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ECOLOGY OF THE FRECKLED DUCK, *STICTONETTA NAEVOSA* (GOULD)

By H. J. FRITH*

[Manuscript received May 13, 1965]

Summary

The freckled duck mainly lives in the inland where its principal breeding habitat is restricted to a few relatively permanent swamps. Its breeding season is basically regular but it retains the capacity to breed out of season when extensive flooding occurs. It is to some extent nomadic but must be considered one of the more sedentary inland ducks. It is largely a filter-feeder.

It is pointed out that the freckled duck is not secure and could decline further following small changes in land-use practices in the inland.

I. INTRODUCTION

The freckled duck is widely distributed in southern Australia and in some years is not uncommon in easily accessible districts where it is regularly encountered by sportsmen. Despite this, however, there is a general lack of published information on the species and accordingly the most recent comprehensive account of the world's waterfowl (Delacour 1954-64) provides no information on its plumage changes, food, breeding, or movements. The data provided on status and distribution are misleading and the illustrations are incorrect in shape and posture.

Special interest has centred around its taxonomic position and affinities since Gould (1865) drew attention to several peculiarities. Its general appearance and shape are duck-like but it possesses a reticulate tarsus, a simple trachea without bulla (Frith 1964a), and its plumage is simple and uniform in colour, there is no speculum and no sexual dimorphism. These features all resemble those of the Anserinae but Delacour and Mayr (1941), whilst recognizing these peculiarities, tentatively placed it as an aberrant member of the Anatinae pending more information on its biology. Verheyen (1953) demonstrated several skeletal characteristics that also suggested Anserine relationships and, arguing from this, Woolfenden (1961) postulated that the bird could be included in the Dendrocygnini. Even the most cursory knowledge of the living bird, however, shows that there is little similarity between *Stictonetta* and the members of this compact group of birds.

Frith (1964a, 1964b) showed that the downy young was very similar to those of the Anserini but quite different from the Dendrocygnini, and with this evidence, as well as previously undescribed features of the trachea and behaviour, postulated that when the current behavioural study is further advanced there will be sufficient evidence to place the bird in a separate monogeneric tribe of the Anserinae.

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The bird's future in Australia is uncertain. It mainly lives and breeds in the few permanent swamps in the inland of south-east and south-west Australia; areas, most of which have been drained, are being drained, or are threatened with early development. There exists a real danger to the continuation of the bird as a reasonably common species. In the absence of biological data the several fauna authorities have been unable to formulate sensible conservation policies. New South Wales, where most of the birds breed, consider it a rare species and have afforded it legal protection from shooting. Neighbouring States, where there is less breeding but where useful drought refuges exist, have no such restriction and consider it a game species. Clearly this anomalous state of affairs calls for closer study of the species and its status.

Since 1950, the freckled duck has been periodically encountered in the field, throughout its range, during studies of other waterfowl, and the observations made are assembled in this paper to provide a brief account of what is known of its ecology.

II. METHODS

No special effort has been made to secure large or regular samples of freckled ducks but favourable opportunities to collect or to observe the birds have been exploited as they occurred during field studies of other wild ducks, mainly in inland New South Wales (Frith 1959a-1959d).

Each bird collected was measured and its gizzard contents preserved in 50% alcohol. In males the testes were removed and their volume recorded, one was preserved in Bouin's fixative and sections from it stained with haematoxylin and eosin. The other testis was preserved in formol-calcium fixative, sections were cut on the freezing microtome, stained with haematoxylin and sharlock R, and examined for lipid development. In females the diameter of the three largest oocytes and the condition of the oviduct were recorded.

As behavioural observations on the species are difficult to make in the wild the birds have now been brought into captivity. These efforts were partially successful in 1958 when a pair were held for 4 months before both were killed by misadventure. In December 1963, Mr. Reg. Taylor was able to secure five newly hatched ducklings; these were reared by Miss C. A. Nichols of the CSIRO Division of Wildlife Research, Perth, W.A., and transferred to the collection of the Division in Canberra, where four have survived to maturity. At the same time an adult pair were caught at Booligal, N.S.W., and later a further pair were caught at Lake George, N.S.W. This small captive colony is maintained on a pond $\frac{2}{3}$ ac in extent and as the birds have settled down and survived for over 1 yr, is probably secure. In the summer of 1964 the males assumed breeding plumage but breeding did not follow in that season.

III. IDENTIFICATION

It is probable that much of the uncertainty about the status of the species and the lack of data on its biology is due to difficulties in instant identification, especially when flying with other ducks. Accordingly, the freckled duck and its field marks are described here.

(i) Description

As described by Mathews (1914) the males are very dark, the ground colour of the head and neck being almost black and elsewhere very dark brown uniformly freckled with white or sometimes buff. The females are very much lighter in coloration being light brown on most of the body and moderately dark brown on the head and neck, the freckles in females are not pure white but pale buff. The sexes are easily distinguished in the hand but not in the field.

It has not been recorded that a distinct juvenile plumage exists that is easily distinguished from the adult. This plumage was complete on the captive birds when they were 9 weeks old. At 32 weeks of age they underwent a complete body moult and assumed the adult plumage. The juvenile plumage is similar to that of the adult female but is very much lighter in colour. The general ground colour of the feathers is pale brown and the freckles are deep buff.

