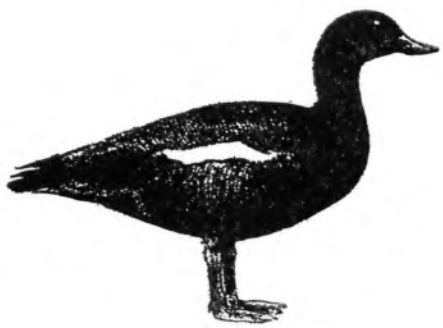

Mortality and exploitation of Paradise Shelduck

MURRAY WILLIAMS

Introduction

The Paradise Shelduck *Tadorna variegata* is probably more intensively exploited by Man than other Tadornini. The largest and most conspicuous of New Zealand's native waterfowl, it was extensively taken as food by Polynesian Man from the beginning of his settlement. Most of the remains which pre-date European settlement have been recovered from Maori camps or middens; the earliest known remains dated A.D. 1249 ± 47, are from Waimataitai (Zander 1967). The Maori appreciated that the species was flightless during moult and Buller (1893) reported them capturing up to 5,000 birds in a single operation in the Marlborough district. Beattie (1920) described in detail a similar round-up on Lake Waihola, Otago, in 1859, the capture technique being similar in many respects to that used during this study.

Following European colonization about 1840, native forest was felled and in its place pasture was established. This resulted in an increase in Paradise Shelduck numbers and an extension of their range. As a consequence, it became an increasingly important game bird, and, in the 104 years of statutorily-controlled shooting, has been subjected to varying levels of exploitation. During the past 20 years, shelduck populations through New Zealand have been declining (Williams 1971). This paper analyses band returns from two populations to determine the role of exploitation in their declines.

Materials and methods

Capture and banding techniques

The Wildlife Service has banded Paradise Shelduck at sites near Gisborne since 1961 and near Taihape since 1962. A total of 6,866 birds were banded in these areas up to and including 1969 and information detailing the recovery of 1,143 birds had been forwarded to the Banding Office by 31st October 1970.

The birds were caught on their moulting areas in early January. Two capture techniques have been used. Small pens were constructed on the water's edge and a long wire-netting lead extended out into the water. Rowing boats then drove the birds slowly around behind and then back down the lead into the pens. On small waters, or following two or three drives on large waters, under-water netting was employed. A four-inch mesh nylon gill net, corked and lightly weighted, of variable length (often 60-80 metres) and approximately two metres deep was extended at right angles to the shore. The birds were herded slowly towards the net and, on reaching the corkline, most dived. This behaviour was encouraged by banging oars on the water and shouting. Birds became entangled in the net and surfaced. The net was quickly gathered into boats and spread out on the shore. The process of disentanglement was performed with great care in order to prevent damaging the developing remiges. There was a 1-2% mortality from drowning in the net.

Three different types of metal bands were used during the study period; aluminium, monel metal and, finally, stainless steel. There is, however, no evidence to suggest aluminium bands failed to last the duration of this study. Aluminium bands have been worn by Black Swan *Cygnus atratus* for as long as 15 years (C. J. R. Robertson pers. com.).

The banded populations

Although the Gisborne and Taihape banding sites (Figure 1) are only about 80 miles apart, there is almost no movement between the populations. The medial recovery distance for both populations is less than 20 miles and 95% of all birds were recovered within 50 miles of their banding site (unpublished data).

The moulting flocks comprise both immatures (i.e. birds 15-18 months old undergoing their first wing moult) and adults. The birds in the banded sample, however, were not allocated to age classes.

Life tables

Readers not conversant with life table terminology are referred to Reid (1966) for a lucid explanation. The method of analysis follows Hickey (1952) and Farner (1955). All but six of the recoveries were made during the shooting season (May and June) and all birds had been shot. The banding year is 1st January to 31st December except for 1970. Thus, the birds are banded 4-5 months before the shooting season in the same banding year. The recovery of bands for birds banded in 1961 and 1962 is considered complete.

