. However, it is noteworthy that the increased sightings of parea occurred not long after the start in September 1989 of a predator control programme in both valleys. This programme is aimed at controlling the predators of taiko and parea, and browsers that compete with parea each spring and autumn. To date 161 cats, 2666 possums, 1355 wekas, 486 rats and many feral sheep and cattle have been killed.

A count carried out in September 1991 gave a total of 46 parea (November 1990 figures were used for the two areas where counts were not carried out) (Table 6). Thus, it seems that the number of adult parea in the study areas and the Waipurua Valley has remained stable. What has changed is the distribution of the population; fewer birds in the Waipurua Valley and more in the lower Tuku. This may result from either a seasonal movement of birds, or because birds moved from an area of poor habitat (no wild animal control in the Waipurua) to one of relatively good habitat. If the latter is

Table 6 Estimated number of parea in the Awatotara, Tuku and Waipurua Valleys, southern Chatham Island, as determined by hill-top watches on three occasions.

Area	Time of observations		
	Nov 90	Sep 91	Feb 92
Awatotara	6 (1)	8	7+[1]
Tuku			
(a) Abyssinia	6 (1)	9	8+[2] (2)
(b) Taiko camp & mid Tuku	10 (1)	12	12+[2] (2)+{1}
(c) Upper Tuku	5 (1)	NC → 5*	3*
(d) Lower Tuku	0	4	10+[5] (2)+{1}
Waipurua	8 (1)	NC → 8*	2 {1}
TOTAL	35 - (41)	33 → 46	42+[10] - (48)+{13}

NC = not counted

() = not sure if these were additional birds

[] = fledglings/juveniles

{ } = not sure if these were additional fledglings/juveniles

* Observation from top of the Grant; previous count made from Taiko Hill

* No count was made for these areas in September 1991 and so the November 1990 figures were used to give an indication of the number of parea present

correct then the total adult population may be still much the same as previously, but just more concentrated in the study areas where they are being intensively monitored.

The 10 juveniles seen during the February 1992 census reflect the recent highly productive breeding season. The population increased 13% (to 52) from the September 1991 estimate of 46 birds (Table 6). The continued survival of these juveniles over winter will be of considerable importance to the parea conservation programme. The total population now probably consists of about 100 birds.

4.2 Diet and movements

Other than the frequent eating of pouteretere fruit and the infrequent eating of kopi fruit, the diet of parea recorded during our field-trips was much the same as that recorded during earlier observations (Morris 1979, Clout and Robertson 1991, and Climo 1991). Considering that parea from both the Awatotara and Tuku Valleys fed on ripe pouteretere fruit and some birds flew more than a kilometre from their nests to reach habitats containing this food source, it is interesting that parea ignored this food when plants were laden with fruit in October-November 1990 (Pearson and Climo 1991). The fruit of mingimingi (*Cyathodes juniperina*) from southern Stewart Island is rich in carbohydrates (James *et al.* 1991) and, probably, so are those of pouteretere. Since pouteretere fruit was a major component of parea diet during the early nesting period in 1991-92 (Table 2, Fig. 3), and since in 1990 parea neither nested nor were known to feed on the fruit this food may be important only to nesting birds.

Fruit is important for breeding of kereru (Clout 1990). Thus, it is noteworthy that much less fruit was eaten during October and December while parea were feeding nestlings and fledglings respectively, than previously or afterwards (Fig. 4). Fruit consumption declined mainly because little was available once hoho fruit had been eaten October, and until matipo fruit began ripening (in December in open forest patches on north-facing slopes, e.g. Blackberry Creek). Leaf material eaten during October and December was mainly that of three herbs: pennywort, chickweed and white clover. Mostly new growth of these herbs was eaten which was probably relatively digestible compared with the mainly mature leaves of mixed hardwoods eaten at other times of year. Comparison of the nutritive values for the herbs and fruit of hoho and matipo will help to determine how suitable the herbs were as substitute foods for nestling growth.

Ground plants, especially introduced clover and grasses, were an important component of the parea's diet in spring 1991. Whether this was due to the reduced availability of native species (because of browsing by introduced mammals and land clearance for farming), or because parea merely ate the most nutritious foods available is unknown as yet.

