



## ECOLOGY OF WILD DUCKS IN INLAND AUSTRALIA\*

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### Summary

In inland Australia waterfowl habitats fluctuate greatly in extent from year to year. Small areas of permanent habitats occur but the most extensive habitats are those that are formed periodically and erratically by flooding of the rivers.

The movement patterns of the various species of wild ducks that inhabit the region vary according to the habitat occupied by the species and vary in regularity according to the permanence of the habitat. Species which are confined to the permanent swamps are very regular in movement, being either sedentary or regularly migratory, but those that utilize the more temporary habitats have developed nomadic habits to a very high degree.

The degree of mobility of the different species is related to their food requirements. The species having regular movements have regular food cycles. Some nomadic species have very adaptable food habits and can utilize a very wide variety of foods, thus being able to exploit all types of water as they occur. One nomadic species, however, is a food specialist and accordingly has developed an extreme type of nomadic wandering.

The species characteristic of permanent swamps have very regular breeding seasons but the nomadic species are able to breed at any time of the year whenever suitable conditions occur. The sexual cycle culminating in breeding is initiated by increasing water level in rivers. In this manner whenever flooding occurs the birds breed in the newly developed floodwater. The same factor, increasing water level, that initiates breeding in the birds initiates breeding in the animals forming the food of the ducklings so that abundant food is available.

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### **Introduction**

In many countries and in the coastal regions of Australia, where the seasons are reasonably regular, the movements, breeding and feeding patterns of waterbirds are well established. In the Northern Hemisphere it has been possible to accurately chart migration routes and breeding seasons and to forecast with some expectation of accuracy the numbers of birds liable to reach the extremities of their migration routes and the dates of their movements.

In inland Australia, however, the climate is arid and erratic. The depth and extent of water areas fluctuate widely from year to year. In some years, following flood, there may be hundreds of square miles of swamp in a region, but this may dry up and the land remain dry and parched for many years. Under conditions such as these it is apparent that waterbirds must develop adaptations to enable them to deal with the rapidly and erratically changing situations. This paper summarizes the results of studies on various aspects of the ecology of wild ducks in inland New South Wales and seeks to explain how wild ducks can exist in very large numbers in this semi-arid environment.

### **The Environment**

The climate of inland Australia has been discussed in detail by many authors (e.g. Lawrence, 1937). The boundaries of the State of New South Wales enclose a typical cross section of all environmental conditions that are found on the continent ranging from the well watered coast to the semi-deserts in the far western parts of the State. The majority of the work on which this paper is based, was carried out in mid-western New South Wales between the 20-inch isohyet in the east and the 8-inch in the west; the rainfall is erratic and seldom approximates the annual average. In the north most of the rain falls in the summer and in the south most of it falls in the winter. Summer temperatures are high and the annual evaporation varies between 50 inches in the east and 100 inches in the west. The region is semi-arid with unreliable rainfall.

The land is flat and forms part of the flood plain of the Murray-Darling river system. The principal rivers, the Murray, Murrumbidgee, Lachlan, Macquarie, and Darling are sluggish and characterised by extensive systems of meanders, "billabongs" (ox-bows) and effluent streams. The levels of the rivers vary greatly; in times of flood the waters of the Murray, Murrumbidgee, and Lachlan may actually join across the plains but at other times the rivers may cease to flow and even dry up. The level of these rivers and flooding of the plains are mainly determined by conditions on the catchments hundreds of miles to the east and local rainfall is seldom sufficient to affect their level. They need have no relation to the local climate at the time and may occur at any time of the year.

### **Waterfowl Habitat**

#### *Streams*

None of the rivers is entirely permanent but although they often cease to flow they seldom dry up entirely. Flooding is rather frequent and each 4 or 5 years on an average much of the region is inundated. The rivers in general have steep bare banks and under these conditions few aquatic plants

grow. Herbs, however, periodically flourish on exposed mud banks and beaches.

The effluent streams are normally dry but when the river reaches a sufficient level water flows into them and is carried far into the plains. The extent of the development of effluents and their type varies greatly between rivers and accordingly minor flooding gives different effects. In some cases a minor increase in water level merely leads to an increased rate of flow through the numerous streams, but in others quite a small rise in river level forces water to flow through the numerous effluents and sends shallow, temporary water across very large areas of swamps and reedbeds.