In the breeding season the males assume a red base to the culmen. Little is known of the persistence of the red coloration or its relationship to the bird's breeding season or sexual cycle. At all seasons the location of the red area is easily recognizable as a different coloured and textured area; it is generally lighter in colour than the rest of the bill due, no doubt, to a proliferation of blood vessels beneath the surface. The captive males began to assume the red coloration at 10 months of age (August 1964). They required 3 weeks before it was fully developed and it was retained until early January 1965 (i.e. at least 5 months). Males captured in November, when egg-laying had been finished for at least 12 weeks locally, judged from the numbers of juvenile birds in the flocks, retained the red bill for a further 6 weeks in captivity. It should be reported that one male shot in October 1951, that had enlarged testes that showed clear and enlarged tubules and many mitoses in the spermatogonia but had not yet produced sperms, did not have a red bill; this specimen was exceptional (Frith, in Delacour 1954).

Table 1 summarizes the measurements of 38 freckled ducks collected mainly at Griffith and Booligal, N.S.W.

(ii) Field Recognition

The freckled duck is nearly always found in what appear to be family parties of 5–6 birds or in pairs, the observation suggesting a relatively long pair bond unlike most Anatini which pair for 1 yr only but similar to many Anserinae in which the pair bond is longer. The parties and pairs are usually associated with flocks of other species of duck and there is little or no tendency to separate from them in flight.

During late winter and spring the parties may congregate into larger groupings, with or without other waterfowl and congregations of 50 or more are quite common. Sometimes these groups may reach 200 birds and have been recorded, in an exceptionally dry year, at 500–600.

The brief account by Hall (1909) of the birds' behaviour "here we have a duck quiet, tame, and sleepy", is at variance with the author's experience and perhaps refers to birds that were aware of the observer, wary or alert, or roosting. Freckled ducks are a little less active than some species, but not excessively so. During the day

the birds are inconspicuous, moving to dense cover to roost. Captive birds, provided with living cumbungi clumps, beat down the centre of the thicket to form a substantial roosting platform. Similar behaviour has been seen with the magpie goose, *Anseranas semipalmata*, (Davies 1962) as well in several rails. In open water, when no cover is available the freckled duck has a very characteristic habit of roosting during the day on the tops of fence posts and stumps protruding a few inches from the water, one bird to each stump. They have not been seen roosting on the shore or on mudbanks with other ducks.

Roosting by day in dense cover in relatively deep water, and needing relatively shallow water for most productive feeding, at dusk the birds move to the edges of the

TABLE 1
MEASUREMENTS OF 27 ADULT MALE AND 11 ADULT FEMALE FRECKLED DUCKS

	Length (cm)	Wingspan (cm)	Wing (cm)	Bill (mm)	Tarsus (mm)	Weight (g)
Mean	56.1	81.7	<i>Male</i> 24.0	56.2	47.8	978
SD	1.6	2.6	1.0	1.3	1.2	85
Mean	50.6	76.9	<i>Female</i> 22.7	50.9	42.1	744
SD	1.4	2.7	1.1	1.2	0.9	62

swamps. In inland New South Wales in cumbungi swamps the groups fly to the edge and actively cruise inshore feeding throughout the night. In dense deep lignum swamps they commonly fly short distances across the plains to shallower pools, creeks, and channels.

The shape in flight is very characteristic but difficult to describe objectively. The wings are smaller in proportion to the body size than those of a black duck, sharper, and the neck is shorter and much thicker, and the head larger. The neck is depressed slightly in flight, giving the bird a hunched appearance. In flight, as the colour is uniform, the bird gives the impression of being much darker than it really is.

Overhead the common species are easily separated from the freckled duck by the underwing pattern. It lacks the white underwings and light throat of the black duck (*Anas superciliosa*), the apparently translucent wings of the hardhead (*Aythya australis*), and the light throat of the grey teal (*Anas gibberifrons*). It appears as a very dark bird in which the abdomen and proximal part of the wings are much lighter than the remainder of the plumage.

(iii) Development of Plumage

The downy young are uniform light grey in colour, darker above than below and quite unlike the downy young of other Anatini (Frith 1964a, 1964b). The development of the plumage, based on observations made by Miss C. A. Nichols during the early

life of the captive birds and subsequently by the author, during the first year of life are summarized in chronological order below.

Day 14.—Four central retrices appeared as quills on one young (No. 1) and papillae were noted in position for the primaries and secondaries. Two other young (Nos. 2 and 3) were found to have two papillae each for the central retrices. The other birds (Nos. 4 and 5) had no sign of feather formation.

Day 17.—Nos. 1, 2, and 3 had six retrice quills, No. 4 had four quills, No. 5 two quills. Quills in the region of the secondaries had appeared on birds 1, 2, and 3, but not on Nos. 4 and 5.

Day 18.—Nos. 1, 2, and 3 each had eight retrice quills, Nos. 4 and 5 had six. The colour pattern could be detected on the protruding feather tips. Feathers were beginning to appear on the secondary quills, but not the primaries.

Day 21.—The retrices penetrated the natal down.

Day 23.—No. 1: feathers were appearing on the flanks, scapulars, upper tail coverts, and back. There were 12 retrices. No. 2: flank and scapular quills bursting, also upper tail coverts, lower central back feathers and there were a few small feathers under the chin. There were 12 retrices. No. 3: similar to No. 2, but feathers slightly further developed. Nos. 4 and 5: these two birds were a little behind the others, feathers were fewer and there were only 10 retrices.

