Clutches, broods, and brood care behaviour in Chestnut Teal

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Introduction

Despite the implications of annual productivity for the management of harvested species of Australian waterfowl, this aspect of reproductive ecology has rarely been studied. Similarly, details of brood mortality and survival, which are also requisite information in understanding aspects of recruitment, are lacking (e.g. Cowardin and Johnson 1979; Talent *et al.* 1983). Riggert (1977) provided some information on brood and duckling survival in the Australian Shelduck *Tadorna tadornoides* and McFadden (1983), working in New Zealand, reported on data obtained from nest boxes used by Grey Teal *Anas gibberifrons*. Though Norman (1982) presented some information on clutch size and egg loss in Chestnut Teal *A. castanea*, the species' productivity has not been discussed. In addition, whilst Phillips (1926) noted that male Chestnut Teal often stayed with females and broods, and Frith (1982) considered that nearly one half of broods were accompanied by males, brood care in the species has not been investigated.

In this paper aspects of annual production of ducklings from clutches laid in nest boxes are examined, and their subsequent survival discussed. Some parameters are then related to observations on broods, brood care and attentiveness by adults.

Methods

Our study area at the Serendip Wildlife Research Station, near Geelong, Victoria (described by Norman *et al.* 1979) includes three interconnected water bodies which have fluctuating levels. Varying cover is provided at the lakes' edges by grass species and by dead and live trees (mainly willows *Salix babylonica)*. Almost all Chestnut Teal in the area nest in artificial, elevated nest boxes provided for that purpose (Norman 1982).

Data were collected every 14 days in nest box checks made in the 1970–71 to 1976–77 breeding seasons. Eggs in boxes were date-marked and ducklings were identified by numbered fish-fingerling tags inserted in the interdigital webbing. Only clutches from which ducklings were eventually tagged (i.e. completed and successful clutches) are included in the analyses. Clutch size, estimated clutch completion date and hatching date, and numbers of ducklings that hatched and successfully left the nest were noted. Ducklings found dead in boxes and elsewhere were also examined for tags. The clutch completion dates, and the dates of tagging, were classed as 'early', 'mid-season' or 'late' by dividing the egg-laying period into three equal sections.

Between October 1969 and September 1977 baited duck traps were routinely set at standard sites around the lakes and ducks caught were examined for the presence of fingerling tags. Tagged birds more than 3–4 weeks old were banded and some were subsequently recaptured in traps or in nest boxes (females); others were also found dead in the study area. During these trapping sessions some ducklings were individually marked with coloured nasal discs. Approximate age determination, based on weights that were compared with those of hand-reared birds, gave some later indication of the timing of independence from adults.

Counts of ducklings present on the whole wetland system were made every 14 or 28 days from August 1970 to December 1977, usually in late evenings and/or early mornings. Broods were assigned to one of seven age categories based on body size and plumage development (e.g. Southwick 1953). The number of ducklings in each brood and (in most cases) the presence of adult birds were recorded. Broods were not observed for extended periods and adult attentiveness was scored on first observation. Some of the older (size 7) ducklings could not be distinguished for sure from females and these were not included. Counts of ducklings were also made at other times (e.g. during nest box checks) and included in the analyses.

Broods using the main lake were observed intensively during 8th–17th October 1980 (3 broods) and 3rd–4th December 1980 (4 broods). Time budget data were

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collected then by observing a single family continuously, as long as the birds remained in view, and noting the activity of male and female every 30 seconds. All threats and rushes made by each parent at other birds were also recorded. Additional notes on the behaviour of parents and ducklings were dictated into a tape recorder. All broods were size 1–4 stage, and each was individually recognisable from day to day by distinctive plumage features of parents and/or by the size and number of ducklings. Observation periods totalled 15 h 48 m in October, 8 h 24 m in December.

Water levels were recorded for the main lake, and rainfall totals at Serendip. All statistical significance levels are at 0.05, unless otherwise indicated, and analyses were performed using the SPSS package (Nie *et al.* 1975).

Results

Clutch size and productivity

Determination of the clutch size of individual females was affected by (a) the disappearance of marked eggs, (b) the presence of eggs remaining from previous clutches, and (c) laying by more than one female in a box. To minimise distortions caused by these factors, "clutch size" is defined as the average maximum number of eggs in clutches that were both incubated and produced ducklings. For 221 clutches that qualify, the average clutch size was 10.6±S.D. 2.94. Analyses of 174 of these clutches that definitely did not include eggs left over from previous clutches showed that clutch size did not vary significantly between seasons. Within seasons, however, mid-season clutches were larger, 11.4±3.36, n=88, than both early clutches, 10.3±2.67, n=97 (P=0.018) and late clutches 9.8±2.08, n=36 (P=0.010).