The significance of the various foods, such as hoho and pouteretere fruit, particularly in promoting and sustaining nesting, may become evident after observations during the next two years. It will be most apparent if parea do not breed in one year of this study so that then their diet and the foods available can be compared between breeding and non-breeding years. Studies of the diet and movements of kereru at Mohi Bush, Hawkes

Bay (Langham 1991), Lake Rotoroa, Nelson (Clout *et al.* 1986) and Bridge Scenic Reserve, Marlborough (Clout *et al.* 1991), indicate the reliance of populations of this subspecies on a range of habitats containing a variety of plant species and therefore a broad spectrum of foods to ensure the birds have readily available food year round. The greater the variety of habitats and food species present, the less likely that parea will be detrimentally effected by the scarcity of a food that in most years is readily available. With this in mind, when revegetating areas of retired pasture in the lower Tuku and Awatotara Valleys, species planted should include those that will improve the variety of foods available to parea, especially in winter and spring when food shortage is most likely. Species planted could include:

1. **Chatham Island nikau** (*Rhopalostylis* sp.) -once widespread, and locally plentiful on moist fertile sites in mixed broadleaf forest (Kelly 1983); such sites existing in the fenced portions of the Tuku and Awatotara Valleys. Fruit of New Zealand nikau (*R. sapida*) was the main food of kereru at Wenderholm, near Auckland, in spring and summer (Clout 1990).
2. **Chatham Island kowhai** (*Sophora microphylla*) -mainly present as groves along the western margin of Te Whanga Lagoon associated with other leaved species on limestone soils (Given 1991). Kowhai flowers in spring, and parea were reported feeding on it in 1991. The foliage of kowhai was an important food of kereru in winter and spring in (Dunn 1981) and Nelson (Clout *et al.* 1986).
3. **Chatham Island ribbonwood** (*Plagianthus betulinus* var. *chathamicus*) - much reduced in distribution, having been cleared from most sites for farmland. Ribbonwood inhabits high fertility soils, such as along streams (Given and Williams 1984). Ribbonwood is deciduous, and the new spring foliage is probably eaten by parea (Morris 1979). Dunn (1981) found that twigs (5-30 mm) with small leaf buds were an important food of kereru in Dunedin Botanic Gardens in winter and some young leaves were eaten in spring.
4. **Tree lucerne** (*Cytisus proliferus*) - an introduced legume which occurs on Chatham Island. Its foliage, flower buds and flowers are an important item in the kereru's diet, particularly in winter and spring (Langham 1991). Planting of tree as shelter belts would assist establishment of native species, and since it grows fairly quickly in sheltered sites, it would soon provide food for parea.

The three Island species suggested for inclusion in the revegetation programme are all threatened species and so their propagation would promote their conservation as well as that of parea. However, the benefit to parea of planting these food species in the Tuku and Awatotara Valleys may take some time to become apparent since Enright (1985) found that New Zealand nikau growing in forest did not produce fruit until they were 80-90 years old. Eventually, all four species would provide food for parea in winter-spring, a period when relatively nutrient-rich items are needed to promote early nesting.

4.3 Breeding

4.3.1 Extent of breeding season

Parea began breeding in August and the last fledgling left its nest in May, a nine month period. If the May fledgling reached independence its parents will have fed it for a further four to six weeks, to about June. Because one breeding cycle takes about 125 days (nest-building-3 days, 10, incubation-27, nestling-45, fledgling-40), there was sufficient time during the 1991-92 season for a pair to nest successfully twice, with or without clutch overlap (see Clout *et al.* 1988). However, the one breeding pair of which one member was tagged did not re-nest after fledging a chick, and there was no evidence of any of the non-tagged pairs attempting to re-nest. From regular observations of parea in the vicinity of where the two pairs began nesting in February 1992 (Nests 10 & 11, Table 3), it seems that they did not attempt to nest earlier in the season. Perhaps a late start to nesting by some pairs and the lack of re-nesting by others was a consequence of energy constraints from moulting. Freshly dropped primaries, secondaries and tail feathers were occasionally found in spring, and all pairs that fledged nestlings began what appeared to be a complete moult while attending fledglings. Moulting studies of the woodpigeon (*Columba palambus*, c. 500 g) in Britain indicated that its primary moult took at least eight months partly because the process was suspended in winter (Ginn and Melville 1983). This result suggests that the moult of the parea is likely to be a nutrient-demanding process, with consequent impacts on the timing of breeding should food availability and/or quality be poor.