Irrigation areas, and Domestic Stock and Water Supply districts have been developed in the region. The channels carry water only periodically but, in some places, their banks support dense growths of *Eleocharis*, *Juncus*, *Polygonum*, and *Carex*, and provide thin strips of green herbage through otherwise dry plains.

### *Billabongs*

For the present purpose three distinct types are recognised. The juvenile billabong is one which has apparently only recently been separated from the river. Its banks are tree lined, steep, deep, and bare of herbage. It has virtually no shallows. The inlet and outlet creeks are always present and almost as deep as the river itself. This means that a rise of a few feet in river level will cause water to flow through the billabong, but also a fall of a few feet will cause it to drain out again. Juvenile billabongs are usually dry or nearly so.

In more mature billabongs the banks are eroded to a gentle slope and the water course itself has partly filled with silt. The water is relatively shallow and supports perennial aquatic plants including *Potamogeton*. They usually have quite extensive shallow edges well colonised by *Carex* and *Eleocharis*. As the billabong silts up further it often loses its characteristic shape and the normal water level recedes further from the tree line which remains to mark flood level. Due to the relative shallowness of the water the whole area is usually colonised by aquatic plants. A lagoon usually has relatively wide shallow edges carrying *Juncas*, *Scirpus*, and *Polygonum*, and in the deeper centre may be *Azolla*, *Marsilea drummondii* and other aquatic plants.

### *Swamps*

Swamps with dense emergent vegetation are formed in the more permanent water areas. Three distinct types are developed depending on the permanence of the water. Where the water is deep and permanent the dominant vegetation is cumbungi, *Typha angustifolia*, which forms dense pure stands. The deeper parts are occupied by *Azolla* and *Myriophyllum*, and the shallow edges usually carry stands of *Eleocharis*, *Carex*, *Marsilea drummondii*, *Agrostis avenaceae*, and *Paspalum distichum*.

In those depressions in which the water is less permanent and shallower, cane grass *Glyceria ramigera* is dominant forming a cane grass swamp. Normally *Marsilea drummondii* and *Azolla* do not occur and the more open parts of the swamp support heavy growth of *Eleocharis*, *Carex*, *Scirpus*, and other aquatic plants.

*Lignum Muehlenbeckia cunninghamii* is the dominant vegetation in areas subject to less frequent inundation, the more frequent the flooding the denser the lignum; few other aquatic plants occur in lignum swamps.

#### Temporary Water

On flooding of the rivers very large areas of the plain are covered by water to a shallow depth. These areas of residual floodwaters make available to the ducks an abundance of submerged dry-land plants and become colonised by large numbers of aquatic animals. They are sometimes sufficiently permanent for aquatic plants to develop.

Temporary water is also held in claypans, naturally occurring, circular depressed areas on the treeless plains. The bottoms are flat and composed of heavy clay, and support no plant growth. In times of heavy rain these collect water and form shallow temporary lakes but this water quickly evaporates and although claypans are often the source of some animal, particularly insect, life, they never support any plant growth.

#### Habitat Utilization

Twelve species of waterfowl, listed below, occur regularly and breed in the region.

Black Swan	<i>Cygnus atratus</i> (Latham)
Mountain Duck (Australian Shelduck)*	<i>Tadorna tadornoides</i> (Jardine & Selby)
Wood Duck (Maned Goose)	<i>Chenonetta jubata</i> (Latham)
(Australian) Black Duck	<i>Anas superciliosa</i> Gmelin
(Australian) Grey Teal	<i>Anas gibberifrons</i> Muller
Chestnut (-breasted) Teal	<i>Anas castanea</i> (Eyton)
(Australian) Blue-winged Shoveler	<i>Anas rhynchotis</i> Latham
Pink-eared Duck	<i>Malacorhynchus membranaceus</i> (Latham)
Freckled Duck	<i>Stictonetta naevosa</i> (Gould)
White-eyed Duck (Australian White-eye)	<i>Aythya australis</i> (Eyton)
Musk Duck	<i>Biziura lobata</i> (Shaw)
(Australian) Blue-billed Duck	<i>Oxyura australis</i> Gould

\*names in parentheses are those used in *A Coloured Key to the Wildfowl of the World*. (P. Scott, 1957).

