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THE BREEDING OF THE BLACK SWAN (CYGNIS ATRATA LATHAM) IN TASMANIA WITH SPECIAL REFERENCE TO SOME MANAGEMENT PROBLEMS

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(With four plates and seven text figures.)

ABSTRACT

The breeding distribution of the Black Swan in Tasmania is given and the breeding history of the species over three years in the principal breeding area at Moulting Lagoon is described. The incubation period was found to be 39± 2 days and cygnets fly 60 days after the appearance of juvenile plumage. Floods are the main source of egg mortality and other factors are relatively unimportant. Direct observation and statistical calculations were used to estimate the annual cygnet production. The statistical methods gave widely divergent estimates. Shooting over the breeding ground has an adverse effect upon breeding, upsetting pair formation. Restriction of this shooting has resulted in a greater cygnet production. Flooding and autodestruction of habitat are important factors in breeding success and recommendations for the management of the species are given.

INTRODUCTION

Much work has been done on the biology of the Anatidae of the world and particularly upon ducks and geese in relation to management problems. These birds are the subject of considerable hunting pressures and the emphasis in the programme is placed upon the maintenance of the populations.

Swan management problems in many other parts of the world are associated with the maintenance of populations which may be reduced to such numbers as to be a threatened species, e.g., Whistling Swan of North America. However, the New Zealand (Oliver, 1955, Miers, 1962), Victorian and Tasmanian problems relate to the shooting of relatively large populations both for sporting purposes and as a control.

STATUS OF THE BLACK SWAN IN TASMANIA

The Black Swan, *Cygnis atrata* (Latham) is widely distributed throughout much of the Australian continent including Tasmania and is established in a successfully breeding feral state in New Zealand. The species is well known in zoological collections readily adapting itself to captivity.

Black Swans are found generally throughout Tasmania on most lakes and large ponds. Many birds live and feed in salt or brackish water while others are found living and feeding in freshwater conditions. The birds usually occur in aggregations from a few pairs to several hundreds, though only one pair may be found occupying small waterholes. The number of Black Swans encountered on any one area of water appears to be controlled by the availability of food though during drought conditions the number of birds on certain waters may greatly exceed the carrying capacity of the area. Under these conditions the available food is soon reduced and the birds are forced to feed ashore.

The number of Black Swans in the early days of white settlement clearly was very great as all the diaries and journals record this feature. Since then it is apparent that the swan population has decreased although no actual counts are recorded. Lord (1927) noted thousands of Black Swans in Port Davey while Green and Mollison (1961) found only 200 and this count appears to be about the maximum found there as shown by aerial survey flights carried out annually for a period of four years.

The Black Swan population is influenced by the success or otherwise of breeding, since the nesting sites are especially prone to flooding. A series of adverse years will result in small year groups but in a species of the longevity of the Black Swan this, together with other short term factors, will tend to even out over a long period.

The greatest influence on Black Swan numbers is the pressure of human activity with habitat alienation and alteration as the major factors and shooting as a locally important subsidiary. The Black Swan was the subject of annual seasons of 3 months but diminution of the population in the 1930's led to the closure of the season and it was not until 1958 that the season was re-opened, although for a shorter period of time and with bag limit restrictions.

Swan shooting is carried out in restricted areas of Tasmania, notably at Moulting Lagoon where the majority of shooters congregate. Thus most of the shooting pressure is exerted upon the East Coast population of Black Swans. The Moulting

Lagoon area is the principal breeding site in Tasmania and the present investigation was carried out to ascertain some of the basic data for the development of a game management programme for this species in Moulting Lagoon. In particular, emphasis has been laid on the breeding of the Black Swans and the relevant general biological data. Observations were made during the 1960-1964 breeding seasons and at other times of these years and specimens were collected regularly during 1960 for laboratory examination.

METHODS

Emphasis was laid on the examination of the factors affecting breeding during the 1960 and 1961 breeding seasons. Eggs were marked and dated during daily visits to the nests which were also marked. The total number of eggs laid in Moulting Lagoon was counted as was the total number of cygnets hatched. Brood sizes were counted from the air and a cygnet mortality figure calculated. During the 1962-64 seasons the total number of eggs laid was counted and the percentage hatch estimated from later counts.

The present paper describes the 1960-62 breeding in detail and comparisons are given for the 1963 and 1964 seasons.

PRINCIPAL BREEDING SITES

Breeding takes place at many locations in Tasmania but most of these places are small lakes, lagoons or waterholes and the number of birds breeding on any one of these waters is small. However, due to the large number of these breeding places and the apparent success of breeding on them, the annual cygnet production from these sources is fairly substantial. I have not estimated this figure as the task of counting the birds in the hundreds of small waterholes is beyond my resources. The main breeding grounds are at Moulting Lagoon on the East Coast, Duck River on the North-West Coast, Port Davey in the South-West. Of the three, Moulting Lagoon is the most important and was selected as the area of major study. This selection was based on grounds of accessibility as well as biological suitability. Port Davey is situated in almost uninhabited country which is difficult of access. However, it was visited by charter aircraft and the number of Black Swans there was counted. Breeding takes place on Flinders Island (off the North-East Coast of Tasmania) but this population is outside the scope of the present study though it may exercise some biological influence on the Tasmanian population. However, the number of Black Swans produced there may be large in good years and although to date there is no banding evidence to support this, it is believed that some considerable interchange of birds takes place between Flinders Island and Tasmania.

