

## Recoveries of Australasian shoveler (*Anas rhynchotis*) banded as ducklings in southern New Zealand

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**Abstract** Dispersal within New Zealand of Australasian shoveler (*Anas rhynchotis*), banded as ducklings in Otago ( $n=489$ ) and Southland ( $n=392$ ) during 1971-1979, was determined from the locations at which 180 were shot by hunters. There were no statistically significant differences in recovery distributions of Otago and Southland birds either when recovered in their year of banding (y-o-b) or in all subsequent years combined (later). About 50% of total recoveries were made in the y-o-b and 2-thirds of these from within 200 km of the banding site. Recoveries in later years were more widely distributed than those made in the y-o-b. North Island recoveries were 28% of total recoveries and were from most large coastal and lowland wetlands as far as Northland, 1400 km from the banding site. Recovery distributions of ducklings were not significantly different from those previously determined for moulting adults banded in the same areas. However, ducklings in their 2nd year of life appear to be more distantly dispersed from their natal sites than during their 1st year or are adults from their moulting sites. We speculate that long distance dispersal may be undertaken mostly by birds that fail to breed in their natal regions in their 1st year of life, and that dispersing birds may become irregular breeders at varying distant locations.

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### INTRODUCTION

The post-fledging period, when young commence their independent life, is one of the least studied or documented periods of the avian life cycle. In large waterfowl, particularly swans and geese (Anserini), there are prolonged associations between parents and brood mates during much of the following year, and sometimes longer (Prevett & MacInnes 1980; Owen & Black 1990). In these Holarctic-breeding waterfowl, locations of migration routes and winter feeding sites are part of the environmental learning conveyed during

such extended parental care (Scott 1980). In ducks (Anatinae), however, and irrespective of whether the ducklings are guarded by the female alone (most) or also by the male, family life ceases once the young can fly.

The immediate post-fledging or post-independence period is characterised by widespread dispersal in birds and by a tendency for females to disperse and settle further from their place of birth than males (Greenwood 1980). In waterfowl (Anatidae), however, females show a greater degree of natal and breeding philopatry than males, a tendency particularly well illustrated by most migratory Holarctic breeding species (Anderson *et al.* 1992). However, in waterfowl

inhabiting more benign climatic zones and where such extensive seasonal dispersal is not undertaken, as in New Zealand and southern Australia, such a consistent tendency is not apparent from evidence provided by band recovery locations. Whereas young female paradise shelduck (*Tadorna variegata*) banded in both Gisborne and Southland, New Zealand, were recovered closer to their banding sites than males (Williams 1979a, 1981a), the recovery distributions of male and female paradise shelducks banded as moulting adults were similar at 9 of 10 sites studied nationwide (Williams 1979b, 1981a). No sex biases in dispersal were reported for black swans (*Cygnus atratus*) (Williams 1977), grey (black) ducks (*Anas superciliosa*) (Balham & Miers 1959) or mallard (*A. platyrhynchos*) (Reid 1966) within New Zealand, nor for black ducks, mountain ducks (*T. tadornoides*), or grey teal (*A. gracilis*) in south-eastern Australia (Norman 1971, 1973).

Within New Zealand, dispersal characteristics of ducks in the genus *Anas* have been studied by banding mixed samples of adults and juveniles captured at locations of seasonal abundance in late summer (Balham & Miers 1959; Mills 1976; Williams 1981b). Although juveniles comprised the bulk of the birds banded (e.g., 65-78%, Balham & Miers 1959) the 2 age classes have not been analysed separately. Balham & Miers (1959) reported the combined year-of-banding recovery distributions of both age classes. The possibility that juveniles and adults may show very different patterns of dispersal, particularly in the year-of-banding, has not been investigated in any study.

The Australasian shoveler (*A. rhynchos*) is the most enigmatic of the species of *Anas* in New Zealand (Caithness 1974; Williams 1981b). The shoveler is exploited as a game bird with an annual harvest of c. 10,000, and this species is commonly encountered on most eutrophic coastal and lowland wetlands (Bull *et al.* 1978). However its general ecology is poorly known (Marchant & Higgins 1990). In particular, the nature, extent, and timing of shoveler movements throughout New Zealand, of particular relevance in the management of the species as a game bird, remain unreported. In this study, we used the return of bands from birds shot by hunters to determine: (i) the extent of movements undertaken by fledgling shoveler during their 1st 4-6 months of life; and (ii) their general distribution throughout New Zealand during their adult years. Our study was complementary to an investigation of dispersal of adult shoveler following their annual wing moult (Caithness *et al.* 2002).