Day 28.—The feathers on the lower abdomen were beginning to appear under the down, cheeks were partially feathered, secondaries well developed, and primary quills were appearing through the down.

Day 32.—Breasts and abdomens almost completely feathered. The primaries were bursting from the quills but greater primary coverts and secondary coverts still in quill. Most down remaining was on the back and rump.

Day 34.—No. 1: secondary coverts well developed. Head, underneck, breast, abdomen, and flank plumage developed. Mantle feathers appearing also a small area on the back. Tail and coverts well developed. Primaries were protruding $\frac{1}{8}$ in. from quills, primary greater coverts bursting, and a few lesser covert quills showed through down. Secondaries and scapulars were well developed. Crown, nape, back, and rump were still in down. The other birds were similar and differed only in detail.

The growth of the primaries and disappearance of remaining down continued steadily until the primaries were fully developed during the ninth week of age. At this time the birds were in complete juvenile plumage. This plumage was similar in both sexes but differed from that of the adult plumage in being a much lighter brown and having much deeper buff marking.

This rate of plumage development is similar to that recorded for chestnut teal and black duck reared in captivity (Frith, unpublished data). In the chestnut teal the first body feathers appeared at 20–29 days of age, the primaries were 1 in. long at 52–65 days and fully grown at 58–80 days. In the black duck these stages were reached at 21–29, 45–65, and 54–69 days, respectively.

At 32 weeks of age the freckled ducks underwent a complete moult and assumed the adult plumage that has been described. For the first time the sexes could be distinguished.

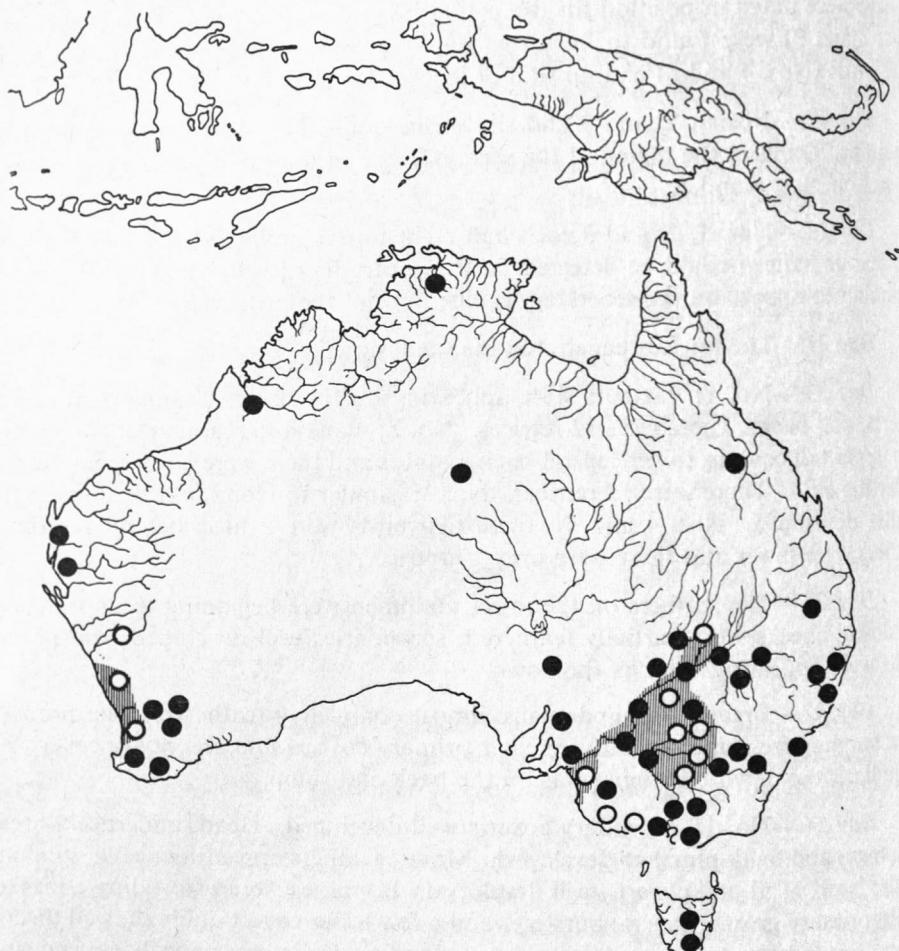


Fig. 1.—Distribution of the freckled ducks. The black spots indicate the districts in which they have been recorded and the open circles refer to breeding records; where several records occur in the same district only one is shown. The shaded area shows where the species can be found, with reasonable certainty, in suitable habitat, at all times.

IV. DISTRIBUTION AND MOVEMENTS

The range of the freckled duck, based on published and personal records, as well as specimens held in Australian museums and in the American Museum of Natural History, is shown in Figure 1.

Within this range during the breeding season it is mainly confined to swamps with dense vegetation, cumbungi (*Typha angustifolia*), lignum (*Muehlenbeckia cunninghamii*), or tea-tree (*Leptospermum* sp.). These may be either permanent swamps or

areas recently flooded. When not breeding it ranges more widely and may be found in most other inland habitats.

