QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES
FAUNA CONSERVATION BRANCH BULLETIN No. 5

STUDIES OF WATERFOWL (ANATIDAE) IN NORTH QUEENSLAND
8. MOULTS OF THE GREY TEAL (ANAS GIBBERIFRONS GRACILIS BULLER)

By H. J. LAVERY, M.Sc., Ph.D.

SUMMARY

The moults of the grey teal (*Anas gibberifrons gracilis* Buller) have been investigated in captivity and in a field population, with similar results.

In north Queensland there was a postnatal, a postjuvenile and an immature moult in each young bird, and a postnuptial and a prenuptial moult in each adult bird in 1968, a year of heavy rainfall and subsequent flooding, and in 1969, a year of average rainfall.

The moults of growing birds were related to age.

Timing of adult moults, on the other hand, was correlated with climatic conditions and this was particularly apparent for the 3-week period of flightlessness of the postnuptial moult. During 1968, with breeding conditions atypically extended, loss of mobility and condition were postponed compared with 1969. Earlier observations indicate this adaptability by adults of both sexes to be of greater importance in delaying effects caused when dry seasons are prolonged into droughts, such as in 1961.

I. INTRODUCTION

Observations made chiefly during 1968–1969 of the process and timing of moulting in the grey teal (*Anas gibberifrons gracilis* Buller), a common resident species in north Queensland, are presented.

II. MATERIALS AND METHODS

(a) Field Studies

Study areas.—Four study areas, in and adjacent to the Townsville Study Region (Lavery 1966), were used. The Charters Towers Study Area was a 1,500 square mile district inland from the Great Dividing Range to include freshwater swamps and lagoons, most of which were artificially constructed (e.g. "Victoria Downs HS Dams"). The Lake Buchanan Study Area, of 700 square miles adjacent to the south of the previous study area, comprised mainly the Lake Buchanan saltpan with some extensive inland freshwater habitat, notably "Cauckingburra Swamps". The Ross River Plains Study Area, of approximately 600 square miles from the Black River southwards to the Haughton River, and to the north of the first study area, consisted of a variety of coastal freshwater habitat types. The Cleveland Bay Study Area adjacent to this along some 35 miles of coastline consisted of the widespread saline habitat types of saltpans, tidal flats and bays.

Freshwaters in the first two study areas were typical breeding habitat, freshwaters in the Ross River Plains Study Area were typical nomadic

habitat, and saline areas, particularly where these were the more permanent types, in the Cleveland Bay Study Area were the typical drought-refuge of the grey teal in north Queensland (Lavery 1970*a*).

Collecting.—Random collections, by shooting, were attempted at the Charters Towers, Ross River Plains and Cleveland Bay Study Areas each month that birds were present in these from March 1968 to March 1969. Few birds were collected from the second study area and none was from large nomadic flocks, which were absent during the study period. Birds were collected in the Lake Buchanan Study Area during October and November 1968, following wet-season flood rains for the first time in 8 years, with subsequent breeding and drought-refuge.

Apteria and pterylae, defined by examining mostly the undersurfaces of skins of flightless young birds, and occurrences of moulting, detected by scrutiny of the major tracts of each body to note any feather loss and renewal, were observed in 316 individuals (113 adults, 184 fledged young (immatures) and 19 flightless young). Tracts observed were classified as ventral (all ventral plumage except that on the flanks, chin and lower tail-coverts), caudal (retrices, upper and lower tail-coverts and feathers encircling the anus), head (throat, ear-coverts, face, crown and forehead), dorsal (nape, mantle and rump), shoulder (scapular and axillary feathers), and alar (remiges, tertials, upper and lower greater-, median- and lesser-coverts, and alula); no measurement was made of the small thigh and crural tracts.

The names of the types of moult follow Amadon (1966).

A numerical scoring system after the method developed progressively by Miller (1961), Ashmole (1962) and Newton (1966) was used to measure the extent of moult in remiges as follows. Each primary and secondary feather of each wing was allocated a score from 0 to 5 according to its state of growth. Thus 0 represented an old feather; 1, feather missing or in small pin stage; 2, large pin or brush feather; 3, brush to half-grown feather; 4, half- to three-quarters grown feather; 5, three-quarters to full length new feather. The primary feathers were considered from the innermost outwards to the remicle; secondaries were considered from the outermost inwards.

All observations of moult were accompanied by measurements of weight and by notes on the broad social organization of the flock from which the specimen had been taken.

Conclusions were supported by data from field observations and samples of the species taken for other purposes in these study areas during the period 1958-1970.

(b) Studies of Captive Animals

Captive birds, originally secured as adults and immatures from the Ross River Plains Study Area in 1964-1965, were maintained in covered aviaries at the Department of Primary Industries' Animal Health Station, Townsville. Food supplied included standard commercial poultry laying pellets and mash. Repeated observations (mean 15 times per bird, at least once per month from March 1968 to March 1969) were made of moulting in 58 adult birds (25 males, 33 females). The sequence of moulting of the feather tracts was defined after determining the duration of each moult type; the extent of the postnuptial moult was estimated from the monthly period when fewest tracts were moulting either side of the time of flightlessness, and this was cross-checked against the period between moult of the same tail feather. The extents of moult of the remiges, and weight of each bird, were measured as in wild-caught individuals.