#### STUDY AREA AND METHODS

Shoveler ducklings were banded annually in December and January at sites in Southland and



Fig. 1 Fyke net used to catch shoveler (*Anas rhynchos*) ducklings in drains and slow flowing watercourses. Ducklings enter holding compartments, set up on the banks, at the ends of the nets. Photo: R.R. Sutton.



Fig. 2 Dogs were used to capture shoveler (*Anas rhynchos*) ducklings hiding in dense vegetation. Photo: R.R. Sutton.

Otago from 1971-72 to 1978-79. Totals of 188 males and 204 females were banded in Southland, and 250 males and 239 females in Otago. By 31 December 2000, the locations of recovery of 84 Southland birds and 96 Otago birds had been reported to the Department of Conservation Bird Banding Office. Four birds were reported 7-11 years after banding, but none longer, and all cohorts are now considered extinct.

In Southland, most ducklings were caught in fyke nets set in drains and small slow-flowing streams within a c. 50 km radius of Invercargill (46° 25'S, 168° 21'E). Fyke nets, designed to catch eels (*Anguilla* spp.) were set with their holding compartment up on the drain's edge so that the birds could clamber out of the water.

In each year some of the attendant females were captured along with their brood. Other ducklings ( $n=41$ ) were captured individually using a dog.

**Table 1** Number of shoveler (*Anas rhynchotis*) ducklings banded in Otago shot at different distances from their banding site in their year-of-banding (y-o-b) and in all later years combined (Later).

Sex (n)	Distance from natal area (km)						
	0-100	101-200	201-400	401-600	601-800	801-1000	>1000
y-o-b Male (26)	7	9	4	0	1	1	4
Female (19)	10	2	2	1	2	1	1
Later Male (33)	7	3	8	0	1	5	9
Female (18)	8	2	1	0	2	2	3
Total	23	16	15	1	6	9	17

**Table 2** Number of shoveler (*Anas rhynchotis*) ducklings banded in Otago shot at different distances from their banding site in their year-of-banding (y-o-b) and in all later years combined (Later).

Sex (n)	Distance from natal area (km)						
	0-100	101-200	201-400	401-600	601-800	801-1000	>1000
y-o-b Male (17)	6	2	3	2	0	0	4
Female (23)	14	5	2	1	0	0	1
Later Male (24)	6	3	1	3	0	3	8
Female (20)	12	2	0	1	0	2	3
Total	38	12	6	7	0	5	16

In Otago, the same 2 techniques were used to capture ducklings in wetlands on the floodplain of the Taieri River near Waihola (46° 01' S, 170° 06' E), near Lake Tuakitoto (46° 13' S, 169° 49' E), and at Merton (45° 37' S, 170° 39' E).

Also included in this paper are 7 recoveries from 20 shoveler ducklings banded at Pukepuke Lagoon (40° 23' S, 175° 15' E) in coastal Manawatu and 10 recoveries from 54 ducklings banded at Piako wetlands (37° 12' S, 175° 30' E) in the Firth of Thames. These data are recorded here to give completeness to the banding data available at this time.

All shoveler were sexed by cloacal examination (Larson & Taber 1980) and banded with a numbered stainless steel band bearing a return address.

Shoveler were shot by hunters during the annual gamebird hunting season in May and June. Bands returned to the Banding Office were recorded in the Banding Scheme files together with date of recovery (as reported by the hunter) and location of recovery. Location was recorded to the nearest 10' of latitude and 10' of longitude (217-296 km<sup>2</sup>, depending on latitude). To assist initial interpretation of distribution, the recorded location of recovery of every bird was plotted on maps of New Zealand, on which a 10' latitude × 10' longitude grid had been drawn. Distribution frequency tables (Tables 1, 2) were constructed by drawing on these maps, consecutive arcs at 100 km intervals from the banding site and counting the number of recoveries in each grid square where >50% of the square's area lay within the interval between successive arcs.

## RESULTS

### Recoveries of shoveler banded in Otago

Of 96 recoveries reported by hunters (Fig. 3A), 45 (47%) were obtained in the gamebird hunting season immediately following banding (y-o-b) and the remainder in subsequent years, extending into the 11th year. Relative to the number banded, significantly more males (23.6%) than females (15.5%) were recovered ( $\chi^2 = 5.10$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ). Although a lower percentage of total recoveries was made in the y-o-b for males (44%) than for females (51%), the difference was not significant ( $\chi^2 = 0.48$ ,  $df = 1$ ,  $P = 0.5$ ).

### Distribution of year-of-banding (y-o-b) recoveries

The locations at which banded shoveler were shot 4-6 months after banding are illustrated in Fig. 3B and distances travelled summarised in Table 1. The recovery distributions of males and females were not significantly different (Fisher exact test,  $P = 0.20$ ).