(i) Breeding Range

From Figure 1 it can be seen that for practical purposes the breeding range is confined to south-east Australia, particularly the Murray-Darling basin and the extreme south-west of Western Australia.

The author's main waterfowl study area is the Riverina district of New South Wales including the Murrumbidgee and Lachlan rivers from Narrandera to Balranald. The area is described and the distribution and utilization of waterfowl habitats outlined (Frith 1959a). In this region there are two places where freckled ducks may always be found and some breeding occurs in most, and probably all, years. These are Barrenbox Swamp, a large permanent cumbungi swamp near Griffith, N.S.W., and the reedbeds (also largely cumbungi) at the junction of the Lachlan and Murrumbidgee rivers. Freckled ducks are found at all times in the lignum swamps and creeks of the two rivers when these contain water but breeding only occurs there, and in box clumps on the plains, following really extensive flooding. At these times, as in 1950, 1955, and 1956, there is widespread breeding throughout the lignum areas west of Booligal and Hillston on the Lachlan River, that is in the complex of channels and swamps of Merrowie, Merungle, Merrimajeel, and Muggabah creeks and along the Willandra Billabong. There is also widespread breeding, in flood time, in the creeks and swamps south of the Murrumbidgee River.

Beyond these areas, in eastern Australia, breeding is known to occur regularly in the Macquarie Marshes, in the cumbungi swamps of the central and lower Murray River, the denser tea-tree swamps of south-east Australia near Naracoorte and Keith, and in some of the lakes of the channel country of south-west Queensland, particularly Bulloo Lake, whenever these are flooded.

There is one specimen in the Australian Museum, Sydney, of a downy duckling derived from an egg hatched under a domestic fowl at West Maitland, N.S.W. It is not known if the egg was collected locally but if so it is the only record of coastal nesting in New South Wales known to the author.

(ii) Nomadic Range

In the non-breeding season freckled ducks are quite nomadic and move erratically throughout the breeding range and beyond. At this time flocks might be encountered almost anywhere, at any time, in inland Australia. Where permanent, heavily vegetated swamps occur, small concentrations of birds develop, so that one can be reasonably certain of finding examples in the same area throughout the winter and spring. Elsewhere movements are less predictable and records refer to nomadic groups that arrive in the area, remain a few days, and then disappear.

In dry seasons movements are much more extensive, in common with most other ducks of the inland. In 1957, a year of drought (Frith 1962), it was seen that as the surface water and small swamps dried freckled ducks concentrated on the few larger, more permanent waters. One such group developed on Lake Merrimajeel where it was estimated that 200 birds were present in January 1958. This number had increased

to 600 by April 1958, they were associated with many thousands of teal and pinkeared ducks. By June 1958 they had dispersed. A similar concentration of freckled ducks was reported by Hobbs (1961) and several other smaller groups were observed, e.g. about 300 on Barrenbox Swamp near Griffith, 100 on Lake Ballyrogan, and 150 on Lake Cowal.*

Following drought-induced dispersal of concentrations quite extensive movements of freckled duck occur and it is of interest to note that most of the records of the species in places distant from the breeding range refer to years of drought. Thus, the specimen from Botany Bay near Sydney, N.S.W., (North 1914) was collected in 1889, the year following what was the greatest drought in history to that time. The next record in that area was in 1897 following the disastrous droughts of 1895 and 1896 and there were no further records until 1958 (Hindwood and McGill 1958), following the 1957 drought. Similarly the records at Ulmara, N.S.W., 1897; Armidale, N.S.W., 1892; the sole record from North-west Cape, W.A., 1884; and the records from Tasmania and from the Alligator River, N.T., in 1902, all followed years of inland drought. The record at Alice Springs (Frith, personal observation) was in 1958, another drought year.

It might be tentatively concluded that the movement pattern of the freckled duck is similar to that of the black duck in inland New South Wales, as described by Frith (1964c). That is, it is basically sedentary, normally having little need for extensive movement because of the permanent nature of its habitat. However, it possesses the ability to move to exploit newly formed habitat and to move very widely when necessary to escape prolonged drought.

V. FOOD AND FEEDING

The captive ducklings were maintained by Miss Nichols during warm days in an open-air pen with a very liquid food mixture provided in a bowl. The 2-day old ducklings were first seen feeding. The action was a filtering one with only the tip of the bill immersed and a noticeable swirl was set up. By 4 days of age they paid much attention to sprouting bird seed in the enclosure, nibbling the green shoots and were seen to occasionally nibble at the soil, presumably to secure grit. They returned to the food bowl at about half-hourly intervals to dabble about in it and feed. On the fourth day, when placed in a small pond covered with floating duck weed (*Lemna*), they fed freely on it, swam slowly and rapidly filtered the plants from the surface, occasionally the head was completely immersed. These feeding actions were continued until, at 74 days of age, in Canberra they were released into a large pen with an earth floor provided with a small running stream. The food provided in the pen was mash in a bowl, small seed on the ground, floating and in water 1-2 in. deep and floating *Lemna*. The birds forthwith abandoned the mash and from then on fed entirely by filtering seed and *Lemna* from the water's surface and from water 1-2 in. deep.

* This total of over 1600 freckled ducks in these few areas in one part of their range makes the estimate of a total Australian population of 2000-3000 birds mentioned by Weller (in Delacour 1954-64), from an unquoted source, seem a gross underestimate.

