The Grey Teal at saline drought-refuges in north Queensland

H. J. LAVERY

Introduction

The precise nature of the habitat at which waterfowl ultimately seek refuge from the effects of frequent and prolonged periods of low rainfall in north Queensland, and the behaviour of flocks at these localities were investigated during 1965-1969 and are the subject of a series of detailed papers (Lavery 1972a, b, c).

The Australian Grey Teal *Anas gibberifrons gracilis* breeds during the late summer wet season at inland localities such as the Charters Towers Study Area, moves coastwards to sites including the Ross River Plains Study Area during winter, and eventually inhabits saline areas such as Cleveland Bay Study Area for the remainder of each dry season; occasionally suitable rainfall occurs to provide perennial habitat of all of these types within one district, as in the Lake Buchanan Study Area. These study areas made up the Townsville Study Region (Lavery 1970a, b, 1971).

Habits at saltwaters

(a) *Behaviour*

Grey Teal used saltwater habitat during the drier months of each year, for varying periods related to the timing and quantity of annual rainfall, particularly that in the adjacent hinterland (Figure 1). Birds first occurred at those saltwaters nearest to freshwaters, that is, usually at upper river estuaries and at saltpans.

Grey Teal at the saline habitat, and nearby freshwaters, were mainly occupied with feeding, locomotion and comfort (Figure 2).

The social organisation was of loosely-bound flocks of pairs, with some unpaired adult and young birds, predominantly males. Immature birds of both sexes were

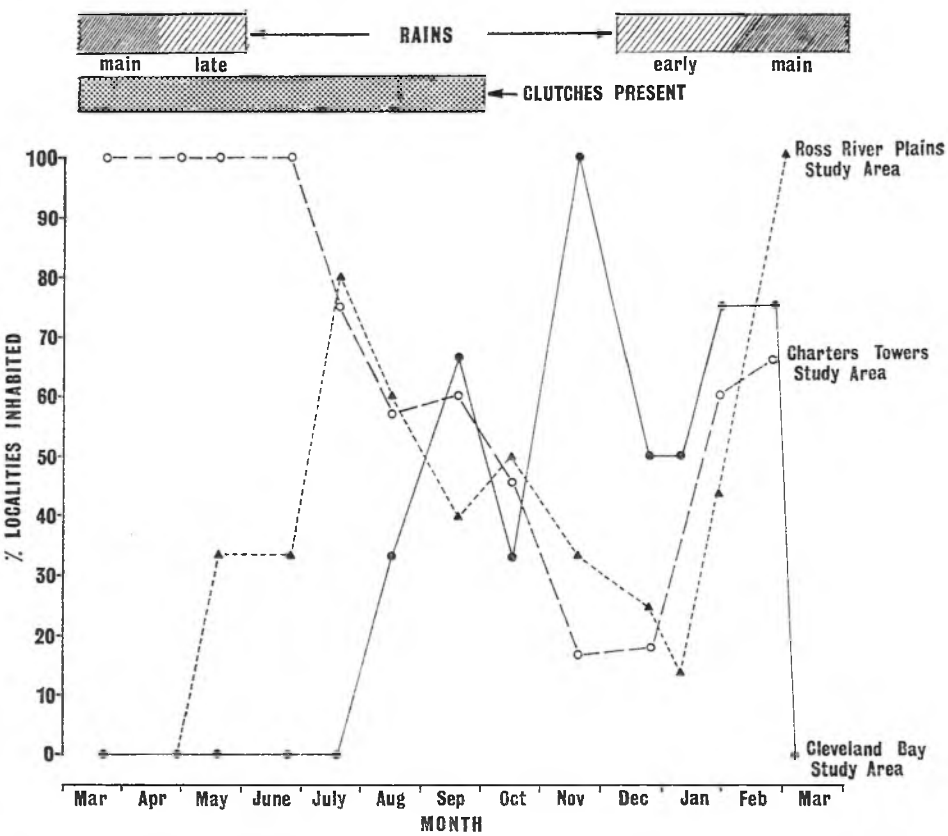

Figure 1. Regional distribution of Grey Teal relative to breeding in north Queensland in the flood year 1968 and late wet season year 1969.