Of 45 y-o-b recoveries, 8 (5 ♂♂, 3 ♀♀) were from North Island, including 2 birds (1 ♂, 1 ♀) banded as broodmates on the same day and shot, 1 day and 25 km apart, in coastal south Taranaki. The most distant recoveries were from Firth of Thames, 1200 km from the banding sites. Most (62%) recoveries were, however, from the Otago-Southland region, within 200 km of the banding locations. Similar proportions of y-o-b recoveries of females (63%) and males (62%) were from within this radius. A cluster of recoveries from the Milton-Waihola region was evidence for

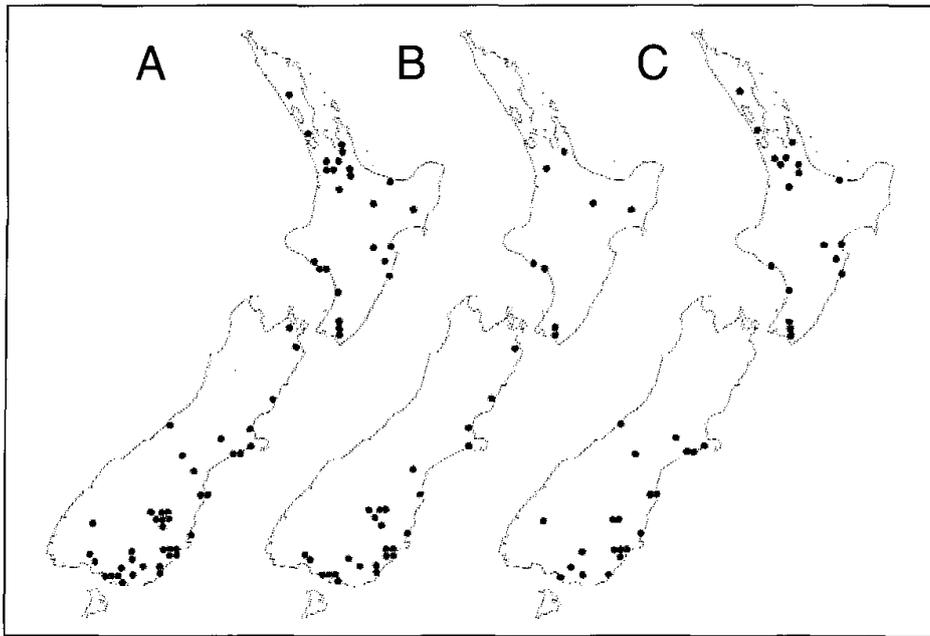


Fig. 3 Locations ( $10' \times 10'$  latitude-longitude squares) in which shoveler (*Anas rhynchos*) ducklings banded in Otago, 1971-79, were recovered: A, all recoveries; B, recoveries made in the year-of-banding; C, recoveries made 1 or more years after banding.

some birds not having dispersed beyond their natal area

#### *Distribution of recoveries from 1 or more years after banding*

Recoveries of females now of adult age were distributed similarly to those of juveniles with most (56%) being recovered within 200 km of the banding sites (Table 1). A small cluster of females were recovered from the Milton-Waihola area close to where many ducklings were banded. This pattern did not hold for males, however; only 30% of male recoveries were within 200 km of banding sites, which was significantly different from the proportion of y-o-b individuals ( $\chi^2 = 5.76$ ,  $df = 1$ ,  $P < 0.02$ ).

Twenty-two recoveries were from North Island (Fig. 3C), 68% of which were males: 40% of the North Island recoveries were made in the Waikato-Firth of Thames area and most of the remainder at Lake Wairarapa, Manawatu, and Hawkes Bay. The oldest bird recovered (10 yrs 5 months after banding) was also the most distant recovery, from near Dargaville in Northland, almost 1400 km from its natal site.

#### **Recoveries of shoveler banded in Southland**

Of 84 recoveries reported by hunters (Fig. 4A), 40 (48%) were obtained in the hunting season immediately following banding (y-o-b) and the remainder in subsequent years extending into the 9th year. Relative to the number banded, similar proportions of males (21.8%) and females (20.6%) were recovered. Although a higher percentage of total recoveries was made in the y-o-b for females (53%) than for males (41%), the difference was not significant ( $\chi^2 = 1.22$ ,  $df = 1$ ,  $0.3 > P > 0.2$ ).