The adult captive birds, maintained on a pond $\frac{2}{3}$ ac in extent, fed in the same manner as typical Anatini but used filtering actions more extensively.

(1) *Bottom Filtering*.—By far the most common method of feeding, the birds wade slowly in shallow water, seldom more than 2 in. deep. The bill is immersed and is held immediately above the soil surface and a rapid filtering action is set up so that the fine particles of mud on the surface swirl up. It has been possible to watch this action at very close range (2 ft) in perfectly clear water many times. The bill has not yet been seen to enter the mud itself but is maintained immediately above it—a true filtering, rather than a dabbling action.

(2) *Surface Filtering*.—The surface filtering is the least frequently seen. The action is exactly similar to the shoveler (Frith 1959c) and several other dabbling ducks. The birds swim slowly, filtering and nibbling at surface particles. Captive birds also spend a great deal of time running their bills along the edges of logs and posts and concrete walls in the water that have become encrusted with algae. The bill action is nibbling and they have been clearly seen to be feeding extensively on the algae.

(3) *Upending*.—When freshly caught wild birds were released on the pond most of their time was spent upending, but this was soon abandoned in favour of bottom filtering. The pond already carried various dabbling ducks including grey teal (*Anas gibberifrons*), chestnut teal (*A. castanea*), shoveler (*A. rhyncotis*) and pinkeared duck (*Malacorhynchus membranaceus*), which had presumably exhausted most of the natural food, and food was only abundant where it was artificially placed on and near the edge of the water, upending in deeper water was thus unprofitable. Upending was practically confined to water about 2 ft deep—it was rarely attempted in deeper water and seldom in shallower; 2 ft is about the depth in which a freckled duck can reach the bottom.

Captive birds placed in a glass tank $6 \times 3 \times 3$ ft with 2 ft of water upended freely and again it was seen that filtering was confined to immediately above the surface of the soil on the bottom. The birds did not dabble in the mud, nor did they pay special attention to plants and food items on the bottom.

Occasionally the birds have been seen to immerse their heads and necks in 6 in. of water but it has not been possible to determine the action of the bill under water.

A total of 27 gizzards, collected mainly at Booligal, N.S.W., in a large lignum swamp, Lake Merrimajeel, and at Griffith in Barrenbox Swamp, a cumbungi swamp, between 1952 and 1964, were available for analysis and their contents are tabulated in Table 2. The only previous notes on the food of freckled ducks located are those of Gould (1865) who reported that the gizzards contained "small fish and minute shells", these items were not seen in the present collection unless "minute shells" could refer to ostracods, and of Hobbs (1957) who saw them feeding on "some red form of duck-weed" (presumably *Azolla* sp.).

From Table 2 it can be seen that the most important food of the freckled duck was of vegetable origin, which amounted to 89% relative volume. Vegetable items were found in every gizzard examined and usually accounted for practically the whole contents. Animal items only provided 11% of the relative volume of the food.

Of the plant food the green algae (Chlorophyceae) were clearly of very great importance. They were found in every gizzard examined and sometimes in large quantities. In several gizzards algae were the only food. The algae included both filamentous and branched types but apart from *Spyrogyra* were not identified. This last was found in more than half 52% of the gizzards and in six cases, collected in Barrenbox Swamp, was the only food found. The very common occurrence of algae, particularly the relatively coarse branched types is well in accord with the observed habit of freckled ducks feeding on the surface growth of submerged posts and logs.

TABLE 2
FOOD ITEMS FOUND IN THE GIZZARDS OF 27 FRECKLED DUCKS

Food Items	Number of Gizzards	Frequency of Occurrence (%)	Relative Volume (%)
<i>Plant Food</i>			
Chlorophyceae	27	100·0	30
Marsiliaceae	10	37·0	3
Polygonaceae	22	81·5	22
Chenopodiaceae	2	7·4	1
Cyperaceae	3	11·0	11
Gramineae	16	59·3	16
Leguminosae	21	77·7	1
Compositae	6	22·2	1
Unidentified	5	18·5	4
<i>Animal Food</i>			
Nematoda	3	11·0	1
Crustacea	7	26·0	1
Mollusca	1	3·7	1
Insecta	22	81·5	6
Unidentified	15	55·5	2

Grasses (Gramineae) were found in 59% of the gizzards and accounted for 16% of the food. The grasses were all aquatic species predominantly *Echinochloa colonum*, *E. crusgalli*, and *Paspalidium jubiflorum*, but occasional seeds of *Paspalum distichum*, *Oryza*, *Cynodon*, and *Danthonia* were found. As in other inland ducks a considerable amount of food was derived from the Polygonaceae and the plants indentified included *Rumex*, *Polygonum aviculare*, *P. prostratum*.

VI. BREEDING SEASON

(i) *Inland N.S.W.*

It has been shown (Frith 1959d) that many ducks of the inland have erratic breeding seasons strongly influenced by climatic factors, particularly the flooding of the rivers and billabongs. Some species (grey teal and pinkeared duck) have breeding seasons that are almost completely controlled by the water-level whereas others, those more characteristic of deep permanent swamps, have more regular breeding, a part of the population breeding each year and at about the same time. These species,

black duck and probably the hardhead (*Aythya australis*), however, retain the capacity to breed also at any time of the year that exceptionally favourable conditions occur.