TABLE 1

LENGTHS OF REMIGES IN 10 WILD-CAUGHT ADULT GREY TEAL IN NORTH QUEENSLAND

Length (mm)	Feather Number										
	Primaries—	11	10	9	8	7	6	5	4	3	2	1
Mean		23·1	124·6	128·3	129·6	126·6	122·0	115·4	107·9	100·6	93·4	86·6
Standard deviation ..		2·33	4·37	7·13	6·55	5·62	5·58	4·09	4·63	3·63	3·72	3·47
	Secondaries—	1	2	3	4	6	7	8	9	10	11	12
Mean		83·5	86·6	86·5	85·8	83·2	82·3	82·1	82·8	83·2	85·8	91·4
Standard deviation ..		4·67	4·60	4·84	4·05	4·13	4·19	4·84	4·37	4·08	4·78	3·20

III. RESULTS

Pterylae and apteria.—The distribution of feather tracts was as described for the genus *Anas* L. by Nitzsch (1867), and of apteria was as described for the mallard (*Anas platyrhynchos* L.) by Humphrey and Clark (1961).

Remiges and retrices.—There were 11 primary and 11 secondary wing feathers, with a conspicuous gap between secondaries 4 and 6 illustrating the typical diastataxic condition of Anatidae (see Gadow 1891). The lengths of remiges are illustrated in Table 1.

TABLE 2

SEASONAL INCIDENCES OF REPLACEMENT DUE TO OCCASIONAL LOSSES OF REMIGES IN ADULT GREY TEAL IN NORTH QUEENSLAND, 1968–1969

Period	Captive Birds		Wild-caught Birds	
	No. Examined	No. with Occasional Remiges Lost	No. Examined	No. with Occasional Remiges Lost
Dry season—				
March–June	214	11	39	9
July–August	107	6	10	1
September–December ..	212	23	26	10
Wet season—				
January–February	106	5	38	15

TABLE 3

MONTHLY OCCURRENCES OF REPLACEMENT OF REMIGES DURING THE POSTNUPTIAL MOULT OF GREY TEAL IN NORTH QUEENSLAND, 1968–1969

Month	No. of Birds with Remiges Commencing Moulting	
	Captive Birds	Wild-caught Birds
March, 1968	1	1
April	3	1
May	Nil	Nil
June	Nil	2
July	Nil	Nil
August	4	Nil
September	6	Nil
October	4	30
November	Nil	5
December	Nil	1
January, 1969	2	2
February	2	2

The caudal tract included 11 retrices in 87·5% of 267 adult and sub-adult birds examined, 14 retrices in 10·9%, 15 retrices in 0·8% and 12 and 18 retrices each in 0·4% of this sample.

Occasional loss of feathers.—The occasional, including accidental, loss of one feather or patch of feathers was distinguished by isolated and asymmetrical occurrence (except in retrices, which usually moulted irregularly without preventing