#### *Distribution of year-of-banding (y-o-b) recoveries*

The locations at which banded shoveler were shot 5-6 months after banding are illustrated in Fig. 4B; distances travelled are summarised in Table 2. Of 40 y-o-b recoveries, 5 (4 ♂♂, 1 ♀) were in the North Island, with 2 in Hawkes Bay and 3 in southern Auckland, and with the most distant recovery being from Firth of Thames. Most (67%) recoveries, however, were from the Southland-Otago region and within 200 km of the banding locations. Although significantly more of the females (83%) than males (47%) were recovered within this radius ( $\chi^2 = 5.63$ ,  $df = 1$ ,  $P < 0.02$ ), the overall distributions of male and female recoveries did not differ significantly (Fisher exact test,  $P = 0.19$ ). A cluster of recoveries from the Invercargill-Riverton region was evidence that some birds had not dispersed from their natal sites at all.

#### *Distribution of recoveries from 1 or more years after banding*

In contrast to y-o-b recoveries, almost equal numbers of later recoveries were made within and beyond 200 km of the banding sites. Females were recovered closer to home than males: 70% of female recoveries but only 37% of male recoveries were within 200 km of the banding site ( $\chi^2 = 4.62$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ). However, the 2 recovery distributions were not significantly different (Fisher exact test,  $P = 0.28$ ). There was a cluster of female recoveries near Invercargill, close to where the birds had been banded.

Sixteen recoveries were from North Island (Fig. 4C), only 5 (31%) of which were females. North Island recoveries included 2 each from Lake

Fig. 4 Locations ( $10' \times 10'$  latitude-longitude squares) in which shoveler (*Anas rhynchos*) ducklings banded in Southland, 1971-79, were recovered: A, all recoveries combined; B, recoveries from within the year of banding; C, recoveries made 1 or more years after banding.

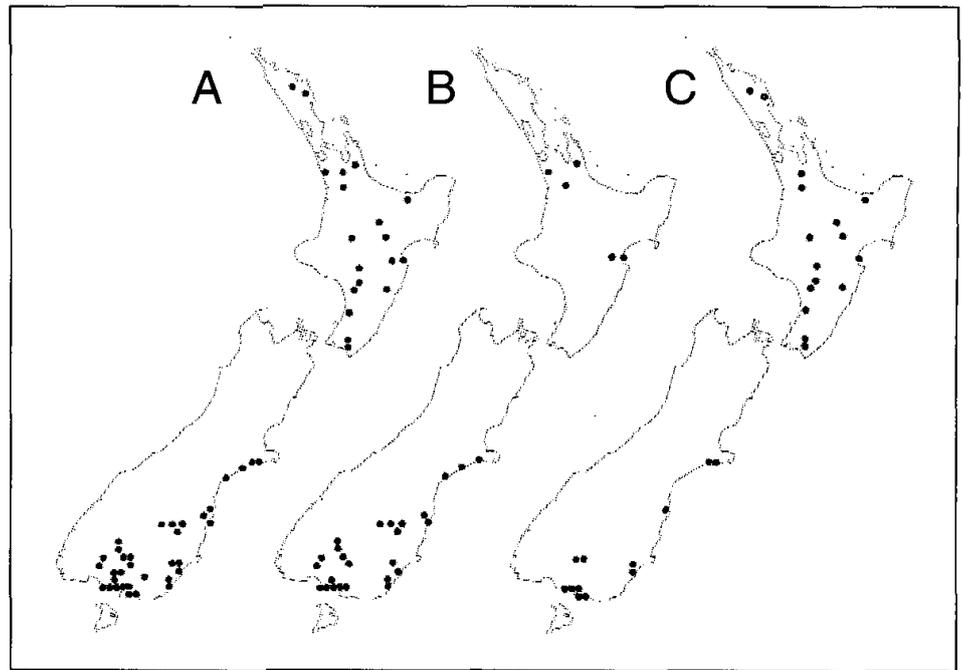
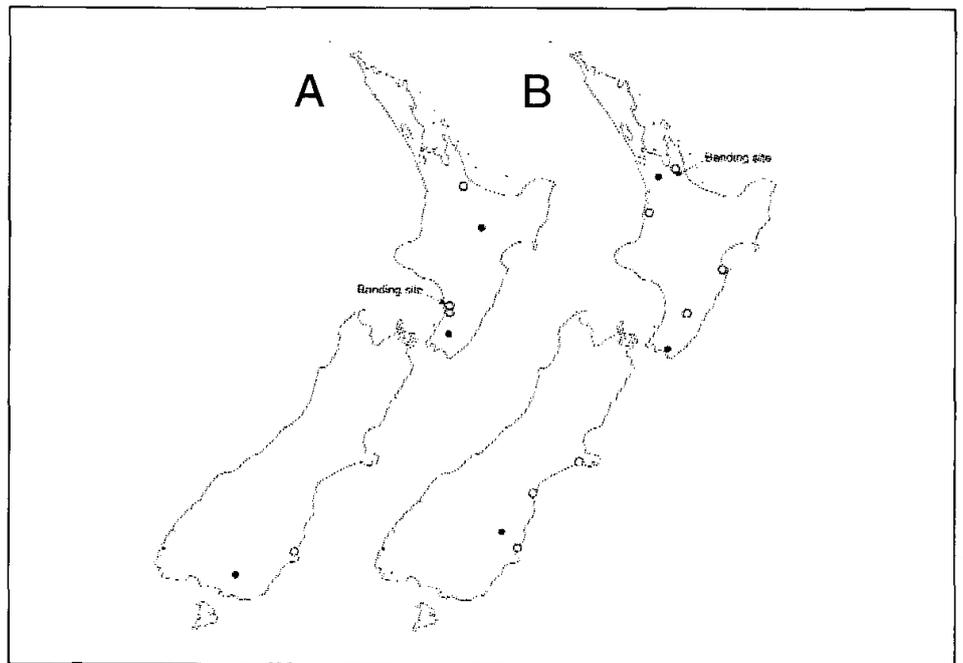