Results

Mortality rates for males and females of both populations are presented in Tables I-IV. At Gisborne (Tables I-II), both sexes experienced similar mortality in the year of banding (i.e. year 0-1) and in subsequent years but at Taihape (Tables III-IV) the females' year-of-banding mortality and weighted mean mortality

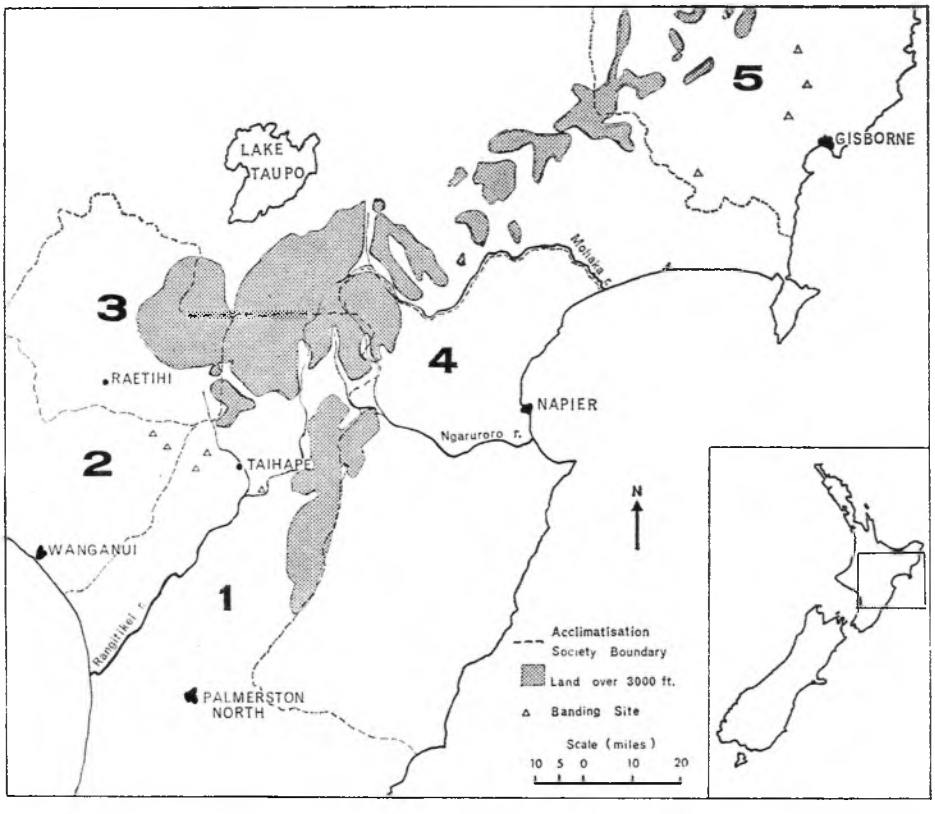

Figure 1. Map showing place names mentioned in the text, banding sites, and Acclimatisation Society districts as follows: 1. Wellington; 2. Wanganui; 3. Waimarino; 4. Hawke's Bay; 5. Gisborne.

(Mw) are higher than those of the males.

Mortality rates were also calculated for the Gisborne population ignoring data from the 1970 shooting season. (In this year, the season was shortened from two months to one month and the daily limit reduced from ten to three.) For females the year-of-banding mortality was 48.0%, the average over the subsequent four years was 27.6% and Mw. for all years up to the 7-8 year class was 38.4%. For males, the corresponding figures were 45.7%, 26.0% and 33.0%. These results are similar to those from Taihape in that females experience a greater overall mortality than males, despite the fact that,

Table I. Mortality, survival and expectation of further life of male Paradise Shelduck banded near Gisborne 1961-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	*Total recovered*
1961	159	14	2	8	2	0	0	0	0	3	0	29
1962	71	3	3	1	4	1	1	0	1	0		14
1963	241	21	9	6	1	1	1	4	0			43
1964	321	30	9	3	4	3	3	1				53
1965	275	24	10	7	4	2	3					50
1966	237	17	8	6	3	1						35
1967	290	29	13	7	2							51
1968	323	44	15	8								67
1969	293	37	22									59
Total	2210	219 of 2210	91 of 2210	46 of 1917	20 of 1594	8 of 1304	8 of 1067	5 of 792	1 of 471	3 of 230	0 of 159	401
% of bands recovered		9.9	4.1	2.4	1.3	0.6	0.8	0.6	0.2	1.3	—	21.2
Mortality series		46.8	19.4	11.3	5.9	2.9	3.5	3.0	1.0	6.1		
Cumulative % of bands recovered		46.8	66.2	77.5	83.4	86.3	89.8	92.8	93.8	99.9		
Survival series		53.2	33.8	22.5	16.6	13.7	10.2	7.2	6.2	—		
Mortality rate %		46.8	36.5	33.6	26.3	17.4	(average 2nd to 5th year classes = 28.5)					
Expectation of further life		1.6 years	3.3 years (using average mortality 2nd to 5th year classes)									
Weighted mean mortality rate (Mw) over years 0-1 to 7-8 = 36.4%												