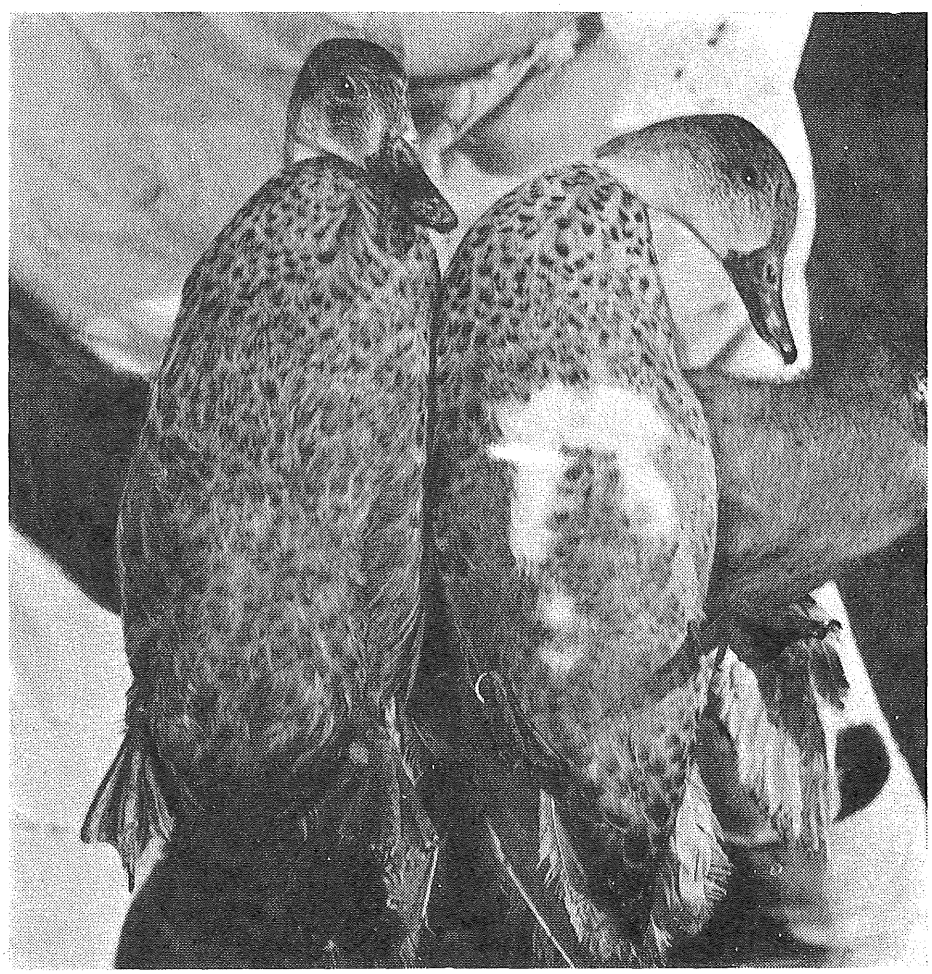

Fig. 1.—Adult grey teal showing lack of pigmentation in some abdominal feathers (right) compared with normal appearance: the same pattern persisted through at least four moults.

flight). These losses were most noticeable in the remiges, where seasonal incidences (Table 2) indicated some relationship of losses with the postnuptial moult (see also Table 3), perhaps abortive attempts to commence this.

Superficial variations in plumage appearance, also disregarded subsequently in this study, were caused by abrasion, especially of barbs at vane margins of feathers exposed to wearing (e.g. on breast and abdomen) and by staining (Lavery 1962); lack of pigmentation, although permanent (Figure 1), was less common.

Types of moult.—Five types of moult occurred: postnatal moult, in which down of all tracts of the flightless young was replaced by contour feathers differing in colour-pattern from those of sub-adult and adult birds, especially on the breast; postjuvenile moult, in which these pale-coloured contour feathers, except on the wings, were shed and were replaced by dark-coloured feathers; immature moult, in which the feathers of all tracts were replaced by plumage of sub-adult/adult pattern; postnuptial moult, in which all feathers of adults were replaced; and prenuptial moult, in which all feathers of adults, except remiges, were replaced again by similar-looking feathers.

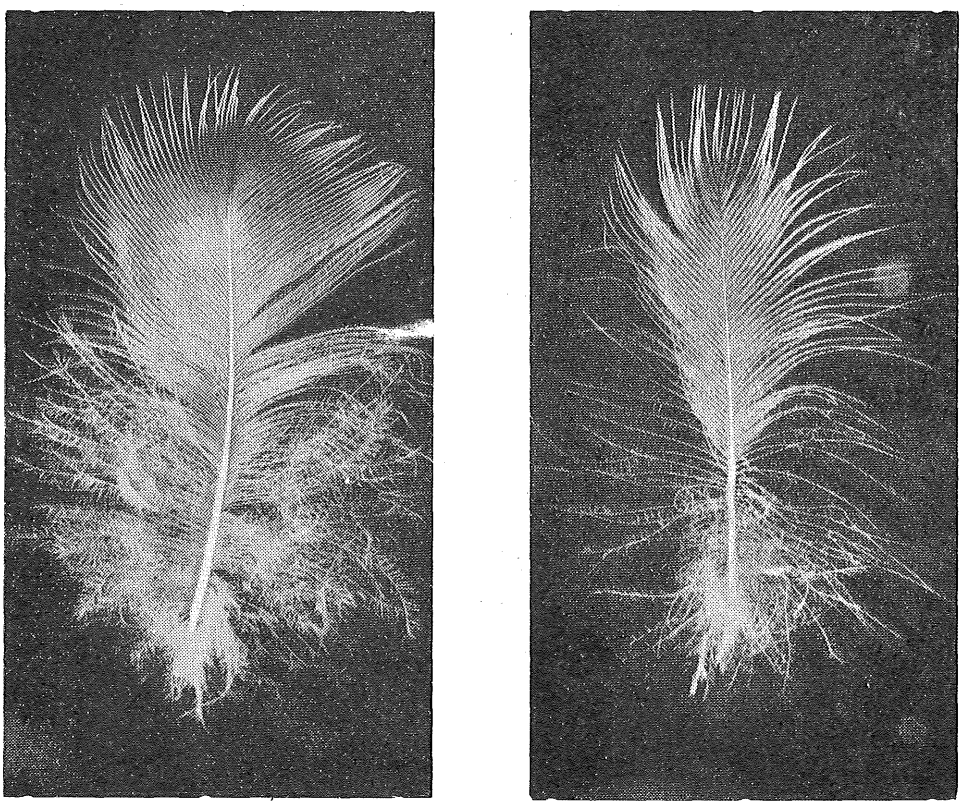

Fig. 2.—Typical grey teal breast feathers showing pattern of dark colouration in immature, postnuptial and prenuptial plumages (left), and in postnatal and postjuvenile plumages (right); the last differs from the postnatal form in having the narrow pattern as dark as older stages.

Postnatal and postjuvenile plumages were readily recognizable by feather colour-patterns (Figure 2). Occurrence of the immature plumage stage required examination for the presence of a bursa of Fabricius. Determination of the adult moult type required observation of moult in the remiges. No eclipse plumage was detectable.