Fig. 5 Locations ( $10' \times 10'$  latitude-longitude squares) in which shoveler (*Anas rhynchos*) ducklings, banded at North Island sites of: A, Pukepuke Lagoon; and B, Piako wetlands, were recovered. Filled circles, year-of-banding recoveries; open circles, recoveries made in subsequent years.



Wairarapa, Manawatu, Hawkes Bay, Waikato lakes, and Northland, along with other birds from the central North Island and Bay of Plenty. Both Northland recoveries were males, banded as members of the same brood at the same place, on the same day. They were both shot 3 yrs 4 months 6 days later, only 30 km apart.

**Live recaptures and sightings**

Seven birds (3 ♂♂, 4 ♀♀) banded as ducklings in Southland and Otago, were recaptured. One female was recaptured, 3 years after banding, at her natal site next to Invercargill airport while

attending a brood, providing the 1st evidence of natal philopatry in this species. Four Southland ducklings (2 ♂♂, 2 ♀♀) were recaptured during their 1st wing moult, 3 at Waituna Lagoon near their natal sites and 1 at Ram Island Lagoon in Otago. One Otago female was recaptured 2 years after banding while moulting at Ram Island Lagoon and an Otago male was recaptured 4 years later while moulting at Lake Whangape in North Island.

Some of the initial ducklings banded in Southland were fitted with nasal saddles (Sugden & Poston 1968). One of these, caught alongside

Invercargill Airport as a member of a brood of near-fledglings, was seen 10 days later 200 km north, at Merton in coastal Otago (JWC *pers. obs.*)

#### Recoveries of shoveler banded in North Island

The locations of recovery of a small sample of ducklings banded at Pukepuke Lagoon in Manawatu and the Piako wetlands in Firth of Thames are illustrated in Fig. 5. Pukepuke ducklings (5 ♂♂, 2 ♀♀) were recovered locally (2 ♂♂, 1 ♀♀) and distantly both to the north and south (Fig 5A). Y-o-b recoveries extended north to near Taupo and south to Gore in Southland (males), and later recoveries from Hauraki Plains (female) and south to near Dunedin (male). Of 3 male broodmates, 2 were recovered locally 17 months after banding, the other from near Taupo 5 months after fledging. The oldest birds recovered were in their 3rd year of life. In addition, an 8-week-old duckling fitted with a nasal saddle was sighted 2 months later at the mouth of the Waimatuka River, Southland (RRS *pers. obs.*)

Recoveries of ducklings banded at Piako (9 ♂♂, 1 ♀) demonstrated an extensive southward dispersal (Fig 5B). The female and 2 males were recovered within 50 km of the banding site, but all others had dispersed more widely including to the central and southern South Island. Recoveries from Lake Wairarapa and the upper Taieri wetlands in Otago were made within 5 months of the birds fledging while the oldest bird recovered, in its 9th year, was shot near Timaru.

## DISCUSSION

### Sampling bias

Caithness *et al.* (2002) discussed the limitations and biases of hunter returns being used for the description of the dispersal and distribution of adult shoveler within New Zealand. They identified as potential sources of bias the presence of refuge areas on which hunting was not permitted, the inability of hunters to reach shoveler which congregate in the middle of large lakes, and the failure of some hunters to report the retrieval of a banded bird. The results presented here for duckling recoveries support this, and emphasise that hunter returns provide evidence of dispersal to locations where birds could be shot and, thus, of the minimal distribution of shoveler during the hunting season. The returns do not provide a quantitative representation of shoveler distribution and abundance within New Zealand, nor do they imply the species' habitat preferences.