Table II. Mortality and expectation of further life of female Paradise Shelduck banded near Gisborne 1961-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	9-10	*Total recovered*
1961	218	23	3	8	4	3	1	0	0	1	1	44
1962	143	8	5	2	1	1	4	1	2	2		26
1963	207	20	5	5	0	2	3	0	1			36
1964	227	16	6	3	2	0	3	1				31
1965	176	23	9	3	2	2	0					39
1966	210	5	10	6	3	1						25
1967	210	20	3	5	1							29
1968	160	13	9	3								25
1969	284	42	15									57
Total	1835	170 of 1835	65 of 1835	35 of 1551	13 of 1391	9 of 1181	11 of 971	2 of 795	3 of 568	3 of 361	1 of 218	312
% of bands recovered		9.3	3.5	2.3	0.9	0.8	1.1	0.3	0.5	0.8	0.4	19.9
Mortality series		46.5	17.8	11.6	4.7	3.8	5.7	1.3	2.7	4.2	2.3	
Mortality rate %		46.5	33.2	32.6	19.4	19.8	(average 2nd to 5th year classes = 26.3)					
Expectation of further life		1.6 years	3.3 years (using average mortality 2nd to 5th year classes)									
Weighted mean mortality rate (Mw) over years 0-1 to 7-8 = 35.0%												

in both areas, the recovery rate for females is lower indicating they are less likely to be shot.

Survival curves (Figure 2) show that cohorts from both populations decline at similar rates for the first three-four years. Thereafter, however, the Taihape cohorts quickly become extinct whereas Gisborne cohorts may survive into the ninth year.

The expectation of life after banding is calculated from the formula: Expectancy (in years) = (2−m)/m (where m = annual mortality). Gisborne birds at banding have an average expectation of further life of almost 1 year 8 months (1.6 years), but those which survive their first year after banding have a further average life expectancy of just over three

Table III. Mortality and expectation of further life of male Paradise Shelduck banded near Taihape 1962-1969.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	*Total recovered*
1962	67	16	5	0	1	0	0	0	0	0	22
1963	49	7	3	1	1	0	1	0	0		13
1964	105	18	6	3	1	4	3	0			35
1965	148	7	12	5	7	1	2				34
1966	211	17	9	6	3	4					39
1967	230	20	16	7	5						48
1968	216	20	8	3							31
1969	379	23	7								30
Total	1405	128 of 1405	66 of 1405	25 of 1026	18 of 810	9 of 580	6 of 369	0 of 221	0 of 116	0 of 67	252
% of bands recovered		9.1	4.7	2.4	2.2	1.6	1.6				21.6
Mortality series		42.0	21.8	11.3	10.2	7.4	7.4				
Mortality rate %		42.0	37.4	31.2	41.2	48.0					

(average 2nd to 5th years classes = 39.7)

Expectation of further life 1.9 years 2.0 years (using average mortality 2nd to 5th year classes)

Weighted mean mortality rate (Mw) over years 0-1 to 4-5 = 39.5%

Table IV. Mortality and expectation of further life of female Paradise Shelduck banded near Taihape 1962-69.