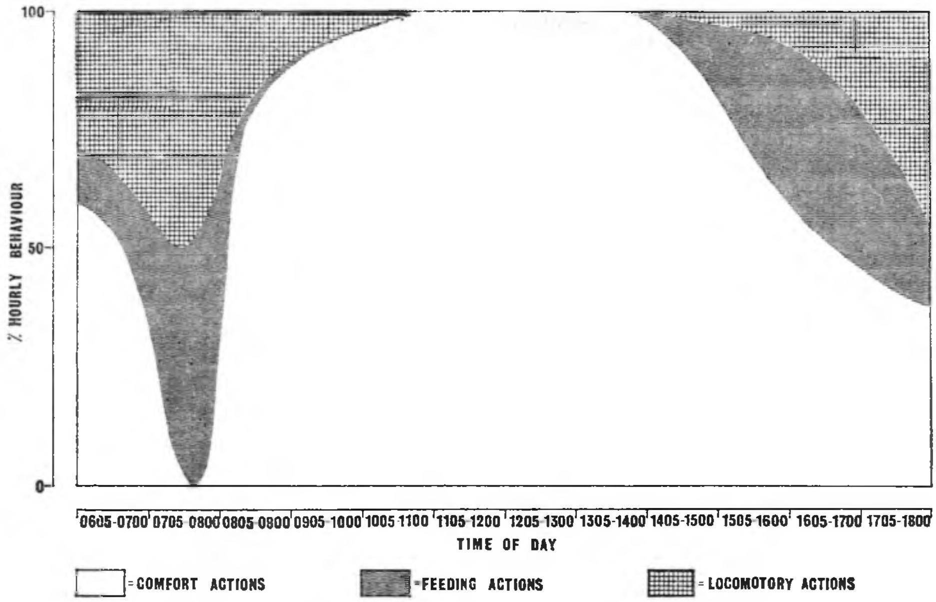

Figure 2. Mean diurnal behaviour of Grey Teal flocks at non-tidal saltwater habitat, Lake Buchanan, Queensland (after Lavery 1972b).

less frequent at saltwaters (1:4.1 adults) than at freshwaters (1:2.3) in samples of 228 birds.

Feeding governed all other activities. At non-tidal areas such as Lake Buchanan, birds fed for approximately five hours before sunset and, less intensely, for some three hours after sunrise. Thereafter they moved to suitable roosting grounds (Figure 2). At tidal localities such as Cleveland Bay, feeding at the water's edge took place at low tides irrespective of time of daylight.

Movements between saltwater and freshwater were rarely seen during daylight, and then at dusk and dawn and following disturbance by shooters. Habits of flocks at night were difficult to determine; night shooting was reasonably successful at some coastal freshwater swamps where no bird was present by day. On the other hand, some individual Grey Teal were seen roosting in the same places at the edge of non-tidal saltwater both at dusk and the following dawn.

(b) Diet

In years when birds arrived early at saltwater habitat, they usually first consumed seeds of coastal club rush *Scirpus littoralis* and other brackish-water plants then abundant. Subsequently the teal, including later arrivals at coastal areas, inhabited localities more and more saline and distant from freshwaters. Two marine molluscs then predominated both in the field and in their diet (Table I). Necklace neritinas *Pictoneritina oualanensis* were distributed in river estuaries confluent with saltpans, mostly below low water spring

Table I. Diet of Grey Teal in north Queensland (after Lavery 1972b).