### Comparisons of Southland and Otago recoveries

Similarities between the composition and distribution of the two sets of recoveries included: (1) an almost identical percentage of total

recoveries in the year of banding (47% Otago, 48% Southland); (2) a similar percentage of y-o-b recoveries made within 200 km from the banding sites (62% Otago, 67% Southland); (3) evidence from both areas of delayed dispersal of juveniles away from their natal sites, and of a tendency for more females than males to be shot close to their natal sites in later years; (4) males being more likely to be recovered from distant locations (>200 km) than females, except for Otago birds in the year-of-banding; and (5) similar proportions of the total samples being obtained from the North Island. Given these similarities, it is not surprising that the recovery distributions of Otago and Southland birds did not differ significantly in any of the 4 time/sex categories (Fisher exact tests: y-o-b males,  $P = 0.32$ ; y-o-b females,  $P = 0.66$ ; later males,  $P = 0.17$ ; later females,  $P = 0.74$ ) and nor, when data for both sexes were combined, did the composite y-o-b and later recovery distributions.

The distribution patterns in Fig. 3 and 4 are very similar. Many of the locations at which shoveler from the 2 areas were recovered were precisely the same, and while this was especially so within Otago and Southland, it was also so for distant North Island locations. For example, birds from both banding areas were recovered at the Firth of Thames and on Lakes Whangape and Waahi in the Waikato 5 months after banding. There were even 2 instances where shoveler banded within a month of each other at each banding area were recovered 4-5 months later and within days of each other, from adjacent wetlands in the Firth of Thames. The birds covered by this study therefore comprised a single population, exploiting the same local wetlands and, perhaps, dispersing farther afield in the very same flocks.

### Comparisons of duckling and adult recoveries

Moulting adult shoveler were banded in Otago and Southland at sites near where the ducklings used in this study were caught. Their recovery locations were examined by Caithness *et al.* (2002). A comparison of the recovery distributions of Otago and Southland adults and ducklings revealed that in none of the 4 time/sex categories did the recovery from the distributions of either Otago or Southland ducklings differ significantly from that of their corresponding adults (Fisher exact tests: Southland y-o-b males,  $P = 0.20$ ; y-o-b females,  $P = 0.95$ ; later males,  $P = 0.62$ ; later females,  $P = 0.46$ ; Otago y-o-b males,  $P = 0.25$ ; y-o-b females,  $P = 0.08$ ; later males,  $P = 0.10$ ; later females,  $P = 0.32$ ).

These findings did not support the expectation that juveniles have different and more extensive patterns of dispersal than adults, particularly in their year-of-banding, which appears to be

counter-intuitive. As Greenwood (1980) and others have indicated, the juvenile is the most widely dispersing phase in the life cycle of most vertebrates and this has been demonstrated in many bird species. The coarseness of our analyses (comparing recovery distributions with large distance intervals) and the small sample sizes may have made it difficult to detect statistically significant differences.

Because the 0-200 km interval from banding site encompasses most of the wetlands of Otago and Southland, and these wetlands within the birds' "home region" could, conceivably, be encountered during a series of short flights, we then defined true dispersal as a movement of >200 km and compared the proportions of the total samples of adults and ducklings that were recovered within and beyond 200 km from the banding sites. In only 1 of the 4 time/sex categories examined for each site did the proportion of the adult and duckling recoveries made within and beyond 200 km of the banding location differ significantly: young Otago females in the y-o-b dispersed more extensively than adults ( $\chi^2 = 5.77$ ,  $df = 1$ ,  $0.02 > P > 0.01$ ). We then combined data for both sexes and compared adults and duckling recoveries in the y-o-b, later, and during both time intervals combined (overall). For Southland birds there was no significant difference between ducklings and adults in either y-o-b or later (y-o-b  $\chi^2 = 1.69$ ,  $df = 1$ ,  $0.2 > P > 0.1$ ; later  $\chi^2 = 2.53$ ,  $df = 1$ ,  $0.2 > P > 0.1$ ) nor overall ( $\chi^2 = 3.34$ ,  $df = 1$ ,  $0.10 > P > 0.05$ ). For Otago shoveler, proportionately more duckling recoveries were made at distant sites than for adults in y-o-b ( $\chi^2 = 9.8$ ,  $df = 1$ ,  $P < 0.01$ ) and overall ( $\chi^2 = 9.56$ ,  $df = 1$ ,  $P < 0.01$ ) but not in later years. These results provide some, but hardly consistent or conclusive evidence, of differences between adult and duckling dispersal.