Year banded	*Number banded*	*Recoveries in years following banding* 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8-9	*Total recovered*
1962	85	12	4	0	0	0	0	0	0	0	16
1963	50	8	1	0	1	0	2	1	0		13
1964	80	14	1	1	2	2	0	0			20
1965	171	8	6	0	6	2	0				22
1966	184	17	9	7	1	2					36
1967	207	17	6	1	3						27
1968	168	6	10	2							18
1969	371	20	6								26
Total	1316	102 of 1316	43 of 1316	11 of 945	13 of 777	6 of 570	2 of 386	1 of 215	0 of 135	0 of 85	178
% of bands recovered		7.7	3.3	1.2	1.7	1.0	0.5	0.5			15.9
Mortality series		48.8	20.6	7.3	10.1	6.6	3.3	3.0			
Mortality rate %		48.8	40.2	23.8	45.0	51.5					

(average 2nd to 5th year classes = 40.1)

Expectation of further life 1.6 years 2.0 years (using average mortality 2nd to 5th year classes)

Weighted mean mortality rate (Mw) over years 0-1 to 4-5 = 43.0%

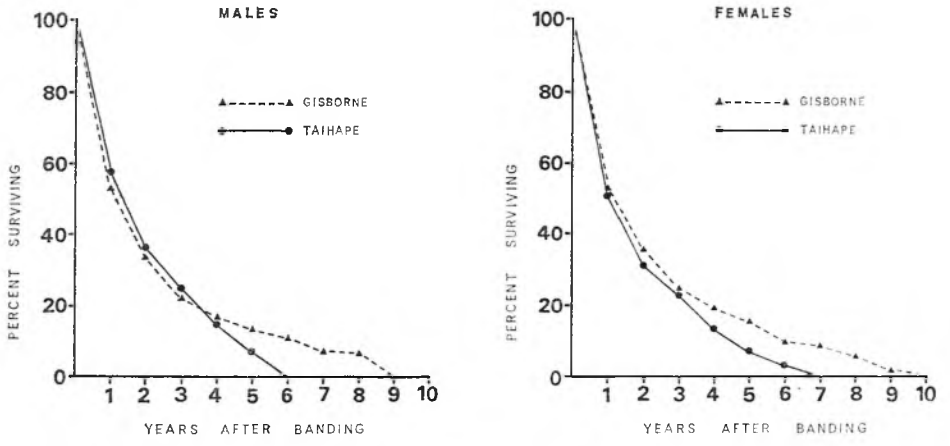

Figure 2. Survival curves of male and female Paradise Shelduck banded at Gisborne and Taihape.

years. Taihape birds have a similar life expectancy at banding and those surviving their first year can expect on average to live another two years.

Exploitation

The aim of management investigations on Paradise Shelduck is to determine the optimum level at which the species may be exploited. This level will necessarily fluctuate from year to year for it will depend on such factors as the success of the breeding season and the effect and intensity of the previous year's shooting.

Many factors influence shooting pressure. Daily bag limits and season length are the statutory regulators of waterfowl harvest. At Gisborne, the daily limit was 10 during 1961-1969 but was reduced to three in 1970. Taihape birds were recovered from areas controlled by the Wellington, Waimarino and Wanganui Acclimatization Societies (Figure 1). These Societies in 1962 allowed daily limits of 15, 10 and 10 respectively but thereafter all limits were 10 per day. Throughout New Zealand, the shooting season is usually of one month's duration. However, during 1962-1970 Paradise Shelduck could be hunted for two months in the Wanganui and Waimarino areas and similarly in Gisborne during 1965-1969.

Weather during the shooting season also affects shooting pressure. Fine weather and clear skies cause birds to fly high and out of gun range resulting in a low harvest.

One statistic widely used as an index of shooting pressure is the year-of-banding recovery rate (Table V) (Balham and Miers 1959; Imber and Williams 1968; Geis *et al.* 1969.) This is in fact a poor indicator of shooting pressure for many factors influence it. If adults survive their year-of-banding better than immatures (as for Mallard *Anas platyrhynchos* in New Zealand (Balham and Miers 1959)) then the immature:adult ratio in the banded sample may influence the first year recovery rate. Another variable is the co-operation of shooters. The percentage of recovered bands that were reported probably varied from year to year during this study. Initially, a shelduck wearing a band was a novelty and, under these circumstances, the shooters probably reported most of the bands they obtained. But as the study progressed, an increasing proportion of the population were wearing bands. Most birds were recovered close to their banding site. There is little novelty in this. A reduction in bag limit and season length may also cause poorer co-operation. The apparent reduction in shooting pressure at Gisborne in 1970 (Table V) as a result of reducing both the length of the season and daily limits is almost certainly not real. Analysis

Table V. Percentage of bands recovered in the year of banding.