The Plumed Tree Duck *Dendrocygna eytoni* (Eyton) is an irregular visitor and may sometimes breed. Among these species some distinct habitat preferences exist.

#### Streams

The main stream of the rivers forms the principal Wood Duck and Mountain Duck habitat in the region. Both these species are almost exclusively grazing animals and feed on the banks. The rivers are used to a very limited extent by Black Duck and Grey Teal, but are completely avoided by the other species. Even in times of drought, when the main streams retain some water, few ducks are found on them. Presumably river water does not provide sufficient food for the wild ducks.

The effluent streams, which are not so deep nor as permanent as the rivers, provide important feeding habitat for all species except the swan and diving ducks. These are apparently excluded by lack of breeding sites and of suitable food. The species utilizing effluent streams vary according to the vegetation. Where the stream flows through living timber Wood Ducks, Black

Ducks, and Grey Teal are abundant; where the timber fringe is not continuous Wood Ducks and Black Ducks are less numerous and Grey Teal the commonest species. Where the stream crosses treeless plains Grey Teal and Pink-eared Ducks may be found in very large numbers but rarely are other species seen. Where the stream is deep and flows through lignum or cane grass the White-eyed Duck and Freckled Duck are the commonest species.

The larger storage dams are deep and usually contain few aquatic plants. They are not generally suitable for the breeding or feeding of waterfowl and few birds are found on them. In times of drought, however, they serve as temporary refuges for congregations of all species, when all other water has dried up. The irrigation channels provide some water habitat through large areas of otherwise dry country. They serve as focal points for Wood Duck flocks and frequently support small numbers of Black Duck and Grey Teal. In general, however, they are not an important waterfowl habitat.

#### *Billabongs*

Billabongs are the principal relatively permanent habitat for wild ducks in the region and are used for breeding, feeding, or refuge by all species. Immature billabongs seldom contain wild ducks apart from small numbers of Black Duck and Grey Teal, but the mature billabongs and lagoons form very important and extensive semi-permanent breeding places for many species and, after breeding, support very large numbers of all species except the diving ducks.

#### *Swamps*

The cumbungi swamps are the breeding and feeding habitat for Musk and Blue-billed Ducks and the usual habitat for Black Swans. A few Black Duck and Grey Teal may breed in them if some trees are available, but they are usually avoided by Wood Ducks. During the summer very large concentrations of Black Duck, Grey Teal, White-eyed and Freckled Ducks congregate in them but usually feed elsewhere (Frith, 1957a).

Lignum and cane grass swamps form almost the sole breeding and feeding habitat for Freckled Ducks and White-eyed Ducks, and sometimes support large numbers of non-breeding Grey Teal. Over the western part of the region studied lignum and cane grass swamps are almost the sole waterfowl habitat.

#### *Temporary Water*

When the rivers flood all vegetation associations are submerged and the waterfowl habitat in the region is increased many hundredfold. The utilization of the floodwater by waterfowl varies according to the type of country flooded and the birds' breeding and feeding requirements. On flooding, especially in the lightly timbered and treeless plains, vast areas of new waterfowl habitat are created and these areas are invaded by very great numbers of Grey Teal, Pink-eared Ducks, and Shovelers, and smaller numbers of Black Duck, and sometimes White-eyed Duck. Normally floodwaters are ignored by other species. The extensive breeding that may occur has been described (Frith, 1957b and unpublished).

Large and relatively deep claypans are an important site for opportunist breeding by Grey Teal and small numbers of Blue-winged Shovelers. They

are also important opportunist feeding places for Grey Teal and Pink-eared Duck. On the whole, however, their filling is infrequent and permanence slight.