Because there were many North Island recoveries of ducklings we then compared North Island recoveries as a proportion of total recoveries (both sexes combined) for ducklings and adults from both banding sites. For Southland shoveler similar proportions of total recoveries of ducklings and adults were made in North Island in the y-o-b and later years and overall. For Otago shoveler, the same results were obtained except for all duckling and all adult data combined (overall) ( $\chi^2 = 4.97$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ). Again, these findings provide some, but hardly convincing, evidence of greater dispersal by ducklings.

We concluded therefore that there was little difference in the dispersal of shoveler ducklings after fledging and of adult shoveler after having completed their annual wing moult. However, it is important to emphasise that the conclusion is based on distribution patterns as revealed by band

returns. Hunting is restricted to May and June and the return of bands by hunters provides a distributional "snapshot" of where banded shoveler were and where hunters were able to hunt them. Sampling distribution patterns by some other means, for example by sightings of conspicuously marked birds, and conducting those observations over a greater period of the year could produce dispersal patterns for young shoveler somewhat different from those observed in this study.

### Dispersal and settlement

One of the outstanding features of the recovery distributions of Otago and Southland ducklings was the high proportion of recoveries (of both sexes) made in the North Island in the years after banding. The differences in the proportions of total recoveries in y-o-b and later made from sites in North Island were significant for both banding sites (Southland  $\chi^2 = 6.36$ ,  $df = 1$ ,  $0.02 > P > 0.01$ ; Otago  $\chi^2 = 4.97$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ). Similarly, when recoveries within and beyond 200 km of the banding site were compared, significantly more of recoveries later than y-o-b recoveries of Otago birds were from distances greater than 200 km ( $\chi^2 = 5.06$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ), although for Southland shoveler, there was no significant difference ( $\chi^2 = 2.01$ ,  $df = 1$ ,  $0.2 > P > 0.1$ ).

These findings lead to 3 competing hypotheses: (1) that long-distance dispersal of ducklings occurs after the hunting season in May rather than before it; (2) that long-distance dispersal occurs earlier in the year once shoveler reach adult age; and (3) many shoveler establish residency beyond their natal region.

A single short sampling period (the hunting season) cannot establish the presence of any temporal pattern to shoveler dispersal. Some shoveler were shown to have dispersed long distances in the 5-month interval between fledging and the onset of the hunting season, just as did some adults immediately after completing their wing moult (Caithness *et al.* 2002). However, the concentration of recoveries, of both sexes, from within the natal regions in the 1st year of life suggests that many ducklings had not journeyed far by the time the hunting season started. Evidence of delayed dispersal would exist if there were higher proportions of total recoveries in the 2nd year at distant locations compared to those made in the y-o-b. Combining data from both banding regions, 13 (15%) of 85 y-o-b recoveries were made in North Island as against 15 (44%) of 35 2nd-year recoveries, a highly significant difference ( $\chi^2 = 10.53$ ,  $df = 1$ ,  $0.01 > P > 0.001$ ). Similarly, 30 (35%) of 85 y-o-b recoveries were from beyond 200 km of the banding sites as against 20

(59%) of 35 2nd-year recoveries, which was also a significant difference ( $\chi^2 = 4.87$ ,  $df = 1$ ,  $0.05 > P > 0.02$ ). The dispersion of ducklings at hunting time in their y-o-b clearly differed from that 1 year later.

The same data could, however, be interpreted as supporting the earlier adult dispersal hypothesis. Perhaps the bulk of the ducklings did not disperse widely at all in their y-o-b but, instead, did so after their first wing moult. One potential test of this possibility was a comparison of 2nd year duckling recoveries with y-o-b recoveries of moulting adults. Combining data for Southland- and Otago-banded adult shoveler from Caithness *et al.* (2002), 9 (13%) of 67 adult y-o-b recoveries were made 200 km or more from the banding sites, 8 of which were from North Island. When these data are compared to those of 2nd-year duckling recoveries 20 (57%) of 35 recoveries beyond 200 km, 15 of which were from North Island), the differences were highly significant (>200 km,  $\chi^2 = 21.58$ ,  $df = 1$ ,  $P < 0.001$ : North Island  $\chi^2 = 12.58$ ,  $df = 1$ ,  $P < 0.001$ ). Even if the recovery distributions for all Otago and Southland adults are combined and then compared with the 2nd-year duckling recovery distribution, significant differences remained; proportionately more of the total duckling recoveries were made 200 km or more from the banding sites than for adults ( $\chi^2 = 11.74$ ,  $df = 1$ ,  $P < 0.001$ ) and proportionately more recoveries were made in the North Island ( $\chi^2 = 11.0$ ,  $df = 1$ ,  $P < 0.001$ ). As a single age class, ducklings, during the hunting season of their 2nd year of life, are more distantly dispersed from their natal sites than are juveniles of the year, or are adults from their most recently used moulting sites.