	Gisborne		*Taihape*	
Year	*Males*	*Females*	*Males*	*Females*
1961	8.8	10.5	—	—
1962	4.2	5.6	23.9	14.1
1963	8.7	9.7	14.3	16.0
1964	9.4	7.1	17.1	17.5
1965	8.7	13.0	4.7	4.7
1966	7.2	2.4	8.0	9.2
1967	10.0	9.5	8.7	8.2
1968	13.6	8.1	9.3	3.6
1969	12.6	14.6	6.1	5.4
1970	6.1	7.0	—	—

of shooting diaries showed that the average harvest per shooter was almost identical in 1969 and 1970 (T. A. Caithness pers. com.).

It is also possible that the distribution of the shooting mortality over the various age classes of the population may fluctuate from year to year. (This does not negate the assumption that recoveries represent age-specific frequencies of death suffered by the population. By using pooled recovery data from several years, these year to year fluctuations are minimised.) An analysis of data from Table I will show that fluctuations in the recovery rate of older age groups do not always follow those of the year-of-banding recovery rate. For example, the year-of-banding recovery rate decreased from 12.6% in 1969 to 6.1% in 1970 (Table V) but that for birds in the second year after banding rose from 5.4% to 8.6% and for birds in their third year after banding from 2.8% to 3.1%.

The non-return of bands, along with crippling losses (i.e. shot birds which die but are not retrieved by the shooter), also affects estimates of the proportions of the population dying from shooting and from other (natural?) causes. For example, Table I shows that of 1,000 birds alive at banding, 468 died during the first year but only 99 of these were reported shot. There are no good data to indicate the magnitude of these two important corrections, merely reasoned guesses. Balham and Miers (1959) suggested 12% as a conservative estimate for crippling losses of Grey Duck *Anas superciliosa* and Mallard and estimated that shooters failed to return about 20% of all bands they obtained. However, Caithness (1969), analysing shooting diaries, considers crippling losses to be no more than 5%. Imber and Williams (1968) discussed a Canada Goose *Branta canadensis* population in which a high percentage were banded. On the basis of questionnaire response, they calculated that 25% of all bands were not returned and, from information supplied by shooters, they thought a crippling loss of 25% might be conservative. Recent work on a sedentary Canada Goose population at Lake Forsyth, New Zealand, in which most birds are banded has lead M. J. Imber (pers. com.) to suggest that shooters there fail to return about 40% of all bands they obtain.

For Paradise Shelduck, the percentage of bands not returned is likely to be similar to that for Canada Geese. They are a comparatively sedentary species and the proportion of the population wearing bands has steadily increased throughout the study. In subsequent discussion I will use the estimate that one band in three is not returned. Crippling losses are probably related to the terrain over which shooting occurs. This species is shot over two very different terrains. Like Grey Duck and Mallard they may be shot over waters surrounded by thick *Typha* marsh; alternatively, they may be hunted, like Canada Geese, over river flats and open hill country. In the absence of any reliable data, in subsequent discussion an arbitrary 10% is used as an estimate of crippling losses.

Let us apply these crude estimates to data from Table III where 20% of bands are recovered after five years.

1) banded birds *reported* shot in first 5 years = 20.0%

but one band in three is not reported

∴ 2) banded birds *shot and collected* = 30.0%

3) crippling loss is 10% = 1/9 collected birds = 3.4%

∴ 4) total banded birds *shot and killed* over five years = 33.4%

Now, the mean annual mortality over these five years = 39.5%

∴ 5) after 5 years, total mortality of banded birds = 92.0%

∴ 6) proportion banded birds that were shot

$$= \frac{33.4\%}{92.0\%}$$

$$= 36.3\%$$

Thus 36.3% of the mortality in any one year is due to shooting. The mean annual mortality of 39.5% is therefore estimated to consist of 14.3% from shooting and 25.5% from other causes.