Food (volume %)	*Ross River Plains Study Area*	*Cleveland Bay Study Area*	
		Ross River estuary	*Cleveland Bay*
Seeds of freshwater plants	72	36	1
Freshwater animals	6	35	—
Seeds of brackish-water plants	22	—	—
Sewage effluents (plant seeds)	—	—	33
Marine animals	—	28	38
Necklace neritinas	—	19	23
Elongate little wedge shells	—	1	12
Indeterminable	—	1	28
No. of gizzards examined	107	26	16

tide level. Early in the dry season the sizes especially favoured by Grey Teal were present, but eventually this food became unavailable owing to unsuitable tides and size. Ultimately, birds moved down the estuaries to the tidal flats of open bays where other molluscs, notably elongate little wedge-shells *Amphidesma angusta*, predominated in the field and in the diet.

Although growing through the season, these shells remained sufficiently small to be consumed; calorific value and nitrogen content of shells also increased despite a decline in population density. The calculated maximum daily intake necessary for maintenance was 21,000 shells (occupying 1.5 $m^2 \times 3$ cm. in depth) for an average adult male Grey Teal. This is comparable with that of the European Rock Pipit *Anthus spinoletta*, a bird of somewhat similar habits (Gibb 1956).

In late wet seasons, as in 1969, birds still inhabited saltwaters in February. Annual extreme spring tide flooding of adjacent saltpans then provided large amounts of harpactacoid copepods and blue-green algae *Microcoleus ?chthonoplastes* as food before either freshwater plants seeded or estuarine foods became available again.

(c) *Conditions of birds at saltwaters*

An improvement in the condition of birds while at saltwaters was clearly demonstrated by the seasonal increase in extent of fat deposition (determined by the method of McCabe (1943)) (Figure 3).

Parasitism by intestinal helminths and malfunction of the alimentary canal through intestinal impactions of fine sand did not occur at important levels. There were negligible changes in competition with associated birds, extent of food supplies, distribution of teal and occurrence of fighting.

(d) *Drinking*

Deliberate drinking of seawater was never observed although this obviously occurred at freshwaters. Salt water was ingested with marine foods; little was taken in compared with freshwater or compared with salt water consumed by other waterfowl such as Black Swans *Cygnus atratus*. Grey Teal maintained under cage conditions could only survive approximately one week without free fresh water.

No evidence of dehydration was apparent in birds collected from saltwaters. Although the freshwater habitat lacked suitable plant foods during drought, sufficient water remained for drinking. Birds moving to fresh water at night, especially in bright moonlight, provided the harvests of duck shooters.

Unusual ingestion of seeds of *Amaranthus* sp. from freshwaters and of tomato *Lycopersicon esculentum* and passionfruit *Passiflora edulis* from sewage, occurred during drinking (Table I) and was of apparently little value.

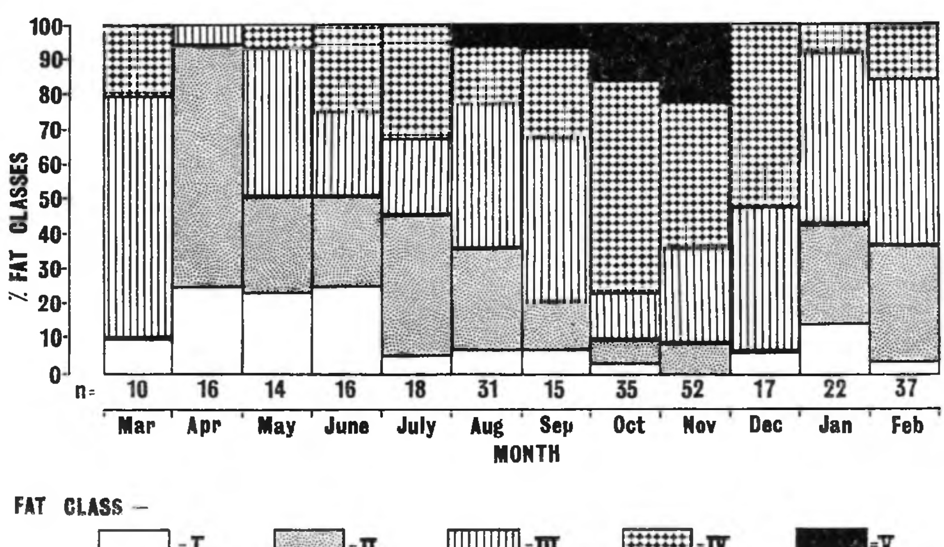

Figure 3. Condition according to extent of fat in Grey Teal collected in north Queensland study areas, 1968-1969 (after Lavery 1972b).