It has been shown that when a major flood occurs in the inland all ducks breed and each species has a definite place in a time sequence of breeding that is related to the water conditions; some breed on a rising water-level, some at a peak level, and some on a declining one. It is often more meaningful to refer to the position of a species' breeding season in that sequence than to allot it to a specific season or month. In this connection the generalized statements of the breeding season of the freckled duck, that appear in standard textbooks, e.g. September–November (North 1913–14) are often only partly true.

Most records of freckled duck breeding refer to the period September–December. These records include Bool Lagoon, S.A., December 1955 (Hood personal communication); near Yalgoo, W.A., October 5, 1963 (Serventy, personal communication); Buckinguy, N.S.W., December 14, 1903 (H. L. White Collection); Darling River, N.S.W., October 17, 1903, November 20, 1923 (South Australian Museum Collection).

There are, however, two records that require further comment. In April 1906 a clutch was taken in the Macquarie Marshes, N.S.W., (Australian Museum Collection). Seven nests with eggs were seen in Bulloo Lake, south-western Queensland, on April 9, 1955 (M. Schraeder, personal communication). Both these out-of-season records were associated with exceptionally heavy rainfall and flooding. In 1906 the average annual rainfall was exceeded twofold in central New South Wales and there was extensive flooding on the Macquarie River (Commonwealth Bureau of Meteorology). In 1955 Bulloo Lake underwent one of its rare replenishments, due to exceptional rain in south-west Queensland. These two events suggest that freckled ducks, like other inland species, can be stimulated to breed by excessive rain or flood and observations made at Griffith, N.S.W., support this hypothesis.

Freckled duck nests or broods are rarely seen and populations are not large enough to permit regular sampling for examination of the bird's sexual state. Accordingly the data are fragmentary but sufficient to permit generalization for the Griffith, N.S.W., district. It has been possible to secure some data on the breeding periods each year between 1952 and 1963 with the exceptions of 1954, 1961, and 1962 when the author was abroad or unable to visit the area frequently. The weather generally and the river levels for the localities, the Murrumbidgee River near Griffith and the Lachlan River near Booligal, have been described (Frith 1959a, 1963). Briefly, 1952, 1955, and 1956 were years of extensive flooding; 1954, 1957, and 1958 were years of low water-levels and mild drought; in the other years there was rain normal for the district and the rivers rose each spring to replenish the billabongs, but there was no significant flooding.

In the flood years 1952, 1955, and 1956 breeding of freckled ducks was widespread and the breeding season extended. The evidence for this is summarized for each year.

(1) *Flood Year 1952*.—A rise in river level began in April on the Murrumbidgee and in May on the Lachlan and by mid June many thousands of square miles were flooded. Grey teal began breeding in early June, black duck in early July, and pinkeared

duck in August (Frith 1959d). On April 16 a male freckled duck was collected in Barrenbox Swamp whose testes were enlarged, active spermatogenesis was in progress and there were bunched spermatozoa in the lumina of the distended spermatic tubules. Several other isolated pairs of obviously mated birds were seen but could not be collected. On September 20 an adult female and two pre-flying juvenile males were secured. The female had small oocytes less than 1 mm diameter and a heavily convoluted oviduct, indications that she had bred. The juveniles had almost fully developed primaries and were therefore about 8 weeks old. The eggs must have been laid about June 20. On November 10 two males were collected in the same swamp, one was undergoing active spermatogenesis and in the other, although the testes were still enlarged, they were regressing. Near Booligal on September 10 two nests of freckled ducks were found, both sets of eggs were fresh and one male, undergoing active spermatogenesis, was shot. On the same day the late Miss Turner showed me three clutches of freckled duck eggs collected on Angora Swamp in that district in "late June".

Obviously in 1952 freckled duck breeding extended from, at the latest, mid June to at least mid September.

(2) *Flood Year 1955*.—The Murrumbidgee River flooded in July. Breeding of grey teal began in late July and continued until the end of October, black ducks bred earlier than usual and the first clutch was begun on July 21 and the last on August 29. Two male freckled ducks were collected in Barrenbox Swamp on July 10 but no sexual activity could be detected in the testes. A male and female were collected on August 30; the female had oocytes up to 15 mm diameter and in the male the spermatic tubules were clear and distended, and there were bunched spermatozoa in some of them. There was no further opportunity to collect freckled ducks in 1955 but it was apparent that breeding had begun in August.

(3) *Flood Year 1956*.—Exceptionally severe floods began on the Murrumbidgee River in March. Grey teal began breeding in late March and this was still in progress on January 10, 1957. Black ducks bred between May 6 and August 10, 1956. Freckled ducks were present but there was no evidence of breeding until on September 28, when a pre-flying juvenile was shot. This bird could not have hatched later than early July. On the same day a brood about 4 weeks old was pursued but not caught, indicating eggs laid about mid October. A female shot on January 2, 1957 had an oocyte 24 mm in diameter and was apparently breeding. No other direct evidence of breeding was seen in 1956. There is, however, sufficient evidence to conclude that it extended at least from the beginning of July until early January 1957.

In the years 1953, 1957, 1958, 1959, and 1960 occasional birds in breeding condition were collected, but in every instance this was in the period September–November.

(ii) *Benger, W. A.*

Benger, W.A., is in the winter rainfall belt and Benger Swamp floods annually. The first rains begin in May and the swamp is full when 12 in. of rain have fallen; usually by the beginning of June or as late as mid June. The swamp declines in level during the summer and is finally drained for agricultural purposes in December.