Sequence, duration and timing of moulting.—Postnatal moult: contour feathers appeared predominantly in the tract sequence caudal, shoulder, ventral, alar, head, dorsal, and were mostly completely formed in the sequence ventral, head, caudal, alar, shoulder, dorsal (Table 4); moulting took place during 3–10 weeks of age.

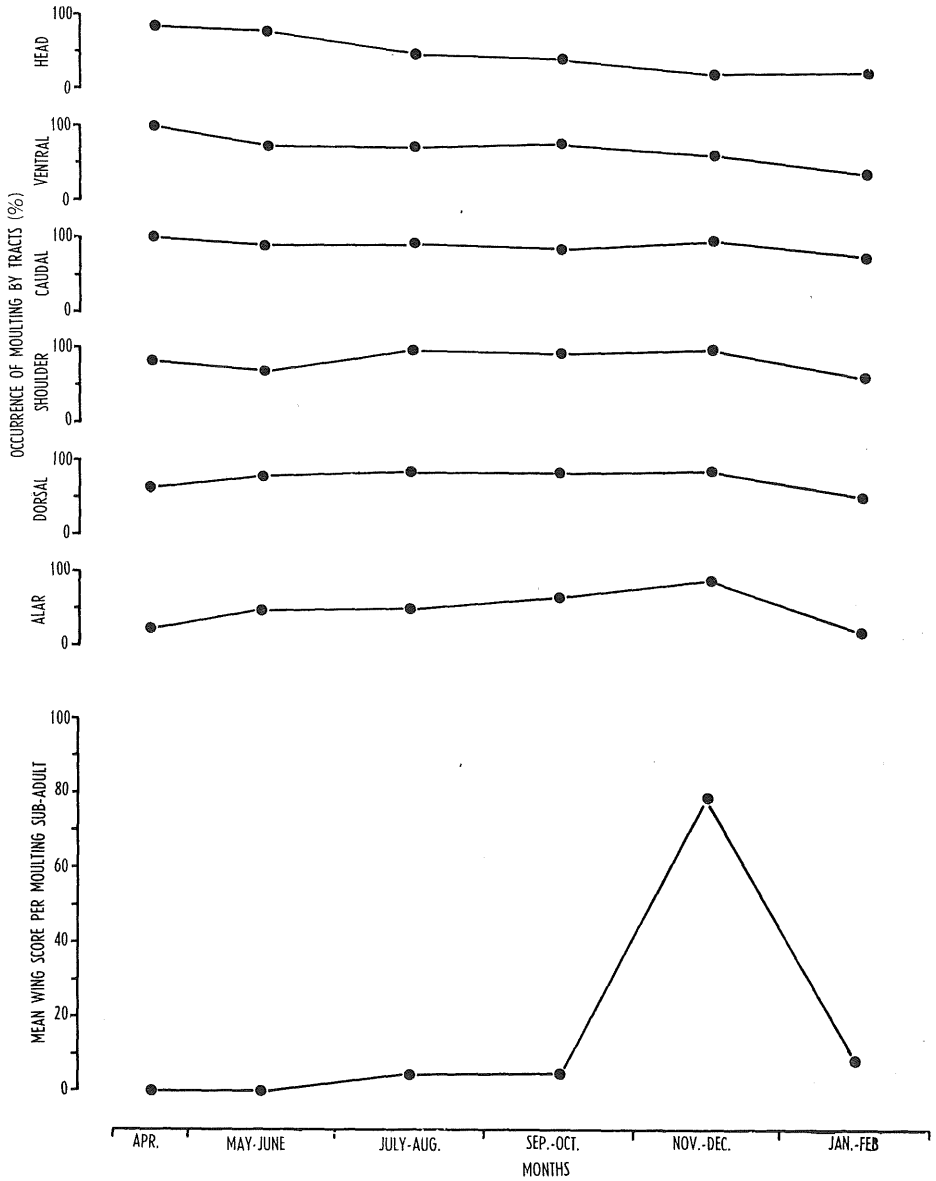

Fig. 3.—Sequence and timing of immature moult, including flightlessness, in wild-caught grey teal in north Queensland, 1968–1969.

TABLE 4

SEQUENCE OF FEATHER TRACT MOULTING DURING POSTNATAL MOULT FROM WILD-CAUGHT GREY TEAL IN NORTH QUEENSLAND

Age Class	Weight (g)	Feather Tract Moulting (x)						Wing Score
		Caudal	Shoulder	Ventral	Alar	Head	Dorsal	
Downy duckling	28	o	o	o	o	o	o	Nil
Downy-flapper duckling	141	x	x	x	o	o	o	Nil
Downy-flapper duckling	185	x	x	x	x	o	o	24
Flapper duckling	229	x	x	x	x	x	x	78
Flapper duckling	290	x	x	o	x	x	x	142
Flapper duckling	317	o	x	o	x	o	x	178

Postjuvenile moult: Moulting of feather tracts overlapped considerably and varied in sequence, most frequently fitting the order head, ventral, dorsal, caudal, shoulder; occurrence was during approximately 10 weeks to 6 months of age.

Postnatal and postjuvenile moults occurred at inland freshwater habitat in connection with breeding season (see Lavery 1970*b*).