(e) Prolonged return to freshwaters

Time of year for departure varied considerably. Birds left, in all years 1959-1969, after a heavy rainfall of about five cm. following approximately 15 cm. of seasonal rain. The gonads of some males were in breeding condition before departure and before the rain had produced noticeable changes in freshwater habitat. Female oocytes enlarged at coastal freshwater habitat in the course of the birds return to inland breeding grounds. The gonads of birds held in captivity adjacent to coastal saline and freshwater habitat responded similarly to the rains.

Rainfall indirectly encouraged movement by instigating growth of freshwater plants; the birds preference for these could be readily stimulated during the drinking flights.

There was adequate food left at saltwaters after the birds departure; indeed, rainfall exposed abundant marine foods. The seasonal flooding raised water levels less than daily tides. Wet season weather conditions such as large wave actions occurred infrequently.

Apart from the abundant food supply, Grey Teal flock at saltwaters because of similar individual requirements of food and water, the patchy distribution of these resources and the relatively small roosting areas. Advantages to a population include maintenance of sex bonds, appropriate sequential utilization of food resources, attraction of immature birds to different habitat type ('local enhancement' of Hinde (1961)), and recognition ('social facilitation' (Hinde loc. cit.)) of breeding season by association of birds with the few males that responded quickly to appropriate stimuli.

Nasal glands

All Grey Teal examined in north Queensland possessed supraorbital nasal glands, 15.0-18.0 mm. in length and 3.5-6.5 mm. in width in adult birds, broadly similar in form to those described for other Anatidae (see for example Marples 1932).

Differences in individual size of nasal glands were in accordance with changes in sizes of the epithelial cells forming the walls of the lumena of the secretory tubules and, to a much lesser extent, in the length and width of the lumena. Histochemical tests for cytoplasmic basophilia, metachromatic substances and carbohydrates, and lipids/phospholipids, indicated an osmoregulatory extrarenal excretion.

Morphological appearances consequent upon histological structure permitted the glands to be classified readily into a series of stages according to weight. A concise histological basis for differentiation was provided by the secretory tubule lumena. Glands were grouped into three stages depending on whether the majority of lumen diameters were <1 mm. throughout their length (stage I, <165 mg. combined weight), <1 mm. in the distal portions only (stage II, 165-315 mg. combined weight), or >1 mm. throughout (stage III, >315 mg. combined weight).

Nasal gland stages II and III became predominant with increasing salinity of habitat (Table II). Moreover, enlarged nasal glands coincided with periods of saltwater utilization; relatively few birds had large nasal glands in years of widespread flooding, as in 1968. Most birds with stage I nasal glands had gizzard contents comprising only freshwater foods (20 out of 33 gizzards examined); birds with stage II glands mostly had a combination of freshwater and saltwater foods (21/30); and birds with stage III glands had saltwater foods dominating (18/19).

Table II. Frequency of occurrence of nasal gland stages in Grey Teal collected in north Queensland study areas, 1965-1967 (after Lavery 1972c)

Study area	*No. of birds in sample*	*Nasal gland stage* I	*II*	*III*
Charters Towers	28	24	4	—
Ross River Plains	45	31	11	3
Cleveland Bay				
Lower Ross River (estuarine)	28	1	14	13
Cleveland Bay (marine)	37	—	14	23

The function of the nasal glands was tested by injecting saline solutions intraperitoneally, equivalent to amounts ingested with foods during the initial periods at saltwater habitat. Administrations of greater loadings were impracticable. The nasal glands enlarged with time, without concomitant decline in condition of the birds (Table III). After injecting a solution of 867 milli-equivalents per litre of sodium ion and 850 mEq./l. of chlorine ion, nasal gland excretion, collected at the external nares, had a mean concentration of 685 mEq./l. sodium ion and 666 mEq./l. chlorine ion, the concentrated sodium and chlorine balance appropriate to excessive sodium chloride, the major component of local saltwaters. Salts were also removed in lesser amounts in faecal material and urine, by evaporation from the general body surface, and by tears which left crystalline deposits around the eyes.