When the swamp floods all local species of ducks colonize it and breed. Since 1958 Mr. R. Taylor has regularly patrolled the swamp by canoe and searched for, and recorded, duck nesting data. He has kindly allowed me to peruse his journals.

The duck breeding season at Benger is quite regular and follows the regular seasonal flooding with the slight variation of two or three weeks from year to year, according to the detail of the rainfall and flooding regime, and a sequence of duck breeding similar to that recorded at Griffith, N.S.W., occurs. Mr. Taylor's findings are summarized in Table 3.

TABLE 3
BREEDING SEASON OF WILD DUCKS AT BENDER, W.A., 1958-63

Species	Earliest Clutch Begun	Latest Clutch Begun
Black duck	June 2	October 16
Hardhead	October 15	November 16
Musk duck	August 10	November 28
Freckled duck	October 16	December 5

Clearly at Benger the freckled duck breeds later in the season than the other species and there are sufficient data to conclude that the freckled duck has a fairly regular breeding season that occurs relatively late in the season, i.e. after the black duck, hardhead, and musk duck; thus it is the latest duck to breed in the sequence.

It can be concluded that timing of the breeding season of the freckled duck is similar to that of the black duck and hardhead. Unlike the grey teal and pinkeared duck the breeding season is basically regular but at least some birds retain the ability to breed at other times of the year in order to exploit exceptionally favourable conditions when they occur, these favourable conditions are initiated by flooding.

(iii) Nesting

The author has only examined two authenticated nests of freckled ducks, in each case they were well constructed bowl-shaped structures of fine sticks of lignum with some *Eleocharis* placed in lignum bushes in 4 ft of water at water-level. Seven nests examined by M. Schraeder in south-west Queensland were similar but placed 1-2 ft above water-level, in a declining swamp; probably they were built at an earlier water-level. Mr. R. Taylor records that he has not yet seen a nest of this description; those he has observed have been built in hollows among flood rubbish in the bases of trees and in artificial sites built by him for the birds' convenience.

The observation (Frith, in Delacour 1954) that the down in freckled duck's nests is used as a lining to the nest, unlike other ducks, where it is distributed among the eggs, must be withdrawn. Many ground nests of chestnut teal, shovellers, and black ducks have, since that date, been seen to have a similar conformation of down, due no doubt, to the mechanical effects of moving the eggs during incubation. A similar state of affairs probably exists in the freckled duck.

The clutch size has been reported as five–seven (Serventy and Whittell 1951). Clutch data collected by the author, R. Taylor, and M. Schraeder, when combined with data of clutches held by Australian museums, show that the clutch varies from 5 to 14 eggs, with 7 as the commonest clutch and 7·7 as the mean clutch size. The distribution of size among 18 clutches was as below where the values in parentheses refer to the number of clutches:

5 eggs (3); 6 eggs (1); 7 eggs (7); 8 eggs (1); 9 eggs (3); 10 eggs (2); 14 eggs (1).

The size of the eggs reported by Serventy and Whittell (1951), 58×42 mm, and adopted by Delacour (1954–64) was possibly based on a clutch of eggs not properly authenticated and perhaps refer to the hardhead. Freckled ducks' eggs are normally larger and the eggs of 10 clutches measured 60–65 mm×45–48 mm.

One completely authenticated clutch, i.e. with the female collected on the nest, was recorded at Bool Lagoon, S.A., in 1946 (Hood, personal communication), the egg measurements were as below (mm):

$$64\cdot4 \times 45\cdot6, 64\cdot3 \times 47\cdot0, 64\cdot0 \times 46\cdot5, \\ 63\cdot2 \times 46\cdot5, 60\cdot0 \times 43\cdot3, 62\cdot2 \times 47\cdot5.$$

The eggs examined by the author differ from those described by Delacour (1954–64) as "thick pale greenish white . . . resembling those of the Grey Duck". The eggs are cream or ivory in colour, glossy and smooth; the shell is thick and softer than other duck eggs. They are less pointed and more nearly oval than the eggs of the black duck (= grey duck [of Delacour]). The size and appearance of the eggs have been correctly described by North (1913–14).

The author has not seen a male freckled duck near either of the two nests nor has Taylor with his nests or broods. The incubation period (Taylor, personal communication) is 26–28 days.