Immature moult: The sequence and timing of this moult, including the period of flightlessness, in wild sub-adult birds collected in all study areas during 1968-1969 are illustrated in Figure 3. Occurrence was recorded only at freshwater habitat during 6–12 months of age.

Adult moults: Figure 4 shows monthly occurrence during 1968-1969 of primary and secondary wing feather moulting in captive birds relative to periods of least moult of all tracts before and after this. There usually was considerable overlapping of these two types of moult, producing an apparently continuous state of moult amongst and within individuals (Table 5). Figure 5 gives a more precise determination of the occurrence and duration of the postnuptial moult, and sequence of tract moulting, from individual captive birds.

TABLE 5

MONTHLY OCCURRENCES OF MOULTING IN CAPTIVE AND WILD-CAUGHT ADULT GREY TEAL IN NORTH QUEENSLAND, 1968–1969

Month	Captive Birds		Wild-caught Birds	
	No. Examined	No. in Postnuptial or Prenuptial Moult	No. Examined	No. in Postnuptial or Prenuptial Moult
March, 1968	52	51	10	9
April	55	54	11	11
May	50	49	8	8
June	53	50	10	10
July	54	54	2	2
August	54	52	9	8
September	54	54	5	5
October	54	54	22	21
November	51	51	38	37
December	50	48	9	8
January, 1969	50	50	15	15
February	51	51	23	21

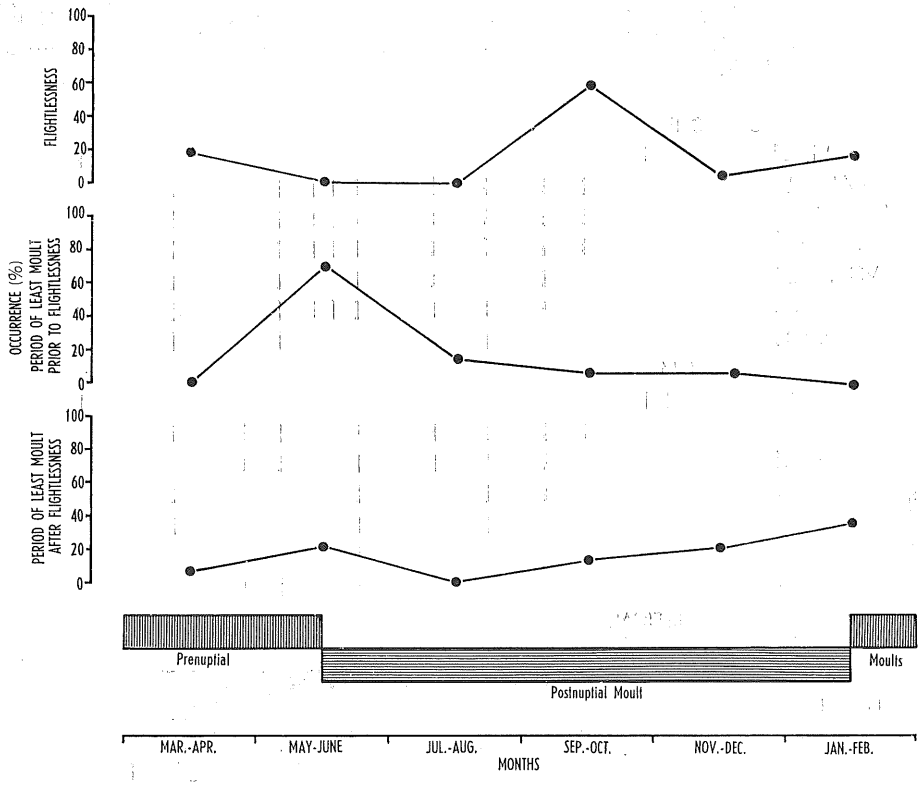

Fig. 4.—Seasonal incidences of flightlessness, periods of least moult prior to this and after this, and consequent estimation of durations of postnuptial and prenuptial moults, in captive grey teal in north Queensland, 1968–1969.

Both general adult body feather moults occurred at all habitat types in all localities.

The remiges were normally the only feathers that, when moulting, prevented flight for a time. The sequence of moulting in these feathers, observed completely in three captive birds, was secondaries commencing first and in the order 12 to 1, and primaries commencing shortly after the start of moulting in secondaries and proceeding in the order 11 to 1. Development of feathers was usually symmetrical and was constant regardless of size of the feather: thus 25 of 31 moulting adult grey teal collected in the two inland study areas during 1968 had primaries symmetrically moulting, with the same score for each wing of an individual.

Flightlessness commenced at score 44 (i.e. score of 1 per feather (nearest score in cage observation 47 and in the wild 42)), and concluded at score 198 (i.e. score of 4·5 per feather (range of scores in cage observations 192 (incapable of flight) to 204 (capable of flight) and in the wild 198 (just capable of flight)). The period of flightlessness in 11 captive birds ranged from 13 to 27 days (mean $\pm$ S.D. $=$ 20 $\pm$ 4·3 days). The rate of growth of remiges during flightlessness also varied within individual captive birds (Table 6). The occurrence of flight-

lessness compared with the postnuptial moult of other tracts was highly variable (Table 7), unlike the relatively fixed late timing of the moult of immature remiges (Figures 3 and 6).