Table III. Distribution of nasal gland stages and other effects of salt loadings in Grey Teal (after Lavery 1972c).

Treatment	*Period (weeks)*	*No. of birds examined*	*Occurrence of nasal excretion daily*	*Nasal gland stage I*	*II*
Nil	0	4	—	4	—
1 × 10 ml. 5%-6% NaCl soln.	1	6	+	6	—
1 × 10 ml. 5%-6% NaCl soln.	2	6	+	4	2
1 × 10 ml. 5%-6% NaCl soln.	3	7	+	5	2
1 × 10 ml. 5%-6% NaCl soln.	4	5	+	1	4
1 × 10 ml. 5%-6% NaCl soln.	5	3	+	—	3
2 × 10 ml. 5%-6% NaCl soln.	5	3	+	—	3
1 × 10 ml. distilled water	5	2	—	2	—

Administration of magnesium chloride solution equivalent in concentration to that in local seawaters also produced a nasal excretion.

Allowing for the rate of development of nasal glands, there was a noticeable rise in concentrating abilities with increase in size.

The nasal glands of Plumed Whistling Ducks *Dendrocygna eytoni*, tested similarly and concurrently, also became progressively larger with time and with increased salinity of injected solutions. Body weight changes during treatment were similar to Grey Teal although recovery to normal weights following initial exposure was slower. Concentrations of sodium chloride in the nasal excretions in all instances increased with nasal gland enlargement. Differences from Grey Teal included (i) an insignificant increase in overall electrolyte discharge with progressive exposure, and (ii) a low ultimate level of concentration, reached earlier and covering a smaller range. It is perhaps relevant that waterfowl species that occasionally ingest saltwater foods, such as Black Ducks *Anas superciliosa rogersi*, have glands larger than freshwater species such as the Plumed Whistling Duck but smaller than the Grey Teal. The relative nasal gland size in Grey Teal was closer to that of species sharing links in ecology rather than taxonomy. Table IV compares the foregoing with Maned Goose *Chenonetta jubata*, Lesser Crested Tern *Sterna bengalensis* and Silver Gull *Larus novaehollandiae*.

Moulting

The ability to move to the marine environment, to and from freshwaters for drinking purposes, and eventually from saline areas for breeding is lacking for a part of each year in Anatini. The timing of the wing-moult is therefore important in the present context.

Captive and wild-caught Grey Teal shed and replace feathers within typical tracts during a postnatal, a postjuvenile and an immature moult, each readily distinguishable in young birds. The adult postnuptial and prenuptial moults, distinguishable only by moult of the flight feathers in the former, are usually repeated annually.

The moults of young birds were linked to their breeding seasons by development, and the flightless period was consistently late relative to the moult of other tracts. Immatures generally were not flightless at the same time as adults (Figure 4). Often the postjuvenile and immature

Table IV. Weights of nasal glands in Grey Teal and some commonly associated species (after Lavery 1972c).

	Cleveland Bay Study Area		*Charters Towers Study Area*	
Species	*No of birds examined*	*Mean relative weight (±S.E.) of combined nasal glands (mg./100 gm. body weight)*	*No of birds examined*	*Mean relative weight (±S.E.) of combined nasal glands (mg./100 gm. body weight)*
Grey Teal	32	89.7 ± 2.06	42	26.6 ± 0.58
Black Duck	2	25.6 (23.0-28.2)	12	18.0 ± 2.69
Maned Goose	5	15.0 (11.4-17.4)	10	16.6 ± 1.18
Plumed Whistling Duck	2	6.3 (5.0-7.6)	17	10.8 ± 0.55
Lesser Crested Tern	15	77.9 ± 3.32	—	—
Silver Gull	41	89.8 ± 2.96	—	—

moults took place at freshwater localities distant from the breeding grounds.