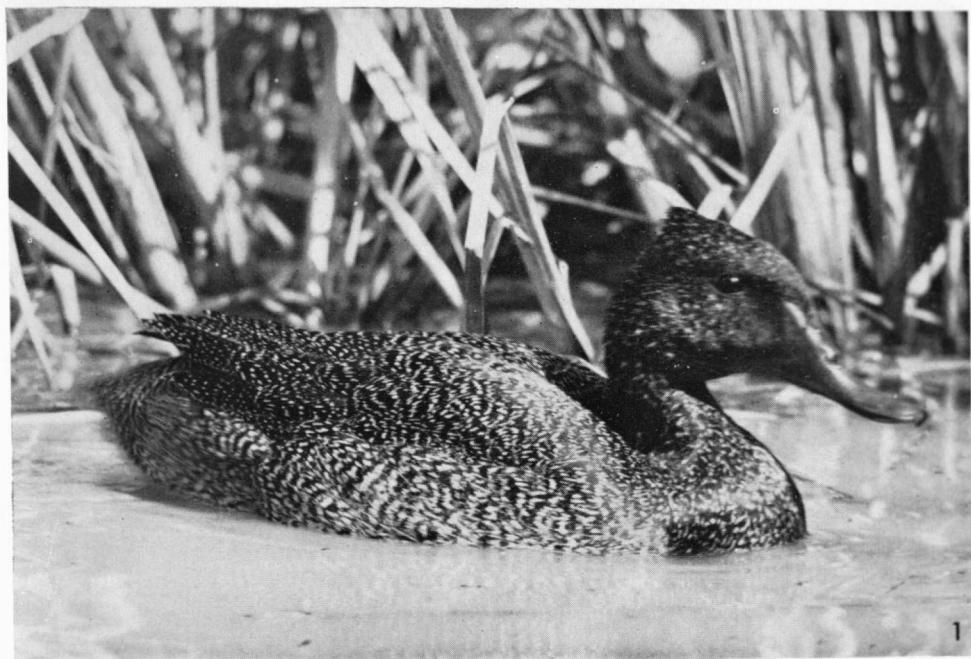
VII. DISCUSSION

The freckled duck, although quite widely distributed, is not numerous and its main populations are supported by a very small number of permanent swamps mainly in inland New South Wales, the population being augmented by occasional flooding of suitable areas of the inland permitting more extensive breeding.

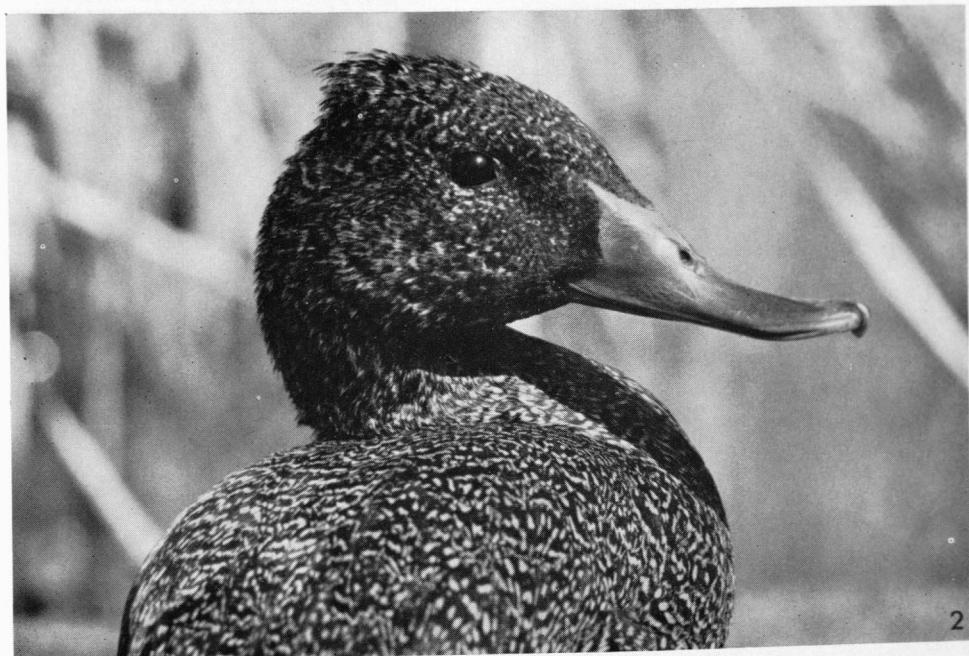
The future of the main breeding swamps is by no means secure, those near Griffith, N.S.W., are merely storage areas for drainage water from the Murrumbidgee Irrigation Areas, this water being subsequently used for other purpose. It is not difficult to imagine that a quite minor change in policy of the controlling body, or an increased demand for this water, would eliminate this swamp as other similar swamps in the area (Fivebough and Tuckerbil) have been eliminated in very recent years.

The more natural breeding areas in the lignum creeks and swamps of the Lachlan and Murrumbidgee rivers are in serious jeopardy, as the present trend of water conservation and usage on these rivers is to decrease the frequency of flooding of the effluents and replenishment of the swamps. The districts in which freckled ducks breed in the greatest numbers in South Australia are the present locations of vigorous drainage programmes.

ECOLOGY OF THE FRECKLED DUCK



1



2

Fig. 1.—Male freckled duck showing posture on water.

Fig. 2.—Head of 1-year-old male freckled duck showing the heavy bill with prominent nail and erectile feathers on head.

(Photographs by Ederic Slater.)

ECOLOGY OF THE FRECKLED DUCK



Fig. 1.—Freckled duck preening in typical daytime roosting posture on submerged log.

Fig. 2.—Freckled duck feeding in shallow pool showing filtering position of bill.

(Photographs by Ederic Slater.)

There is little doubt that the freckled duck's position is insecure and it could decline rather rapidly in the quite near future, due to destruction of its habitat. Behavioural work in progress suggests that it is a rather unique primitive species, perhaps closer to the original stock of the Family Anatidae than any other present-day species, and on these grounds alone urgent consideration should be given to its conservation.

VIII. ACKNOWLEDGMENTS

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Mr. J. B. Hood and Mr. M. Schraeder have kindly provided information from their personal journals.

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