From the 221 clutches, an average of 8.3±2.71 eggs hatched (78.3%) and 7.9±2.88 ducklings left the boxes (74.5%). The figures were significantly higher in some seasons (1973–74, 1976–77) than in others (1970–71, 1971–72). In general, rates of hatching and of leaving the nest did not vary in relation to the stage in the breeding season but clutches showed significant variations between seasons.

Tagged Ducklings

Between 1970 and 1977, 1,289 ducklings were caught in the nest boxes and marked soon after hatching (Table 1). On average, 5.8±3.21 ducklings were tagged in each of the 221 clutches involved. Forty-six (3.6%) of the tagged ducklings were later found dead in the boxes, and a further six elsewhere. Analyses of the 174 clutches that did not include left-over eggs showed that significantly more of these tagged ducklings died in mid-season clutches 0.37±0.91, n=68, than in early clutches 0.11±0.36, n=79 (t=test, P=0.024).

In the final season of regular trapping the maximum period between the marking of a duckling and its eventual recapture was 161 days. This period has been used to establish equal opportunity of recapture for all years. The overall recapture rate of tagged ducklings within their season of hatch was low (9.8%) and few birds were captured subsequently. However, the recapture rate varied greatly from year to year (Table 2), probably reflecting differences in the survival of ducklings to banding age.

For all clutches there were few significant correlations between water levels, rainfall and duckling production. However, total ducklings tagged per season was significantly related to the average main lake level in the first half of each breeding season (r=0.7064, P=0.0379). Omitting the first season, when no recaptures were made,

Table 1. Recapture data for 1289 Chestnut Teal ducklings tagged in nest boxes, Serendip, Victoria, 1970–77.

	Age in days									
	0–7	8–14	15–21	22–28	29–35	36–42	43–49	50–56	57–63	64+
Number finally recaptured	180	156	151	147	139	137	123	113	103	96
Percentage recaptured	14.0	12.1	11.7	11.4	10.8	10.6	9.5	8.8	8.0	7.4

Table 2. Summary of tagging, banding and recapture details for ducklings marked in nest boxes, Serendip, Victoria 1970–77.

No. ducklings	1970 –1971	1971 –1972	1972 –1973	1973 –1974	1974 –1975	1975 –1976	1976 –1977	All seasons
Tagged	39	250	172	151	214	275	189	1289
Recaptured at < 4 wks	–	32	2	4	–	–	–	38
Banded [a]	–	12	19	44	12	48	77	212
Banded [b]	–	8	15	43	10	47	5	128
Dead in box	–	18	6	1	7	6	8	46
Dead elsewhere	–	4	2	–	–	–	–	6

[a] = number banded at any time.
[b] = number banded within period of equal capture chance (161 days).

numbers of ducklings tagged were also correlated with water levels in the later parts of breeding seasons (r=0.7788, p=0.0339). Numbers of ducklings recaptured and banded were also significantly and negatively correlated with water levels in the earlier parts of seasons (r=-0.7380, p=0.0469).

Of the ducklings tagged, 121 were sexed on subsequent recapture; 53 were males and 68 females. Ten females were subsequently caught on nest boxes at Serendip, some up to eight years after their original tagging.

Brood sizes

Broods present on the lake system were counted on 774 occasions (Table 3). In general, there was a progressive reduction in the numbers of ducklings in brood as the age of the brood increased. Thus by size 7 there had been a loss of about 33% from those counted in broods at size 1. Compared with the average number of ducklings that left the boxes (7.9) there was an overall loss of 60%.

Differences in brood sizes varied significantly between years (analysis of variance, P=0.0001), but there were generally no such differences for within-season observations of the same size classes. However, in the size 2 class, fewer ducklings were present in broods during the earlier part of seasons (2.92±2.71, n=26) than in mid-(4.29±2.71, n=98) or late season (4.86±3.33, n=51) surveys, and the differences were significant (P=0.0188). In contrast, broods of size 7 ducklings in late season (2.81±1.97, n=94) were smaller than in early (4.20±1.30, n=5) or mid season (3.75±2.60, n=44) and again such differences were significant (P=0.0343).