In the adult, replacement of all body feathers was prolonged and variable within and among tracts. Moulting was broadly continuous, occurring at all freshwater and saline habitat types.

Timing of the adult moults, as judged by the commencement of flightlessness, was no more regular than breeding, with which the postnuptial moult clearly was associated (Figure 4). No specific external factor initiated either general body or flight feather moulting, widespread at the same time in other waterbirds. No related loss of weight took place in adults during the protracted body moult; some loss of condition occurred during flightlessness but this was quickly regained.

Adults were flightless during the postnuptial moult for about three weeks (20 ± 4.3 days in 11 captive birds). The period varied, individually, in relation to other feather tracts (Table V), and in time of year. Both isolated birds and flocks moulted at freshwater habitat after the nesting season, the sexes remaining together. An extended breeding season, due to prolongation of the rains, as in 1968, led to postponement of the flightless period (Figure 4).

Adult Grey Teal thus have a highly flexible moult, particularly with regard to flightlessness. It follows that during years of relatively low rainfall when breeding is unsuccessful and saltwater habitat is used extensively, as in 1961, flightlessness can be postponed. This permits continued mobility at the rapidly diminishing freshwaters, and at saltwaters, and avoids

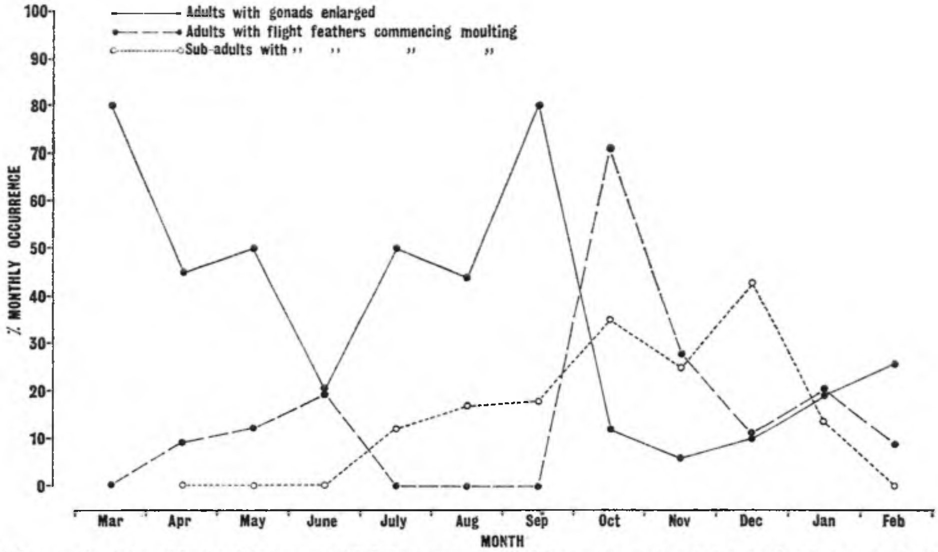

Figure 4. Monthly incidence of flightlessness in wild-caught sub-adults and adults, and of breeding in wild-caught adult Grey Teal collected in north Queensland, 1968-1969 (after Lavery 1972a).

Table V. Relative occurrences of synthesis of remiges in captive adult Grey Teal (after Lavery 1972a).

	Remiges commenced moulting (X)		*Remiges completed moulting (X)*	
Tract	*Before commencement of tract*	*After commencement of tract*	*Before commencement of tract*	*After commencement of tract*
Breast	X	X	X	X
Lower tail-coverts		X	X	X
Crown	X	X	X	X
Nape	X	X	X	X
Scapulars		X	X	
Tertials	X	X	X	X
Alula	X			X
Upper wing-coverts	X	X	X	X
Lower wing-coverts	X	X	X	X

additional loss of condition. The feathers of some birds during such periods are extremely worn.