The above result raises questions about when and where, in relation to their natal area, young shoveler are recruited into the breeding population. The moulting sites at which banded shoveler were recaptured may serve to indicate the localities near which those individuals spent the preceding breeding season. Three of 4 Southland-banded ducklings were recaptured at Southland's principal moulting site, Waituna Lagoon, and the 4th at Ram Island Lagoon in Otago, c. 120 km from its banding site. These data provide further, albeit scant, support for the hypothesis of limited dispersal by ducklings in their y-o-b. But that begs the question of their dispersal pattern in later years.

Data for birds banded as ducklings are sparse. One female Otago-banded duckling was caught moulting locally 2 years after fledging while a male was recaptured 4 years after banding at Lake Whangape in North Island. Amongst moulting adults, however, most (93%,  $n=73$ ) recaptures of previously banded moulting adults (Caithness *et al.* 2002) were made at the site of initial capture.

Given that these birds, as adults, ought to have been breeders, these data imply that the birds moult close to where they spent the breeding season. If so, then it is interesting that 5 moulting adults changed location – 2 Southland birds to Otago, and 2 Southland and 1 Otago birds to Lake Whangape. Whether this is evidence that the birds changed their locations of settlement is unclear, as is how we should interpret the recapture at Lake Whangape of 2 birds banded, not in moult, but as breeding adults in drains alongside Invercargill airport 5 and 6 years previously.

Clearly, the present data are an insufficient basis from which to draw conclusions about the nature of dispersal and settlement of Australasian shoveler in New Zealand. While it is reasonable to suggest that birds moult at a site close to where they spent the preceding breeding season, there are, as yet, no supporting data. The closest we come are the y-o-b recaptures, close to home, of 4 Southland ducklings. Without confirmation of this point, it is difficult to determine whether the many recoveries, in their adult years, of Southland and Otago ducklings well over 200 km of their natal sites is evidence of distant settlement or simply reflects patterns of seasonal or annual nationwide movement, the timing and causes of which presently remain unclear.

## CONCLUSIONS

We conclude that Australasian shoveler ducklings show limited dispersal away from their natal areas in their 1st year, notwithstanding some trans-island movements. As a population, the shoveler were more highly dispersive in their 2nd year of life, undertaking spectacular long-distance flights in the interval between completion of their 1st wing moult (January-February) and the start of the annual duck hunting season in May. We speculate many shoveler may breed away from their natal sites, despite evidence of natal philopatry by some females. Although data from this study do not allow us to discriminate between possible interpretations, not just because of small sample sizes but also because of the restricted period of sampling, we think shoveler dispersal could be examined further by following cohorts of ducklings more closely, especially throughout their 1st year of life.

Some of the conundrums raised could conceivably be explained by there being 2 components within the shoveler population: a resident component which establishes itself by breeding in the 1st year of life within its natal region; and a more mobile component, perhaps comprising mostly males (because of the considerable male bias in sex ratio in the pre-breeding flocks – Caithness 1975), whose

members do not pair and breed every year, but when they do, may breed in different locations and moult at different sites in consecutive years.

Finally, we make the point that this study, arising from a need to manage shoveler as a game bird, started 30 years ago, and field observations ceased 15 years ago. Since then, much has changed in the lowland wetlands of New Zealand. For example, the ecology of all major lakes in Waikato, including the significant shoveler moulting site of Lake Whangape, is now dominated by phytoplankton production and suspended sediments instead of the clear water and extensive beds of aquatic macrophytes and marginal adventives that were outstanding characters 30 years ago (JWC, MW, pers. obs.). Similarly, significant wetlands, such as Te Hopai Lagoon, around Lake Wairarapa on which shoveler formerly congregated in spectacular pre-breeding flocks, have been drained and Lake Wairarapa itself now lacks beds of macrophytes that dampened the shoreline waves and limited sediment suspension (Moore *et al.* 1984). Ecological changes of these types and on these scales, which are also apparent in other parts of New Zealand, are bound to have affected the ecology of shoveler. The patterns of dispersal revealed in this study as applying in the 1970s and 1980s may not be entirely representative of the present. While our results provide further support for the management recommendations advanced by Caithness *et al.* (2002), we suggest that a repetition of this study in the contemporary wetland environments of New Zealand is needed.

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