### **Movements**

It has frequently been observed that the numbers of wild ducks in different localities usually vary greatly from year to year (e.g. Morgan, 1954; Downes, 1955; Hobbs, 1957) and that, in the southern and coastal parts of the continent, a tendency exists for the numbers to increase during the summer. Banding returns and field observations, however, show that these movements cannot be explained as a simple migration. It is apparent that both migration and nomadic movements, dictated by climatic conditions, must be considered in the interpretation of waterfowl movements. Among the different species and, in some cases, within the one species, every movement pattern from completely sedentary through erratically nomadic to regularly migratory can be found. The movement patterns of the different species seem to be determined largely by their habitat requirements and alterations in the extent of this habitat.

Those species which inhabit the permanent swamps, exclusively, are quite regular in their movements. Thus the Musk Duck, which is confined to the heavily vegetated permanent swamps, is sedentary and is practically never seen beyond these swamps. The Blue-billed Duck which inhabits the same swamps has very regular seasonal movements. Both species can apparently afford to be regular in habit, in the one case sedentary and in the other migratory, because their habitats are permanent and "safe."

The White-eyed Duck, whilst mainly confined to the deep permanent swamps is also able to utilize deep semi-permanent floodwater. In accordance with these habitat requirements a regular north-south movement occurs in the permanent swamps, the species being more numerous in southern regions during the summer. In times of drought, when the permanent swamps decrease in area, this movement, however, decreases in volume or may not occur. In addition to this regular movement the birds are sufficiently adaptable to utilize deep floodwaters at any time of the year wherever they occur. Severe flooding is usually followed by an influx of White-eyed Ducks, but this influx when compared to the species discussed below is slight except into those areas where lignum and cane grass are flooded.

The Black Duck prefers deep, heavily-vegetated swamps but is more elastic in its habitat requirements than the White-eyed Duck and is able to utilize, to some extent, most other habitats for breeding and feeding. Each permanent swamp contains some Black Ducks always, but annually the number of birds in southern and coastal regions increases each summer and decreases each winter. The movements are, however, strongly affected by climatic conditions and, although dry seasons are characterized by an increased volume of movement to the coast, the majority of birds remain in the inland where great concentrations occur. In times of flood a movement to the flooded area occurs in any direction and at any time of the year. This movement however, in volume, is only a fraction of that of the Grey Teal.

The Grey Teal is a true nomad and may move over the whole continent in all directions and at all seasons in search of suitable living conditions. In

the inland each creek, swamp and billabong supports small numbers of birds and, as in the Black Duck, these numbers increase annually in the better watered areas of the south and on the coast; this movement superficially resembles true migration. However it has been shown by banding (Frith, unpublished data) that these movements are erratic. Birds from one breeding place may disperse over the whole continent in all directions. In time of flood immense numbers of Grey Teal arrive in that area within a few days. In time of drought virtually the whole population vacates the interior and concentrates on the coast or wherever rain has fallen. This is in contrast to the Black Duck which at these times has a tendency to concentrate in increasing numbers on the permanent waters inland.

The Pink-eared Duck is even more strongly nomadic than the Grey Teal. Whereas, in the Grey Teal, there are birds permanently in most areas and some semblance of regular movements, at times, in the Pink-eared Duck there is none. The whole population is nomadic and may appear in a district in very great numbers in one year but then disappear and not be seen again for many years. The birds require for their habitat expanses of shallow water, dirty, stagnant and dense with plankton. This type of water in the inland is only provided by flooding and under the conditions of high evaporation that exist is very temporary, and as it dries up the Pink-eared Ducks vacate the district completely. Extreme mobility is apparently essential for their survival.

#### Food Habits

In the period 1952-56 about 4,000 gizzards of the six common species of ducks in the inland were examined. From this study it was apparent that most of the movements of wild ducks could be explained by fluctuations in the food supply due to flooding or rainfall.