Discussion

In north Queensland the Grey Teal characteristically used abundant foods available from saltwater habitat during the regular long periods when freshwater habitat was impoverished. Possibly all birds of each local population were involved and 80% of the diet was of marine origin during drought. The extent of dependence could not be fully assessed because of the birds seemingly erratic visits to freshwaters for drinking, when the quality of the atypical foods ingested with this water was unknown.

As birds moved farther from freshwater habitat, the opportunity to rejoin the populations remaining there declined. This was particularly so because the latter were continually on the move and because the saltwater birds flew in to drink water during those hours when freshwater birds were moving.

There was sufficient range and overlap in the times of availability of major food species to allow for the variation in birds habits based on the small annual differences in the pattern of rainfall in north Queensland. The use of saltwaters became less valuable the farther a bird moved from its breeding ground. For nomadic populations from southern Australia, there was little opportunity to synchronise their movements with the availability of those foods that facilitated the gradual process of acclimatization to saltwater habitat—particularly the enlargement of nasal glands to counter the excessive body salt loadings.

The general improvement in condition of birds during the period when saline drought-refuges were sought and occupied was in accordance with their limited activity, the continued occurrence of a suitable quantity and quality of food, and the absence of deleterious factors. This circumstantial evidence of good survival must be advanced because dead birds could not be located and because of the practical difficulties in banding.

Sex and age ratios stabilised at saltwaters following the decline from a high proportion of immatures in adjacent freshwater flocks. These latter birds did not possess enlarged nasal glands, indicating an avoidance of saline habitat, to be expected of freshwater-drinking birds about to become flightless.

The young from parents that bred sufficiently early in the year to allow their maturation could follow the sequence of foods leading to the marine environment, and had an advantage over later-bred birds. Birds that bred near to, although not necessarily beside, the saltwaters would thus be the most successful.

Because the Grey Teal is a highly fecund species, survival during the period at the saline drought-refuge implies mortality elsewhere, the local population remaining reasonably stable. The late immatures, accompanied by some parents, could be forced to move widely as nomadic flocks in search of freshwaters at which to moult, with small chance of survival (see also Frith 1963). The greatest mortality amongst the remainder may be due to starvation of birds at recently inundated freshwater habitat while returning to inland breeding grounds. Similar seasonal mortality has been described by Ward (1965) for the African passerine *Quelea quelea*.

It is important to relate the peculiar habits of the Grey Teal in north Queensland to general waterfowl conservation practices, which notably provide only protected freshwater habitat. The species is physiologically equipped to utilise a permanent over-abundance of marine food, so long as fresh water is near for drinking. Provision of sufficient freshwater localities along a coastal region could encourage a local saline drought-refuge population, although probably at the expense of adjacent districts; 16 of the 22 permanent freshwater localities nearest to Cleveland Bay were artificially constructed for other purposes. Provision of foods at these either by natural growth or artificial production is clearly unnecessary. The emission of fresh water into the sea, as at sewage outlets, is beneficial to Grey Teal, particularly in view of the relative impermanence of other artificial wetlands. (Lavery and Blackman 1971).

It is unnecessary to protect drinking localities against shooting because of the irregular nocturnal habits of the birds and the present low hunting pressure. Some additional pressure would not be harmful because the loosely-bound flocks can retreat out of reach to the sea. However, too severe exploitation could permanently affect a wide-ranging population limited by a sequence of food sources leading and conditioning birds from freshwaters to the sea after rapid breeding and moulting.

The physiological adaptation displayed by Grey Teal during periods of drought does not require the additional complex behavioural adaptations of species such as the Plumed Whistling Duck which survive dry seasons by becoming gregarious upland grazers while remaining at freshwater habitat. Management effort should be concentrated on these species.

Acknowledgements
Studies referred to in this paper were conducted in part within the School of Biological Sciences, James Cook University of North Queensland.

Summary
Investigations were made of Grey Teal *Anas gibberifrons gracilis* in north Queensland, particularly at saltwater habitat during 1965-1969.