The time of egg laying at seven parea nests found prior to 1990 occurred within the laying season evident in 1991-92; August (1), September (1), October (1), December (1) and January (3). Kereru also have a protracted egg-laying season; September to April at Wenderholm, Auckland, and November to March at Pelorus Bridge, Marlborough (M.N. Clout pers. comm.). However, the peak of egg laying was December-February, whereas it was September-October for parea. Comparisons of the incidence and timing of kereru breeding from year to year at three sites suggest that fruit availability is important in initiating and sustaining breeding (Clout 1990). Thus, the significance of the timing and extent of the parea breeding season in 1991-92 will become apparent only after another season or two of information.

4.3.2 Nesting duration

The duration of kereru incubation and nestling periods are 28-30 days and 35-45 days respectively (Moon 1967, Clout 1990). The little information obtained in 1991-92 about the duration of these periods for the parea indicate that they are similar; 27 and 40-50 days respectively. Since most kereru nests found by researchers in recent years have failed to fledge nestlings, no comparative information is available about how long fledgling kereru are fed by and remain with their parents.

4.3.3 Nesting behaviour

Information about the roles of the sexes during the breeding cycle for parea indicates they behave as do kereru (Clout 1990) and species *Columba* species in general (Goodwin 1967). That is, while the male brings material to the nest site, the female remains there, accepts the twigs and builds the nest; incubation and brooding are

shared, with the male attending the nest for much of the day and the female taking over from early evening until mid-morning.

4.3.4 Nesting success

The minimum of six juveniles produced from 10 nests (60.0%) is a good result given that only 10 young fledged from 74 kereru nests (13.5%) found at Pelorus Bridge (45), Mohi Bush (9) and Wenderholm (20) (M.N. Clout pers. comm.). The main cause of kereru nesting failure was predation, often at the egg stage by rats and stoats (*Mustela erminea*). Even though rat control measures were undertaken about each parea nest soon after it was found, two of the seven successful nests were not located and protected until after the chicks had hatched, and at least five pairs that probably nested in the Tuku catchment, produced fledglings without rat control measures about their nests. Ship rat numbers were high in the Tuku Valley in spring 1991 at 18 captures per 100 trap nights; in New Zealand the species has been trapped at up to 22 captures per 100 trap nights, with peak numbers usually in autumn (Innes 1990). Therefore, the nesting success of parea in 1991-92 suggests that, in some seasons at least, ship rats have little impact on chick survival. Because finding parea nests and controlling rat numbers around them is time consuming and expensive, it will be important to determine whether this is necessary.

4.4 Genetics and morphology

Marked differences of measurements and form of various bones between parea and kereru provide convincing evidence that the two forms should be treated as separate species. Once more parea feather samples are available, they and samples from kereru, will be submitted for DNA analyses to determine whether the two forms can be distinguished as two distinct species as readily as they can morphologically. We expect to obtain feather samples from more parea during 1992-93; from nestlings when they are handed and from adults when they are mist-netted for radio-tagging.

5. RECOMMENDATIONS

1. That hilltop watches for parea in the Awatotara, Tuku and Waipurua Valleys be carried out each January-February from the sites used in 1992 to provide comparative information about the number of parea present.
2. That Chatham Island nikau, Chatham Island kowhai, Chatham Island ribbonwood and tree lucerne be included among the species planted in the recently retired pasture areas of the Awatotara and Tuku Valleys so that, in the long-term, parea have a more varied diet available, particularly in winter and spring.
3. That to determine whether parea eggs and nestlings need to be protected from rat predation by trapping and poisoning, every second nest found in the 1992-93 season be left unprotected and that the occupancy of such nests be determined from as far away as possible so as to reduce the likelihood of attracting predators to them.