The Moulting Lagoon area (Lat. 42°S., Long. 148° 13'E.) contains two regions of brackish to salt water, namely the Swan River and Moulting Lagoon (Fig. 1). The Swan River widens on the northern side to form King Bay, an important feeding and nesting area for swans. The river then receives water from Moulting Lagoon proper and proceeds in a south-easterly direction to the sea, with Pelican Bay, another nesting and feeding ground, on the north-eastern side of the upper estuary.

Moulting Lagoon is connected by a wide entrance to the Swan River and it consists of three main bays, Watson's Bay off which to the south is Little Bay and Moulting Bay extending to the north to the Apsley Marshes through which runs the Apsley River.

The nature and usage of these waters is important in the problem of Black Swan management (Table 1). In all areas, the bottom is of thick mud with weed coverage across which it is impossible to walk or row a boat at sufficient speed to perform any useful function. In many places mud banks render any movement out of the question and the term "very shallow" refers to water of less than 4 inches depth.

TABLE 1

Moulting Lagoon waterways and their usage by Swans

Waterway	Nature	Usage by Swans
Upper Swan River	Navigable by small boat	Negligible in upper reaches
King Bay	Very shallow, unusable even by "flatties"	Very great. Feeding and resting
Lower Swan River	Navigable only in channel	Some numbers. Feeding and resting in shallows
Swan Estuary	Navigable by small boats	Nil
Pelican Bay	Shallow. Navigable only in "flatties"	Sporadic. Feeding and resting
Little Bay	Very shallow, unnavigable	Very great. Feeding and resting
Watson's Bay	Mostly navigable	Very great. Feeding and resting, with breeding on Sabinas Island
Moulting Bay	Mostly very shallow, navigable at times in channels	Very great. Feeding, nesting and breeding
Apsley Marshes	Unnavigable	Some numbers feeding, resting and breeding
Apsley River	Navigable	Some numbers feeding, resting and breeding