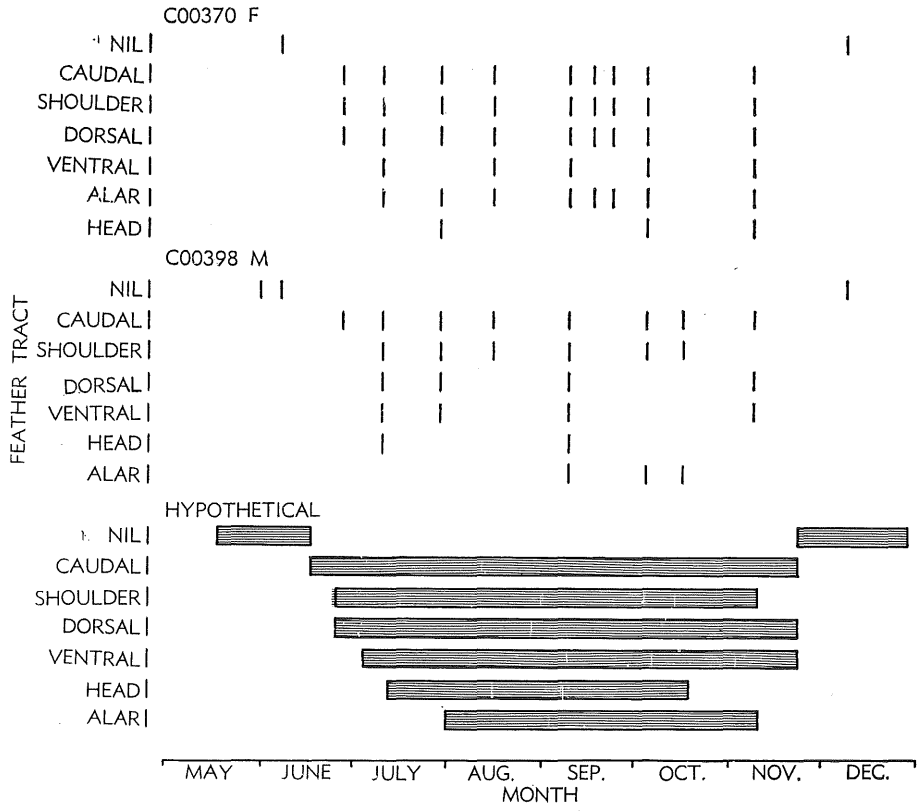

Fig. 5.—Occurrence of the postnuptial moult in major feather tracts of representative captive individuals, and consequent estimation of sequence and duration of this moult, in grey teal in north Queensland, 1968–1969.

TABLE 6

RATES OF SYNTHESIS OF REMIGES IN SOME CAPTIVE ADULT GREY TEAL IN NORTH QUEENSLAND, 1968–1969

Specimen No.	Date of Examination	Score	Rate of Increase in Wing Score in Points per Day
COO352♂	9.ix.68	77	
	17.ix.68	169	11·50 (8 days)
	23.ix.68	214	7·50 (6 days)
COO385♀	17.ix.68	47	
	23.ix.68	92	7·50 (6 days)
	4. x.68	214	11·09 (11 days)
COO503♂	30.iv.68	52	
	9. v.68	129	8·56 (9 days)
	16. v.68	176	6·71 (7 days)
	23. v.68	204	4·00 (7 days)

TABLE 7

RELATIVE OCCURRENCES OF SYNTHESIS OF REMIGES IN CAPTIVE ADULT GREY TEAL IN NORTH QUEENSLAND, 1968–1969

Tract	Remiges Commenced Moulting (x)		Remiges Completed Moulting (x)	
	Before Commencement of Tract	After Commencement of Tract	Before Commencement of Tract	After Commencement of Tract
Ventral				
e.g. Breast	x	x	x	x
Caudal				
e.g. Lower tail-coverts ..	o	x	x	x
Head				
e.g. Crown	x	x	x	x
Dorsal				
e.g. Nape	x	x	x	x
Shoulder				
e.g. Scapulars	o	x	x	o
Other Alar				
e.g. Tertials	x	x	x	x
Alula	x	o	o	x
Upper wing-coverts ..	x	x	x	x
Lower wing-coverts ..	x	x	x	x