Among the nomadic species, the Grey Teal had a very variable diet. On the average the food consisted of 27% of plants usually growing on dry land, 40% aquatic plants and 33% aquatic animals, predominantly insects. The composition of the diet at any time, however, rarely approximated the average and varied greatly from place to place and from time to time according to the weather and the flooding of the rivers. There was no regular annual cycle of food but a cycle existed that depended on the stage of flooding in the area. Thus as the streams increased in level, or flooded, the birds fed almost entirely on dry-land plants and dry-land insects but as these were exhausted and the swamp plants (e.g. *Carex*, *Polygonum*, *Eleocharis*) were established the seeds of these swamp plants became the most important source of food. As the waters fell in level or evaporated the aquatic insects became more concentrated and these in turn became the most important source of food until ultimately the diet consisted entirely of them.

The Blue-winged Shoveler ate mainly aquatic animals, insects being most important, and was less dependent on vegetable food than the Teal. Of the vegetable food the majority was collected from the bottom of shallow water and negligible amounts only were derived from growing swamp plants. In conformity with this food preference the Shoveler occupies principally flood-waters at a rather later stage in their development arriving as the waters are receding and these foods are abundant.

The Pink-eared Duck fed almost exclusively on aquatic animals, including large quantities of microscopic forms collected by filtration of water and not from the bottom or edge as in other species. Accordingly Pink-eared Ducks do not compete with other species for food and at the same time the type of water in which they can live is limited. They are extremely mobile and arrive in an area as the floodwaters are receding and evaporating and can remain longer than most other species.

The diet of the less mobile Black Duck was similar to that of the Grey Teal but included greater quantities of swamp plants and aquatic animals. The Black Duck fed predominantly on the animals and seeds of larger size and characteristic of more permanent water. They were not adapted to collecting small submerged grass seeds and so were not able to exploit freshly flooded areas as efficiently as the Grey Teal; accordingly floodwaters were only used to a limited extent. Similarly the White-eyed Duck, Musk Duck, and Blue-billed Duck fed predominantly on the larger animals characteristic of deep permanent water. These species were unable to utilize temporary floodwater and their movements correspondingly restricted.

In inland Australia where the water areas fluctuate rapidly both in extent and depth, it is apparent that for a water bird to exist permanently in very great numbers it must be sufficiently adaptable, in its food habits, to deal with a food supply that may alter rapidly in both composition and abundance. The seeding swamp plants being used as food one day may be covered by several feet depth of clear water the next, whereas the dry grass seed far from the river may equally suddenly become available due to flooding.

The Grey Teal has evolved great adaptability in both the food eaten, the methods of collection and feeding habitat. This adaptability enables it to exploit most types of water and food as soon as they occur. There is no doubt that this adaptability to the food supply accounts, at least in part, for the Grey Teal being the commonest and most widespread and mobile species of wild duck in Australia.

The movements of the other highly nomadic species, the Pink-eared Duck, may also be explained on its food requirements. The birds are completely dependent on plankton and insects which are only common in drying waters. In order to secure this food regularly the birds must be prepared to move very widely and rapidly as water conditions alter.

The Black Duck and White-eyed Duck are adapted to utilize the foods produced by more permanent water than the other species. Their distribution and movements are controlled by the availability of this water, and as changes in its extent cannot be widespread nor rapid these species are accordingly comparatively local in distribution and relatively low in numbers in the inland.

## **Breeding**

### *Breeding Seasons*

The breeding of many species of wild ducks is strongly affected by rainfall and flooding. Among the common species every stage exists between those having regular annual breeding seasons and those that may breed at any time of the year when conditions are suitable; they may breed at a different time and in a different place in successive years. In the period



1950-1957 observations were made on the breeding of the common species of wild ducks in the Murrumbidgee and Lachlan regions, New South Wales. In this period conditions varied from extensive unprecedented flooding in 1951 and 1956 to droughts in 1954 and 1957. The volume of breeding also of many species varied directly with the seasonal conditions in each year.

Those species which inhabit the permanent stable water areas have regular breeding seasons. Thus the Musk Duck which is sedentary and confined to the cumbungi swamps where the water is deep and permanent with dense emergent growth of bulrushes has a regular breeding season beginning in late August and continuing until mid-October. Neither the extensive flooding that occurred in some years nor the droughts in others caused any significant departure from these dates or differences in the volume of breeding in different years. Similarly the Blue-billed Duck and Black Swan which occupy the same habitat are regular spring breeders and are not noticeably affected by flood or rain.