How meaningful are these estimates? The 1962, 1963 and 1964 cohorts in Table III have provided band returns of 32.8%, 26.6% and 33.4% respectively (the latter two are not yet complete) which indicates the *minimum* proportion dying from shooting. After only two years, 20% of the 1969 cohort in Table II have been reported shot. If, as deduced above, almost two-thirds of total mortality is due to causes other than shooting, it is remarkable that not one recovery has been made of a bird found dead outside the shooting season. I can only conclude that my estimates of crippling losses and the non-return of bands considerably understate the true situation. New Zealand shooters may be failing to report almost

as many bands as they return or crippling losses are considerably greater than previously believed, or both. The necessity for reliable data on these factors is obvious and in their absence, meaningful estimates of shooting mortality are precluded.

Mortality and productivity

In managing this species an important question is whether its reproductive output can sustain a population subjected to the mortality rates described earlier.

The average number of young per pair that must survive to the start of the life tables (15-18 months) in order to maintain a stable population may be calculated from the survival series thus:

$$X = \frac{1}{\frac{1}{2}(S_1 + S_2 \ldots S_n)} \quad \ldots \quad \ldots \quad (1)$$

where X = number of young per pair that must live to 15-18 months

$(S_1 + S_2 \ldots S_n)$ = survival series

Alternatively, it may be calculated, as Balham and Miers (1959) have shown, from the formula

$$X = \frac{Mw}{50(1-M)} \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

where Mw = weighted mean mortality rate

M = year-of-banding mortality rate.

Note:

(a) For ease of calculation, subsequent discussion assumes all birds are 15-18 months old at banding. The banded sample does include an unknown proportion of adults (27-30 months and older). In 1970, the immature:adult ratio in the moulting flocks at Gisborne was 65:35.

(b) Survival series is derived from the cumulative percent of bands recovered and is illustrated in Table I (see also Reid 1966).

Using data from Table II, Gisborne pairs are required to rear 1.15 (by formula 1) or 1.31 (by formula 2) young to the age of 18 months. Using Table IV, Taihape pairs are required to rear 1.57 (by formula 1) or 1.68 (by formula 2) young to 18 mnoths.

The productivity of Paradise Shelduck is largely unknown but is currently being studied. Oliver (1955) records clutches of 5 to 11 and McAllum (1965) reported the average size of 22 successful broods at fledging was 6.0. If we accept, for a working example, 6.0 young per pair at fledging, 1.31 and 1.68 per pair at 18 months and assume that all birds of banded age and older breed successfully, then mortality from fledging to banding cannot exceed 78% at Gisborne or 72% at Taihape. Obviously, all members of the population will not breed successfully and it is doubtful if many two-year-olds will even attempt to breed (Boyd 1962). In the Common Shelduck *T. tadorna* more than 50% of pairs attempting to breed may fail to produce young (Hori 1964). The only data so far available on Paradise Shelduck breeding success is recorded by G. P. Adams (N.Z. Wildlife Service files) where only nine of 24 intensively observed pairs appeared with broods. If only half of the population did not attempt breeding or failed completely and the remainder fledged 6 young per pair, then mortality of young from fledging to banding age cannot exceed, at Gisborne 57% and at Taihape 44%. The mortality of Paradise Shelduck in their first year of life is unknown (but under investigation). It will obviously be higher than that recorded in any life table in this paper (Lack 1954). Male Mallard in New Zealand, banded 2-3 months after fledging, suffer 65.9% mortality in the subsequent year (Balham and Miers 1959). If the various assumptions and estimates involved in these calculations are only approximately correct, clearly Paradise Shelduck cannot withstand current mortality rates without declining in numbers, as are both the Gisborne and Taihape populations (Williams 1971).

Mortality of other New Zealand waterfowl

Table VI lists the mortality rates of five of the six game waterfowl in New Zealand (data not yet available for Shoveler *Anas rhynchotis*). Balham and Miers (1959) considered that about 57% of the Grey Duck population die from shooting but only 30% of Mallard do so. Imber and Williams (1968) suggested that, in the period 1957-1962, approximately 29% of Canada Geese died from shooting. In the period 1963-1966, with the advent of special shooting seasons, 70% of all adult mortality was due to shooting. Since these authors may have underestimated the proportion which die from shooting, it is clear that New Zealand waterfowl are subjected to an intensive shooting pressure and Paradise Shelduck obviously share this.