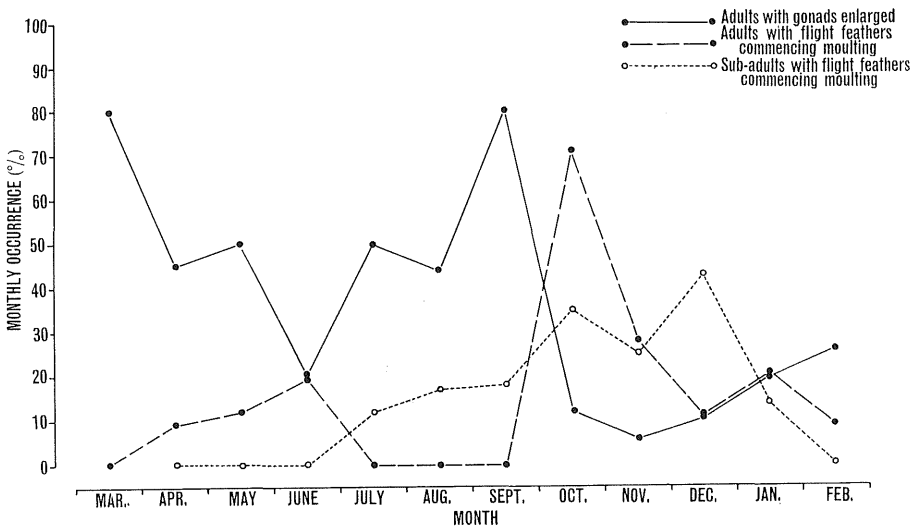

Fig. 6.—Monthly incidences of flightlessness in wild-caught sub-adults and adults, and of breeding in wild-caught adult grey teal in north Queensland, 1968–1969.

Both sexes moulted the flight feathers together and at any time of the year; e.g. 17 of 26 flightless adults collected from October 29 to November 1, 1968, were males; differences in estimated times of onset of flightlessness between males

and females of both captive and wild-caught samples such as in the above local population (mean score of remiges in males 125 and in females 92) were insignificant.

Although flightlessness in captive birds occurred slightly earlier and over a more protracted period (Table 3), as might be anticipated in unsuccessful breeders living under modified environmental conditions, there was no evidence to suggest that sequences and durations of each total adult moult varied significantly between captive and wild grey teal.

Flightlessness was found in wild adult birds only at inland freshwater habitat, either in individual birds at isolated small localities (e.g. "Victoria Downs HS Dams") or in concentrations of many hundreds of birds of both sexes (e.g. at "Cauckingburra Swamps"). Flightlessness coincided mainly with the conclusion of major breeding periods (Figure 6), and there was similar asynchronous timing of flightlessness and breeding amongst individuals (e.g. 32 adult birds collected on one day (November 1, 1968), comprising individuals in breeding and in non-breeding conditions, had wing scores ranging from 0 to 198). Examples of flightlessness more closely linked with breeding season include a parent female, plus flapper young, with wing score 3 (note simultaneous parent female, plus downy ducklings, with wing score 0).

Figure 7 illustrates changes in weights of individual captive adult grey teal undergoing moulting. Such changes were undetectable when mean weights of either wild-caught sub-adult or adult grey teal with recognizable moult types were considered (Table 8). Individual examples were noted in males, however, where there was unusually little fat deposition despite normal body-weight; loss of condition from moulting in wild-caught females was disguised by the effect of breeding.

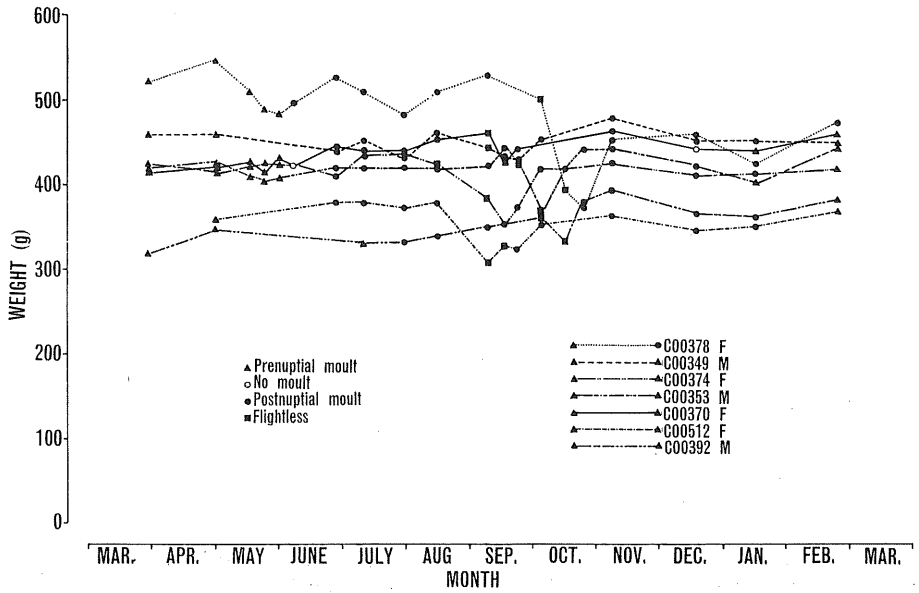

Fig. 7.—Weights of individual captive grey teal during postnuptial moulting.

TABLE 8

MEAN WEIGHTS AT DIFFERENT STAGES OF THE POSTNUPTIAL MOULT IN WILD-CAUGHT SUB-ADULT AND ADULT GREY TEAL FROM CHARTERS TOWERS AND LAKE BUCHANAN STUDY AREAS, NORTH QUEENSLAND, OCTOBER–NOVEMBER, 1968

Age Class	Plumage	Mean Weight (± S.E.) of Birds (g) (n) = No. Examined		Mean Difference in Weights at Different Periods of Moult
		During General Body Moult	During Flightlessness	
Sub-adult	Immature ..	453·7 ± 14·23 (21)	423·6 ± 18·89 (5)	30·1 ± 30·85 N.S.
Adult	Postnuptial ..	490·9 ± 9·76 (32)	470·3 ± 6·99 (26)	20·7 ± 12·01 N.S.