In the nomadic species the position is quite different and no regular breeding season exists. The birds breed wherever and whenever suitable conditions occur. Small numbers of Grey Teal are widely distributed throughout but they do not breed unless exceptionally heavy rainfall or, more usually, a fresh in the river causes an increase in water level. Such an increase in level is followed immediately by sexual display and, within a few days, by ovulation. In addition to the resident Grey Teal, however, very large nomadic flocks move about the inland from place to place as water areas change in extent. In 1955 for instance extensive breeding of these nomadic birds occurred in widely separated parts of the country throughout the whole year as floods or heavy rain occurred at different times. This breeding season began in February in southwestern Queensland, in March in northern New South Wales, in April in central New South Wales, in May on the Lachlan River (south-western N.S.W.), in July on the Murrumbidgee River, in August on the Murray River, and again in October on the Lachlan River. The movements and breeding of the Pink-eared Duck are completely dominated by the climate and there is no regular breeding season, they move and breed wherever and whenever the correct habitat is provided. When breeding is finished and the water dries up the whole population moves elsewhere and no residue remains.

The Black Duck is intermediate in habitat requirement; it is commonest in permanent swamps but is less regularly found in the temporary waters. Similarly the Black Duck is intermediate in its degree of nomadism and regularity of breeding season. The species tends to have a regular breeding season but apparently individuals differ greatly in the sensitivity of their response to the proximate factors initiating breeding. In unfavourable seasons, those with low rainfall and shrinking water levels, very few birds breed. In seasons of normal rainfall all the local birds breed and when floods occur the local birds are reinforced by newcomers who occupy and breed in the extra habitat created. In the Grey Teal unusually good conditions are utilized by a great influx of nomads and an extension of the length of the breeding season, but in the Black Duck there is no such extension of the breeding period but the good conditions are exploited by a greater proportion of the local birds breeding.

*Effect of Water Level on Breeding*

There have been several observations that, in inland Australia, breeding seasons of birds are closely associated with rainfall (Serventy & Whittell, 1948; Keast & Marshall, 1955). Serventy & Marshall (1957) concluded that in W.A. photoperiodicity was of little importance as a regulator of most birds, and that the critical stimuli to breeding were environmental conditions arising after rainfall in relatively high temperatures. In wild ducks where some species have completely erratic breeding seasons ranging from mid-winter to midsummer, clearly fixed annual factors such as daylength or air temperature could have little effect in determining the onset of breeding.

In studies of the sexual cycle of wild ducks (Frith, unpublished) it has been shown that in the Grey Teal every outburst of sexual activity followed an increase in water level and every increase in water level was followed by sexual activity whether rain had fallen or not. The response to a rise in water level is very rapid; sexual activity begins immediately and eggs may be laid 7—10 days later. There is little doubt that in the Grey Teal the breeding season is initiated by an increase in water level.

The Pink-eared Duck carries the adaptation towards a breeding season initiated by a rise in water level one stage further. In the Grey Teal an increase in level sufficient to fill the lagoons is followed by ovulation. The Pink-eared Duck, even if already present in the district is not affected sexually by such a change in level. The sexual cycle leading to ovulation does not begin until actual flooding of low-lying land occurs—the species only breeds when these conditions occur.

In both the preceding species it has been shown that the rising water level which initiates the breeding season also initiates an increase in the amount of food available for the ducklings. Grey Teal ducklings feed entirely on animal food, principally Corixidae and Dytiscidae (Insecta). It has been shown that each increase in water level is followed by the sudden appearance of large numbers of juvenile forms and ultimately an increase in the number of insects available. Apparently the breeding season of the insects is also initiated by a rise in water level. The result is that a greatly increased food supply is available for the ducklings.

Similarly the ducklings of the Pink-eared Duck require large quantities of plankton. These organisms are only abundant in drying floodwater; the flooding of low-lying country, whilst initiating the sexual cycle of the ducks, at the same time provides conditions suitable for an increase in the duckling food supply. Synchrony of the ducklings and their food supply, which increases slowly, is achieved by a relatively slow development of the Pink-eared duck gonad following its initial stimulation.

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