Table VI also indicates that Paradise Shelduck are experiencing a mortality rate almost twice that suffered by Common Shelduck in Britain and Europe.

Table VI. Adult mortality rates of hunted New Zealand waterfowl and other shelducks.

Species	*Sex*	*Year of banding mortality rate* *Male*	*Female*	*Mw (all years)* *Male*	*Female*	*Source*
Mallard	M	47.6	59.9[a]	49.4	58.0[a]	1
Grey Duck	M	64.7	73.2[a]	59.2	69.2[a]	1
Canada Goose				33.4[b]		2
Black Swan				15.3[c]		3
Paradise Shelduck (Gisborne)	M	46.8	46.5	36.4	35.0	Table I, II
Paradise Shelduck (Taihape)	M	42.0	48.8	39.5	43.0	Table III, IV
Common Shelduck				20 ± 5		4
Common Shelduck				22.5 ± 3.5		5

Notes:
(a) Figures include both adult and juvenile females as the authors were unable to accept the ageing of females to be accurate.
(b) Birds were one year old or older at banding.
(c) Refers to Lake Ellesmere population. Birds are banded as cygnets; the Mw is the average adult mortality over years 4-5 to 9-10.

Sources:
1 Balham and Miers 1959. 2 Imber and Williams 1968. 3 M. J. Williams unpublished data. 4 Boyd 1962. 5 Young 1964.

Conclusion

Data presented in this paper suggest that the mortality rates of Gisborne and Taihape Paradise Shelduck are greater than these populations can sustain without declining in numbers. The role of shooting in causing the present decline cannot however be established with any degree of validity until reliable estimates of productivity, first year mortality, crippling losses and non-return of bands are available. However, because shooting pressure is the one factor that can be easily altered and controlled, it would seem essential to lower it so that mortality and productivity are equated. The recently reduced daily limits at Gisborne, and over most of New Zealand, are an important first step in reducing the level of exploitation. It remains to be seen, however, if the new limit of three is the effective conservation measure required. It may require less shooter-effort to reach the new limit and it may also act as an incentive to shooters to 'get their limit'. If it were found that shooting pressure remained too high, a useful alternative would be to apply a more severe restriction to that part of the game season during which the majority of birds are shot. Analysis of shooting diaries (Caithness 1969) showed that in 1969 at Gisborne, 50% of the total harvest occurred during the opening weekend, the remaining seven weekends of the season each accounted for approximately 7% of the kill. This pattern is similar to that recorded by Balham and Miers (1959) for Grey Duck and Mallard. At Taihape in 1969, 30% died on opening weekend and 10% on other weekends. By applying a lower limit to the opening weekend, the total harvest may be significantly reduced.

The Paradise Shelduck is a particularly important game bird in the Gisborne and Taihape areas. Caithness (1969) recorded it comprised 25% of the total waterfowl harvest at Gisborne and 30% at Taihape compared with an average of 3% over the rest of New Zealand. Elsewhere it is shot in substantial numbers only in Southern Lakes and South Canterbury districts of the South Island where it forms 14% of the harvest.

Paradise Shelduck are well adapted to the open hill farmland of New Zealand and there is no shortage of this habitat. Prudent management at this time, starting with a reduction in shooting mortality, perhaps even total protection for a limited period, will allow consolidation of the species' recent spread over the entire country and ensure its continued availability as a game bird.

Acknowledgements

This paper owes much to the efforts of Mr. H. McAllum who, while an Officer of the New Zealand Wildlife Service, initiated studies on Paradise Shelduck. It is also the result of considerable field effort by many Wildlife Service Field Officers and trainees, particularly Messrs. A. G. Hall, P. T. Fisher and T.

Thompson. Neither would it have been possible without the co-operation of shooters in the two districts and the landowners on whose properties the moulting sites are located.

I wish also to record my gratitude to Messrs. C. J. R. Robertson and G. Hatzakortzian for their assistance with sorting the banding data, Mr. J. Cheyne for undertaking a preliminary analysis of the data and to M. J. Imber and T. A. Caithness, Wildlife Service, and Professor G. M. Dunnet and Dr. I. J. Patterson, Aberdeen University, for helpful criticism of the manuscript and constructive comment.