Separation of the broods into those

Table 3. Average (± SD) numbers in broods seen on the Serendip lake system, 1970–77. Sample sizes in parentheses.

Duckling Size	1970–71	1971–72	1972–73	1973–74	1974–75	1975–76	1976–77	All seasons
1	5.04±2.73 (48)	4.00±2.25 (40)	4.80±2.59 (5)	6.00±4.00 (5)	6.50±2.38 (4)	6.00±2.83 (2)	1.00 (1)	4.71±2.64 (105)
2	4.19±2.97 (59)	3.77±2.43 (57)	4.59±2.56 (34)	4.00±5.12 (9)	6.57±3.78 (7)	4.86±1.86 (7)	5.00±2.83 (2)	4.26±2.88 (175)
3	4.22±2.73 (41)	3.54±2.24 (37)	4.20±2.66 (25)	5.33±2.66 (9)	5.00±1.41 (2)	2.60±1.14 (5)	5.00 (1)	4.07±2.51 (120)
4	3.33±2.29 (27)	3.48±2.55 (25)	4.81±2.43 (16)	5.36±3.47 (11)	4.09±3.30 (11)	2.00±1.41 (2)	–	3.95±2.70 (92)
5	2.80±1.23 (10)	3.14±2.25 (22)	3.22±1.79 (9)	3.25±1.83 (8)	4.00±2.49 (12)	2.50±0.58 (4)	2.67±1.53 (3)	3.23±1.95 (68)
6	4.83±1.72 (6)	3.37±1.83 (30)	5.41±3.18 (17)	3.50±3.53 (2)	2.75±2.06 (4)	3.78±1.99 (9)	3.00±1.00 (3)	3.96±2.36 (71)
7	2.82±1.57 (33)	2.93±2.17 (44)	4.04±2.91 (27)	2.87±1.96 (16)	2.64±1.63 (11)	3.78±2.78 (9)	3.33±2.08 (3)	3.17±2.19 (143)

accompanied by one, both, or no adults shows a general decline in numbers of ducklings in broods containing young of increasing size (Table 4). However, broods containing young of all sizes with no adult present tended to be smaller than those with at least one parent. If broods are grouped into 3 major age categories, 1–3, 4–6 and 7, each group contained more ducklings if both adults were present than when the broods were accompanied by a single male or female (analyses of variance, $P=0.0005-0.002$). Broods for which attendance was not determined were often larger in average number than broods of the same age with parents.

Table 4. Numbers in broods compared with parental attendance, Serendip, 1970–77.

Duckling Size	Male and Female	Male only	Female only	No Adult	Not Determined
1	4.61±2.63 (82)	5.00±2.82 (2)	5.00±1.90 (6)	1.50±0.70 (2)	5.69+2.98 (13)
2	4.75±2.88 (118)	3.14±2.11 (7)	3.60±1.99 (15)	2.07±1.83 (15)	3.85±3.12 (20)
3	4.10±2.51 (87)	2.67±1.21 (6)	2.60±2.07 (5)	2.71±2.98 (7)	5.33±2.29 (15)
4	4.13±2.65 (59)	1.00 (1)	2.33±0.52 (6)	1.43±0.79 (7)	4.89±3.05 (19)
5	3.80±2.08 (41)	2.33±2.31 (3)	2.70±1.49 (10)	2.00±1.12 (9)	2.00±0.71 (5)
6	3.73±1.81 (49)	3.67±1.53 (3)	3.57±1.51 (7)	1.00 (1)	5.73±4.12 (11)
7	3.80±2.40 (66)	1.00 (1)	2.58±1.50 (12)	2.18±1.43 (45)	3.63±2.56 (19)

In the observations where attendance was determined (672), no parents were present in only 12.8% of sightings. Males were present, either with females or alone, with broods in 78.1% of the counts, and females in 83.5%. The attendance by males was generally higher with the younger ducklings of size 1 (91.3%) or sizes 1-3 (85.8%) than with size 4-6 (79.6%) or the oldest ducklings of size 7 (54.0%). Males, which on several occasions were accompanying broods whilst in wing moult, were seen alone with broods in 4.5% of observations of ducklings of sizes 1-3. Although only one instance was recorded of parents leaving a brood concealed in dense vegetation, small (1–3) and older (4–6) ducklings were unaccompanied on 6.8% and 8.7% of sightings respectively. The oldest (size 7) ducklings were alone on 36.3% of occasions.