4. That trapping and/or poisoning of cats and possums be continued twice annually (July-August and March-April) in the Awatotara and Tuku Valleys, and that possum control efforts be extended to the lower fenced areas of each valley.
5. That the grazed patch of open forest by Blackberry Creek be fenced because it contains a wide range of parea food species and was a very important source of ripening matipo fruit for nesting parea in 1991-92.

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APPENDIX 2

Genetic analysis of Chatham Island pigeon

by Dr. S. Triggs

A1. Aim

To determine the genetic relationship between the Chatham Island and mainland subspecies of pigeon (This is a preliminary analysis based on a very small sample size).

A2. Methods

Tissue samples (liver, muscle, kidney) were obtained from one parea and 10 kereru from Thames (2), Te Kuiti (1), Wellington (2), Nelson (2), and an unknown location (1). One feral pigeon (FP) *Columba livia*, which is from the same family but a different subfamily, was used as an outgroup. Allele frequencies were compared for 24 allozyme loci obtained by starch gel electrophoresis.

A3. Results

1. The parea had a lower level of variation than both the kereru and feral pigeon (percentage of polymorphic loci $P = 4\%$ vs 25% and 16% respectively; heterozygosity $H=0.04$ vs 0.09 and 0.17).
2. A very large difference was found between parea/kereru and feral pigeon (Nei's $D = 0.26$) as expected for different genera. This result indicates that the technique provides good resolution for pigeons.
3. The parea was very similar to kereru ($D = 0.07$). All loci in the parea are fixed for the common allele found in kereru, except for the single variable parea locus, which shares the same alleles as the kereru.
4. When kereru are grouped by geographic region (Fig. A1) the parea, instead of falling outside the kereru groups, falls within the kereru cluster. The most divergent group is the southern (Dunedin) birds. The northern (Te Kuiti, Thames), and central (Wellington, Nelson) kereru and parea differ by $D = 0.000-0.004$.

A4. Conclusions

It would appear, based on the electrophoretic analysis alone, that the parea is not very distinct from the kereru (i.e. they are the same species, contrary to their early classification (Oliver 1930, 1955)). They also seem to be less variable than kereru, 1: perhaps because of their smaller population size, although this is very tentative until a larger sample size is examined.

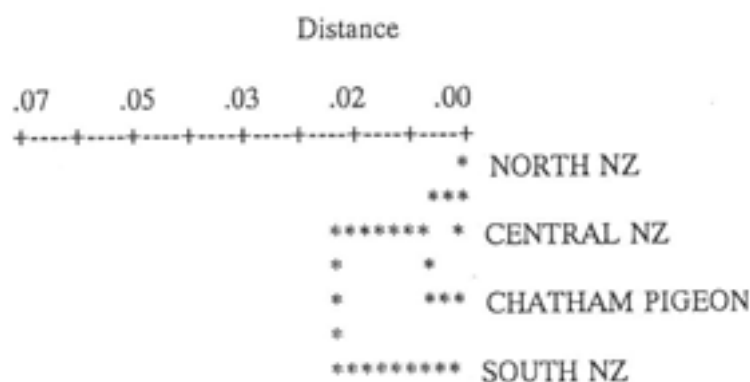


Fig. A1 Genetic relationships of parea and kereru, shown as a dendrogram using UPGMA and Nei's genetic distance.

The question of subspecies status is always a difficult one in birds as even morphologically/behaviourally well-defined avian subspecies tend to be similar electrophoretically. Nei's D of 0.007 is fairly average for different subspecies of birds. The finding that parea is less different from kereru than they are from southern kereru does tend to hint at the close relationship between the parea and kereru, but the sample size is much too small to draw any conclusions from this. The kereru samples were not perfectly preserved and therefore some of the variability of kereru may have been due to enzyme modification.

Further work using more discriminating techniques (i.e. DNA analysis) and larger sample sizes is needed to determine the true relationship between parea and kereru. It would also be of interest to pursue the possible geographic differences within kereru, as the southern samples seem relatively well differentiated from the northern and central samples. A similar pattern occurs in other species (e.g. yellow-crowned parakeets, various lizards) but again confirmation is required from larger sample sizes as the differences were in gene frequency only.