Summary

Two apparently discrete populations of Paradise Shelduck *Tadorna variegata* were studied in New Zealand. Of 6,866 banded when moulting at 15-18 months or older, 1,143 were reported shot. Weighted mean annual mortality after 15-18 months for all years in one population was 36.4% for males and 35.0% for females; for the other 39.5% and 43.0%.

The recovery rate for females was lower than males indicating they are less likely to be shot. Year-of-banding recovery rate (%) is shown to be an unreliable statistic for monitoring the intensity of shooting.

In the absence of reliable data, crippling losses and non-return of bands were arbitrarily estimated to be 10% and 33% respectively, but reasons are given for believing these estimates considerably understate the true situation.

If half the adult pairs raise six young per pair to fledging, a stable situation can only result if mortality from fledging to banding is less than 57% for one population and 44% for the other. Mortality rates are compared with those of other waterfowl hunted in New Zealand and other shelducks.

Both populations are declining and shooting pressure should be reduced until population stability is achieved. Ways of doing this are discussed.

References

BALHAM, R. W. and K. H. MIERS. 1959. Mortality and survival of grey and mallard ducks banded in New Zealand. *New Zealand Dept. of Internal Affairs, Wildlife Publ.* No. 5. 56 pp.

BEATTIE, H. H. 1920. Nature lore of the southern Maori. *Trans. N.Z. Inst.* 53 : 53-77.

BOYD, H. 1962. Population dynamics and the exploitation of ducks and geese. Pp 85-95 in Le Cren, F. D. and M. W. Holgate (Editors), *The exploitation of natural animal populations.* Oxford: Blackwell.

BULLER, W. L. 1893. Notes on New Zealand birds. *Trans. N.Z. Inst.* 25 : 53-63.

CAITHNESS, T. A. 1969. A summary of the 1969 waterfowl shooting season. Dept of Internal Affairs, Wellington, New Zealand. 19 pp. Mimeo.

FARNER, D. S. 1955. Bird banding in the study of population dynamics. Pages 397-449 in Wolfson, A. (Editor), *Recent studies in avian biology.* Urbana: Univ. Illinois Press.

GEIS, A. D., R. K. MARTINSON and D. R. ANDERSON. 1969. Establishing hunting regulations and allowable harvest of mallards in the United States. *J. Wildl. Mgmt.* 33 : 848-59.

HICKEY, J. J. 1952. Survival studies of banded birds. *U.S. Fish and Wildlife Service Special Scientific Report* : Wildl. 15. 177 pp.

HORI, J. 1964. The breeding biology of the shelduck *Tadorna tadorna. Ibis* 106 : 333-60.

IMBER, M. J. and G. R. WILLIAMS. 1968. Mortality rates of a Canada goose population in New Zealand. *J. Wildl. Mgmt.* 32 : 256-67.

LACK, D. 1954. *The Natural regulation of animal numbers.* Oxford: University Press.

MCALLUM, H. 1965. The adaptation and increase in the paradise shelduck (*Tadorna variegata*) within a man-modified environment. *Trans. Roy. Soc. N.Z., Zool.* 6 : 115-25.

OLIVER, W. R. B. 1955. *New Zealand birds.* Wellington: A. H. and A. W. Reed.

REID, B. 1966. Hand-reared mallards in Southland. *N.Z.J.Sc.* 9 : 630-50.

WILLIAMS, MURRAY. 1971. The distribution and abundance of the paradise shelduck (*Tadorna variegata*, Gmelin) in New Zealand from pre-European times to the present day. *Notornis* 18 : 71-86.

YOUNG, C. M. 1964. An ecological study of the common shelduck (*Tadorna tadorna* L.) with special reference to the regulation of the Ythan population. Unpublished Ph.D. Thesis, University of Aberdeen.

ZANDER, R. C. W. 1967. The paradise duck (*Tadorna variegata*) in the Southland and Otago Acclimatisation district. Unpublished Diploma of Wildlife Management dissertation, Zoology Dept., Otago University.

Murray Williams, Wildlife Service, Department of Internal Affairs, Wellington, New Zealand.