In the 1970–71 and 1971–72 breeding seasons ducklings were individually marked with coloured nasal discs. Of these, 36 were seen later on one or more occasions when their approximate ages were known. Some of these ducklings were apparently independent after 4–5 weeks, a third of the observations were of unaccompanied ducklings by 6–7 weeks, and over half of those 8–9 weeks old were unattended.

Brood-care behaviour

The time budgets cover activities while broods were in view and usually when the birds were actively moving about. Rest periods, when parents and ducklings came out on shore to preen and sleep, could not be recorded accurately because the birds usually rested out of sight under overhanging willows at the edge of the lake. While broods were moving both parents were usually in alert postures, although males held their heads noticeably higher than females. Males spent more time in alert postures than females, while females fed more than males (Table 5). Only two instances were recorded in which parents flew off and left their broods unattended for short periods (one timed at 12 minutes); the adults probably left to feed with pinioned waterfowl in nearby pens.

When broods were very close to the blinds females could be heard giving quiet squeaky or chittering calls continuously. When ducklings became widely dispersed,

Table 5. Percent of time spent in various activities by males and females accompanying broods during 1980.

	Alert	Feed	Comfort	Threat	Other*
October					
Males	86.8	4.6	3.0	1.2	4.4
Females	71.4	15.6	3.9	2.2	6.8
December					
Males	91.7	5.1	3.2	–+	–+
Females	87.2	9.3	3.5	–	–

*When broods were out of view for long periods, records were stopped; therefore rest/sleep periods are under-represented.

+These categories were not recorded systematically in December.

one female gave loud, repeated "kaduk" calls (n=6 occasions) and the ducklings mostly seemed to respond by returning to her (n=4). Similar calls were heard when this female was leading her brood in tight formation across a wide stretch of open water. Females gave loud, raucous "raa, raa, raa" quacks during raptor attacks on the brood (n=12).

Males were not heard to give the continuous quiet calls while escorting broods, but they gave loud "Kek" calls (with characteristic upward and forward head movement and wide open bill) when ducklings became widely dispersed (n=5) or during an alarm (e.g. when a raptor was sighted or came close to the brood) (n=22). These calls are similar to those used by males in courtship ("Burp" display, Johnsgard 1965) and as contact calls between mates. In brood-care contexts, they appear to warn the female and she then protects the brood. The male's calls may warn ducklings also, perhaps causing dispersed ducklings to assemble, but since the female was always present we could not be sure that this was happening. During some raptor attacks on the brood, one male also gave rapid series of evenly-spaced calls with no obvious head movement (n=3).

Although ducklings often moved away from their parents while feeding, dabbling and picking at the water surface or along a shoreline, both male and female usually appeared to monitor the ducklings' positions quite closely. When ducklings lagged behind the female and other ducklings, we noted that the male waited and then escorted them back to the female (n=15). When crossing stretches of open water, ducklings usually followed the female in a tight group, but once two ducklings were seen to follow the male. In another instance, several ducklings became separated from the brood and the parents did not seem to miss them. When one of the separated ducklings gave "lost peeping" calls, however, both parents flew to join the separated group and then swam back with them to the main brood. On other occasions also, it was obvious that both parents responded to duckling alarm calls.

Many Chestnut Teal, a few Grey Teal, and various other water birds used the study lake and brood-tending Chestnut Teal behaved aggressively toward many of them. Broods inevitably came close to other birds as they swam around the lake (ducklings often moving ahead of the adults) and these were frequently threatened or rushed at by the parents, mainly towards Chestnut Teal (158 threats, 238 rushes) and Grey Teal (29, 46), with others scored at 12 and 10. With rare exceptions, the other ducks moved away out of the path of the family, though generally broods avoided coming close to Australian Shelducks. At times, Chestnut Teal (n=29), Grey Teal (n=6), and Pacific Black Duck *Anas superciliosa* (n=1) showed interest in ducklings and followed broods around. The intent of these "followers" was not always clear; in the case of Chestnut Teal, 11 single males, 4 single females, and 9 pairs behaving in this way were recorded. Often, however, it looked as though a follower was about to peck at a duckling and on 6 occasions a male Chestnut Teal did so, but the ducklings always escaped, apparently without damage. Persistent followers were invariably threatened or rushed at by one or both parents, and attacks were especially vigorous on birds that pecked at ducklings. On 5 occasions, single males gave "Kek" calls to a brood-tending female, apparently showing interest in courting her, but the female promptly threatened or rushed at these males and they soon left.