N.S. = Not significant.

IV. DISCUSSION

The usual pattern of moulting in the grey teal in north Queensland was indicated by regular observations of captive and wild-caught birds. It consisted of the shedding and replacement of feathers within typical tracts during a post-natal, a postjuvenile and an immature moult, each readily distinguishable, in young birds, and during repetitive adult postnuptial and prenuptial moults, distinguishable only by moult of remiges in the former.

The moults of young birds were fixed in time to breeding seasons as a consequence of growth development (see e.g. Table 4); the flightless period of the immature moult, for instance, was constant in its occurrence relative to the moult of other tracts within an individual (Figure 3) and to flightlessness in other young birds (Figure 3) mostly of the same age because of limited suitable breeding opportunities each year (Lavery 1970*b*). Immature flightlessness mostly did not correspond in time with adult flightlessness (Figure 6). Often the postjuvenile and immature moults progressed at freshwater localities distant from the breeding grounds.

In the adult moults, replacement of all body feather tracts was prolonged and variable within and amongst tracts (Table 5, Figures 4, 5). Moulting was a broadly continuous procedure occurring at all freshwater and saline habitat types.

Timing of the adult moults, judged for example at commencement of flightlessness, was no more regular than breeding, with which the postnuptial moult clearly was associated (see e.g. Figure 6). No specific external element acted directly to initiate either general body or flight feather moulting, then widespread in other water-birds such as black ducks (*Anas superciliosa rogersi* Mathews), great crested grebes (*Podiceps cristatus* (L.)) and coots (*Fulica atra* L.).

No related loss of weight took place in adult birds during the protracted body moults; some loss of condition, best demonstrated by extent of fat deposition in males, occurred during flightlessness but the normal state was quickly regained (Table 8, Figure 7).

Flightlessness occurred during the postnuptial moult for approximately 3 weeks until the remiges were three-quarters grown (see Table 1); the period varied, however, in individual extent (Table 6), in onset in relation

to other feather tracts (Table 7), in seasonal occurrence (Table 3), and in annual occurrence (as examples, no individual captive bird moulted flight feathers at the same time of the year in 1968 as in 1969, and no wild bird occurred at "Cauckingburra Swamps" in October-November of most years).

Flightlessness, undertaken by isolated birds and in concentrations, took place at freshwater habitat immediately after the breeding season. The sexes did not separate after breeding (e.g. 10 out of 16 grey teal broods to flapper stage each had two adult birds present). Extension of the breeding season due to prolongation of wet-season conditions was accompanied by postponement of the flightless period (Figure 6). Adult grey teal thus have a highly flexible moulting process, particularly with regard to flightlessness.

Conclusions that follow from this include that during years of relatively low rainfall when breeding is unsuccessful, as in 1961 (Lavery 1970*b*) flightlessness at rapidly diminishing habitat could be postponed indefinitely to permit continued mobility and to avoid additional loss of condition; some birds with extremely worn feathers were observed in earlier studies. This would be a more important adaptation by the population to the north Queensland environment than the ability to postpone flightlessness to allow for prolonged breeding seasons that are almost as infrequent, are affected by regression of gonads, and are proportionately unproductive.

It follows also that the resident population of grey teal in north Queensland could have a moult schedule distinct from that of the temperate-region populations, including nomadic populations appearing in north Queensland from time to time.

REFERENCES

AMADON, D. (1966).—Avian plumages and molts. *Condor* 68:263-78.

ASHMOLE, N. P. (1962).—The black noddy *Anous tenuirostris* on Ascension Island. Part 1: General biology. *Ibis* 103b:235-73.

GADOW, H. (1891).—*"Dr. H. G. Bronn's Klassen und Ordnungen des Thier-Reichs, VI. 4. Abt. Vogel 1."* (C. F. Winter'sche Verlagshandlung:Leipzig.)

HUMPHREY, P. S., and CLARK, G. A., Jr. (1961).—Pterylosis of the mallard duck. *Condor* 63:365-85.

LAVERY, H. J. (1962).—Plumage stains on wild ducks in north Queensland. *Qd J. agric. Sci.* 19:433-4.

LAVERY, H. J. (1966).—Studies of waterfowl (Anatidae) in north Queensland. 1. Introduction, species, distribution and habitat. *Qd J. agric. Anim. Sci.* 23:573-90.

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

LAVERY, H. J. (1970*b*).—Studies of waterfowl (Anatidae) in north Queensland. 5. Breeding. *Qd J. agric. Anim. Sci.* 27:425-36.

MILLER, A. H. (1961).—Molt cycles in equatorial Andean sparrows. *Condor* 63:143-61.

NEWTON, I. (1966).—The moult of the bullfinch *Pyrrhula pyrrhula*. *Ibis* 108:41-67.

NITZSCH, C. L. (1867).—*"Nitzsch's Pterylography, Translated from the German."* (Ray Society/Hardwicke:London).

(Received for publication January 13, 1972)

The author is an officer of Fauna Conservation Branch, Queensland Department of Primary Industries, stationed at Townsville.