Non-breeding, mainly adult birds utilised saline areas during the annual dry seasons especially in droughts. The sequence of diet imposed by availability and by the birds physiological capabilities, was from brackish-water plant seeds in saltpans, to marine molluscs along open bays. Foods at the ultimate drought-refuge, mostly bivalve molluscs, were of sufficient quantity and quality to bring all birds into extremely good condition. Contact was maintained with freshwater habitat for drinking.

Departure from saltwaters was initiated by males after the wet season rainfall; a less strict sequence of decreasingly saline localities was quickly visited during the return to the breeding grounds while gonads of females became active. A preference for freshwater foods, coupled with breeding requirements, enforced departure despite the suitable food supplies still at saltwaters.

Use of saline areas for foods resulted in increased ingestion of salts. Functional supraorbital nasal glands provided the chief means of maintaining ionic balance; this physiological adaptation by Grey Teal is modest compared with the complex behavioural changes required of other local waterfowl.

The use of saltwater habitat with freshwater contact was facilitated in adults by an adjustable flightless period during the postnuptial moult; the disadvantages of lessened mobility and condition were thus delayed when necessary. Flightlessness during the immature moult was stereotyped and the advantage clearly lay with early-bred birds.

The majority of the population of Grey Teal in the region remained in good condition during drought. Mortality of such a highly fecund species was apportioned to late-bred immatures incapable of using saltwater habitat, and to birds returning to breeding grounds over drought-recovering countryside.

In north Queensland the general management techniques currently practised during drought to protect waterfowl are adequate for the Grey Teal population; the peculiar habits of this species confer additional insurance against the effects of an essentially arid environment.

References

FRITH, H. J. 1963. Movements and mortality rates of the black duck and grey teal in south-eastern Australia. *C.S.I.R.O. Wildl. Res.* 8 : 119-31.

GIBB, J. 1956. Food, feeding habits and territory of the Rock Pipit *Anthus spinoletta. Ibis* 98 : 506-30.

HINDE, R. A. 1961. Behaviour. Pages 373-411 in *Biology and Comparative Physiology of Birds.* Vol. II. Ed. A. J. Marshall. London: Academic Press.

LAVERY, H. J. 1970a. Studies of waterfowl (Anatidae) in north Queensland. 4. Movements. *Qd J. agric. Anim. Sci.* 27 : 411-24.

LAVERY, H. J. 1970b. The comparative ecology of waterfowl in north Queensland. *Wildfowl* 21 : 69-77.

LAVERY, H. J. 1971. *Wild Ducks and Other Waterfowl in Queensland.* Brisbane: Department of Primary Industries.

LAVERY, H. J. 1972a. Studies of waterfowl (Anatidae) in north Queensland. 8. Moults of the grey teal (*Anas gibberifrons gracilis* Buller). *Qd J. agric. Anim. Sci* 29 (in press).

LAVERY, H. J. 1972b. Studies of waterfowl (Anatidae) in north Queensland. 9. Grey teal (*Anas gibberifrons gracilis* Buller) at saltwater habitat. *Qd J. agric. Anim. Sci.* 29 (in press).

LAVERY, H. J. 1972c. Studies of waterfowl (Anatidae) in north Queensland. 10. Nasal glands in grey teal (*Anas gibberifrons gracilis* Buller). *Qd J. agric. Anim. Sci.* 29 (in press).

LAVERY, H. J. and J. G. BLACKMAN. 1971. Studies of waterfowl (Anatidae) in north Queensland. 7. Long-term changes in habitat. *Qd J. agric. Anim. Sci.* 28: 275-80.

MARPLES, B. J. 1932. Structure and development of the nasal glands of birds. *Proc. Zool. Soc. Lond.* 4 : 829-44.

MCCABE, T. T. 1943. An aspect of the collector's technique. *Auk* 60 : 550-8.

WARD, P. 1965. Feeding ecology of the black-faced dioch *Quelea quelea* in Nigeria. *Ibis* 107 : 173-214.

Dr. H. J. Lavery, Department of Primary Industries, Animal Health Station, P.O. Box 1085, Townsville, Queensland 4810, Australia.