For the best-studied pair 395 aggressive actions (threats and rushes) directed by the parents toward other birds were documented (Table 6). Overall, the female made more threats + rushes than the male; at times the pair also acted in unison, but this was less frequent. Both parents made more aggressive moves toward male than female Chestnut Teal (totals of 162 vs. 86), but the male directed a higher proportion of his aggressive actions toward males (78%) than the female did (61%). This male's aggressiveness apparently declined between the first and second week of the study period (n=74 for 8th–12th October, n=27 for 13th–17th October); no corresponding decline was apparent in the female's aggressive behaviour (n=115 and n=116). Numbers of aggressive actions recorded in other pairs with ducklings were too few to allow comparisons.

Only three interactions between Chestnut Teal families were seen. In all cases, the parents behaved aggressively toward one another rather than to the strange ducklings.

Although occasional instances of aggressive behaviour by parents toward species other than Chestnut Teal and Grey Teal were recorded, these were exceptions. More usually parents ignored Coot *Fulica atra*, Dusky Moorhen *Gallinula tenebrosa*, Hoary-headed Grebe *Podiceps poliocephalus*. However, none of these species was as abundant as Chestnut Teal on the lake, and none of them showed an interest in following broods.

Potential predators on ducklings were present in the area every day. Fifty-two incidents were seen involving approaches to broods or attacks on ducklings by 6 species of predators, and 5 instances of successful predation were recorded. The responses of ducklings and their parents varied somewhat toward the different predators.

One or a pair of Little Ravens *Corvus mellori* patrolled the shoreline frequently. They approached and followed broods closely on many occasions, and three ducklings were observed to be taken. The best-studied brood dwindled in size from 9 to 3 between 8th and 17th October, and it was suspected that ravens took most of these ducklings. Ravens appeared to be no threat to broods swimming in open water, but parents were especially watchful when broods passed through an area of flooded dead trees (where the ravens could perch close to passing ducklings) and especially when they crossed open ground. Several broods made regular crossings over a strip of short grass (about 15 metres across) to reach a favoured feeding area, and this was where the ravens succeeded in taking ducklings. Both parents, but especially the male, actively defended the ducklings by threatening or lunging at the ravens when they came close to the brood. One of the 4 recorded attacks was repelled by both adults flying at the raven (which held a duckling in its foot) and forcing it down into water where they pecked at it. The duckling was released in mid-air.

When Marsh Harriers *Circus aeruginosus* were sighted in flight, parents became very alert, cocking their heads to follow the raptor's movements, and males gave "Kek" calls. Broods almost always moved quickly

Table 6. Targets of aggressive behaviour (threats + rushes) by male and female Chestnut Teal parents of the best-studied brood, October 8th–17th.

	AGGRESSOR			
Target	Male	Female	Male & Female Together	Total
Chestnut Teal male	51	111	8	170
Chestnut Teal female	14	72	7	93
Chestnut Teal pair	8	13	11	32
Other birds	28	35	19	100
Totals	101	231	45	395

to shelter beneath overhanging willows when a harrier was in the vicinity. This appeared to be an effective strategy because, unlike the ravens, harriers attacked swimming ducklings by hovering overhead and plunging down at them. During the 11 attacks, female teal gave loud calls, both parents often adopted pre-diving postures with wing-tips pointed upward, and occasionally a parent lunged at the harrier. Meanwhile the ducklings usually dived repeatedly; once an adult dived also. One duckling disappeared during a harrier attack and, since no ravens were in the vicinity at the time, it was probably taken by the harrier.

Only one attack was seen by a Whistling Kite *Haliastur sphenurus*. Responses were similar to those described for Marsh Harriers, including lunges by the female. One instance of predation by Purple Swamphen *Porphyrio porphyrio* was recorded. In this case, the female teal rushed at and pecked the swamphen. In another record (van Tets 1965) both parents chased the swamphen as it walked off with a duckling in its beak. Usually broods showed only mild alarm to swamphens, but avoided coming very close to them. Once a Pied Cormorant *Phalacrocorax varius* was seen to peck at a duckling. The duckling seemed unhurt, and the parents ignored the cormorant. Cormorants roosted in the willows used by the study broods and if they are serious predators on ducklings more attempts should have been seen.

Musk Duck *Biziura lobata* were not present during the period when the broods were watched intensively. However, there was one record of a Musk Duck taking a duckling by a sneak underwater attack, and the Musk Duck was then mobbed by a small flock of adult teal. This species could be a serious predator in some breeding areas.

Female Chestnut Teal with broods were seen to peck, nibble, or prod at their own ducklings on nine occasions. Although some of these pecks looked quite vigorous (in one case the duckling was flipped on to its back), ducklings showed no ill effects, nor did they seem to try to avoid being pecked. In five cases, the situations were "stressful" for the females concerned (harassment by followers, raptors, or another brood); in two cases, the females seemed to be urging their ducklings to move along faster to reach cover. The significance of this behaviour remains obscure.

Distraction displays, similar to those performed by other dabbling ducks, were recorded in both parents by Gosper (1973) when 4 Chestnut Teal families were suddenly startled and flushed from cover. The occurrence of this response to humans in both parents was confirmed in the present study, but females seem to be more active than males.

Discussion

This study amplifies findings on clutch sizes and reproductive success reported earlier (Norman 1982) for the Serendip population of box-nesting Chestnut Teal. Data collected by daily box checks in 1970–71 had shown that 40.3% of 837 eggs laid disappeared from the boxes, presumably removed by Little Ravens. Also, the occurrence of "egg dumping" had been established, by noting the laying of more than one egg per day in certain boxes. By extending the study through to the 1976–77 breeding season, with regular box checks, more confident estimates of clutch sizes and the fates of eggs and ducklings have been made possible.

Fluctuations in hatching and nest-leaving rates from year to year could have been caused by variations in climate, water conditions, food, predation, and egg dumping. Losses at the egg stage do not appear to have major effects on the productivity of females that incubate clutches in this population. However, the high density of nest boxes does facilitate egg dumping and some broods contain progeny from more than one female.

Variations in clutch sizes within breeding seasons were established, the largest clutches occurring in the middle part of the season. A similar result was found by McFadden (1983), in a similarly dense, box-nesting population of Grey Teal in New Zealand. Here again, the influence of the egg dumping patterns of individual females might be a factor.

Relatively few ducklings were found dead in boxes, but duckling losses were high during the first days after leaving the nest. Presumably these data underestimate early mortality because they omit losses of entire broods (Ball *et al.* 1975; Ringleman *et al.* 1982).

Heavy losses of ducklings, especially in the first two weeks (e.g. McGilvrey 1969), are not unusual in ducks. In the Serendip Chestnut Teal population, data from recaptures of tagged ducklings indicated a minimum survival of only 12.1% to two weeks, 8.8% to eight weeks (when some reach flying age, Frith 1982). Overall productivity, including unsuccessful nesting attempts, which may be of the order of 50% (Norman 1982), is probably much lower.

In other duck species, duckling losses have been attributed to predation, scattering of broods, or accidents (Talent *et al.* 1983), to early breaks in the brood-parent bond (Ball *et al.* 1975), to food shortages (Street 1977), or to a combination of predation and disease (Mendenhall and Milne 1985). In some situations, losses may be high on the journey from nest to water (Dzubin and Gollop 1972) but this is probably not an important factor when the distance involved is short (Haramis and Thompson 1984). The Serendip boxes are above or very close to water and the initial journey does not entail special risks.

Flooded grasses and rushes, rocky shores, and dry areas of grass are the most important feeding areas for small Chestnut Teal ducklings (Norman *et al.* 1979) and escape cover is usually close at hand. Nevertheless, ducklings are vulnerable to predators such as Marsh Harriers when surprised in open water and Little Ravens when crossing open land. Ducklings are taken regularly by these two species, and their predation is probably a major source of mortality in this high density nesting situation.

Parental behaviour of several kinds appeared to protect ducklings against predators. Vigilance by both parents, but especially by males, ensured that warning was usually given of an approaching raptor. Ducklings usually responded to parental alarm calls by moving to cover, by bunching together, and during raptor attacks in open water by diving repeatedly. Both parents remained with their ducklings during attacks, and both made threats and lunges at the predators. This often seemed to deter or distract a predator, and many attempts to take ducklings were abandoned.

Isolated ducklings were undoubtedly at greater risk from predators than those with their parents in a tight family formation. Parents showed increasing uneasiness when their ducklings became widely dispersed, females called to regroup the brood, and males attended lagging ducklings. Ravens appeared to watch for opportunities to grab isolated ducklings, and the ones seen taken were lagging individuals.

Parental protection of ducklings also extended to interactions with other ducks, especially conspecifics. Both parents threatened or chased other ducks that the family approached as it moved about, and they were especially aggressive toward individual ducks that followed their ducklings. When followed or pecked at, ducklings took evasive action by rushing away. The hostility by parents toward other ducks probably minimises harassment and ensures uninterrupted feeding by the ducklings.

More direct evidence for the importance of the male's presence to duckling survival comes from the brood count data. When both parents were present, broods of all ages were on average larger than when one parent or no parent was present. The comparison between double- and single-parent broods is especially important, because observations of broods without a parent are difficult to interpret. The latter could be the result of desertion, separation, or mortality of parents; alternatively the parents might be only temporarily absent. A previous attempt to relate brood size to bi-parental attendance was made by Siegfried (1974) for Red-billed Teal *Anas erythrorhyncha* and Cape Shoveler *A. smithii* but no differences were established.

The presence of two adults with broods has been recorded in a number of tropical and/or Southern Hemisphere *Anas* species (Weller 1968; Kear 1970; Siegfried 1974; McKinney 1985). Although marked birds have rarely been involved (except in captivity), it is generally assumed that these are the two parents and that the males are contributing to parental care. On the other hand, Siegfried (1974) suggested that males accompany broods mainly to maintain their pair-bonds and he thought that, in species such as the Cape Teal *Anas capensis*, where males are almost always in attendance, male contributions to parental care are secondary. The comparative evidence on this topic (reviewed in McKinney 1985) shows that (a) in some species male attendance is almost invariable and males appear to contribute to duckling care e.g. Cape Teal, Chiloe Wigeon *Anas sibilatrix*; (b) in some species males are rarely present and brood-care is by females only e.g. Hottentot Teal *A. punctata*; (c) in some species the male's presence and/or care is variable e.g. Speckled Teal *A. flavirostris*. Our study confirms earlier reports of active brood defense by males in the Chestnut Teal (van Tets 1965; Gosper 1973) and provides evidence that males contribute to duckling survival. This places this species in the first of the three categories outlined above.

The possibility that male Chestnut Teal are also securing their pair-bonds by accompanying their mates during the brood-rearing phase, that male vigilance contributes to female safety, and/or that the male's presence allows the female to feed more efficiently cannot be dismissed. However, the data show that males are less often present with broods in the middle and later age categories than they are with young ducklings, indicating that males tend to leave their females during the latter part of the brood-rearing period. Although the data on the best-studied family show that the male directed a higher proportion of aggressive moves at males than at females, he did behave aggressively toward both sexes (as well as other species) and his aggressiveness waned as the ducklings became older. This does not support the view that males accompany broods primarily to maintain their pair-bonds; rather it suggests that the male is present mainly because of the need to help protect his ducklings while they are small and most vulnerable to predation.

A final noteworthy point is that the Chestnut Teal is a strongly dichromatic species. There has been a tendency in the literature to view male brood care, long-term pair-bonds, and monochromatism as associated features characteristic of Southern Hemisphere *Anas* species. The need for caution on this question is underlined by the fact that male brood-care is also highly developed in the Brown Teal *A. aucklandica* (Blanshard 1964), which shows reduced dichromatism, while the regularity of the male attendance on broods in the Grey Teal, which is monochromatic, is uncertain and not well documented (see McKinney 1985). Obviously there is a need for more intensive field studies on the behaviour of males in species where they accompany broods.

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Summary

Details of clutch sizes and subsequent productivity are presented for Chestnut Teal *Anas castanea* using artificial nest boxes. Survival of ducklings marked in the nests and subsequently trapped is discussed in relation to contemporary counts of broods. The role of both parents in brood care was investigated.

Clutch sizes were affected by the disappearance of marked eggs and by the presence of eggs from previous clutches and other females. There was little evidence to show between-season variations in clutch sizes but separation into early, mid, or late season clutches did show some differences. Relatively few tagged ducklings were found dead in boxes but mortality, particularly in the period immediately after leaving the boxes, was high.

In general, broods of all ages were smaller when no parent was in attendance, and broods attended by both parents were larger than those accompanied by a single parent of either sex. Male Chestnut Teal attendance declined with increasing brood age. Males were observed to take active roles in brood protection and defense. It is concluded that males are not accompanying broods primarily to maintain a pair-bond, but rather they are protecting the smaller ducklings especially prone to predation.

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