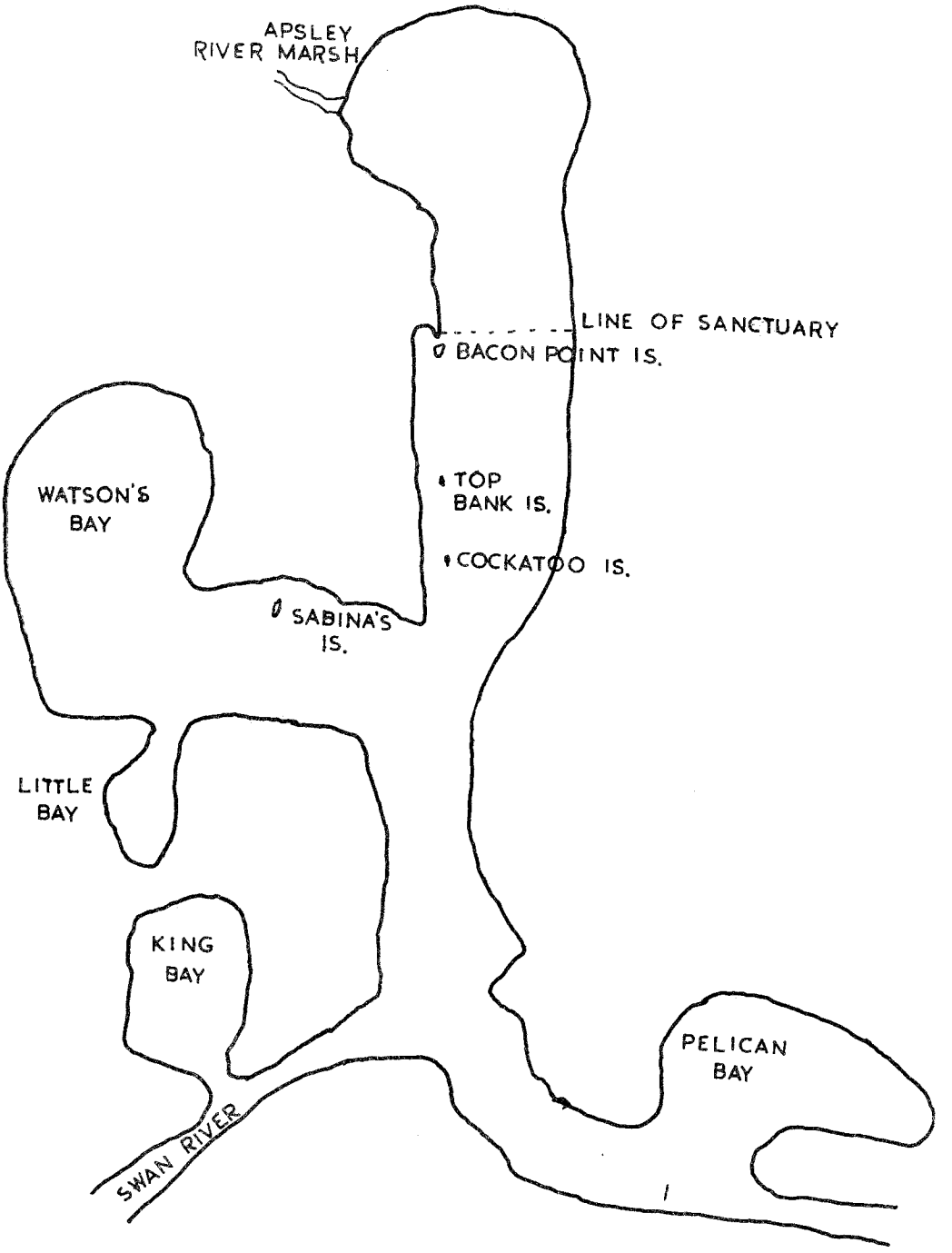

FIG. 1.—Sketch map of Moulting Lagoon, Tasmania, showing localities mentioned in the text.

From this table it is apparent that boat work must be confined to Watson's Bay and parts of Moulting Bay at those times when the water is sufficiently deep to enable an outboard motor to be used. The Apsley River can be used at all times, but it is difficult of access and only a few Black Swans can be caught there. The important populations in Little Bay, King Bay and much of Moulting Bay are quite inaccessible and can only be caught by their being driven out into navigable waters by various methods such as shooting. This method cannot be used in the northern end of Moulting Bay which is a Sanctuary.

There are 11 islands in Moulting Lagoon which are of importance. The largest of these is Sabinas Island in Watson's Bay. This island has scattered *Casuarina* trees with grassy tussocks and is used to some extent in breeding. Three other islands situated in Moulting Bay are of prime importance in breeding. These are Bacon Point Island to the north together with two tussocks adjoining it, with Top Bank Island and Cockatoo Island to the south. Bacon Point Island is of 1 acre in extent and Cockatoo and Top Bank Island are ½ and ¼ acre in extent. In addition to these, there are five islands at the southern end of Moulting Bay which are extensively used by Black Swans. These islands, with the exception of Sabinas Island, are very low lying and subject to flooding.

The shores of the lagoon are mostly low lying and either stony, muddy, sandy or vegetation covered. Only the latter are important to swans and this type of shore forms the minor portion of the edges of the lagoon. In some places there is a reed fringe of narrow extent, but this band may be as much as 100 metres in width and intercrossed by deep water channels. Such a place is from Bacon Point to the Apsley Marshes. These areas are very important for breeding. The shores of Little Bay and King Bay are composed of salt bush, *Arthrocnemon* spp. and *Salicornia* sp., neither of which are of direct importance to the breeding swans. The Apsley Marshes have a dense covering of tea tree (*Leptospermum* sp.) in very low lying swampy ground, the whole interspersed with deep-water channels. The tea tree area is important to breeding at irregular intervals. The upper parts of the marsh are devoid of tea tree but thick with rushes and a small number of pairs of swans are found breeding here.

THE NESTING SITES

1. Apsley Marshes

Nests are constructed, sometimes in large numbers, in the lower marshes and a smaller number of birds utilise the reed beds of the upper marshes for nest building. The area in the upper marsh appears to be used to some extent but they are not a major breeding area.

2. The Tea Tree

The Tea Tree area at the mouth of the Apsley River is used at irregular intervals, the birds building nests on the ground amongst the closely growing trees. Whenever the Tea Tree is used, it is utilised by large numbers of swans. It was extensively utilised in 1963 and 1964.

3. Bacon Point

This area from the Apsley Marshes to Bacon Point is formed of reeds intersected with water channels and is one of the major breeding areas. During 1960 the birds bred on an area at the north end of Bacon Point, but during 1961, 1962 and 1964 this region was used by a few birds only, the majority using an area close to the Tea Tree at the Apsley River.

4. Bacon Point Island

The island consists mainly of reeds with rushes on the eastern shore. There is some grass around the roots of the reeds.

The island was used extensively in 1960, but there were no nests built there in 1961. Few nests were used on this island in 1962 and 1963, but it had 21 nests in 1964. The adjoining mainland had a few nests built amongst the narrow reed belt in 1960 but none in 1961. The two tussocks were utilised each by one pair of birds in 1960 but none in 1961 and again by one pair in 1962.

5. Top Bank Island

The island is very low lying and is without a reed fringe, having some tussocks of grass as the principal windbreak. The absence of reeds is correlated with the rocky shoreline and the absence of mud. This island was utilised in years 1960-1964 but on account of its small size it cannot be a major breeding site, but nevertheless it is fully utilised each year (Plate I).

6. Cockatoo Island

The island is similar in topography to Top Bank Island but is higher, reaching about 70 cm. above water level. It was used extensively during the 1960-1964 seasons (Plate II).

7. Sabinas Island

This island is higher than any of the other sites, never being completely submerged. The vegetation is tussock grass (*Poa* sp.) with scattered *Casuarina* trees. Nests were built here in all the years of the survey.

8. Lagoon Nests

About 90 pairs of Black Swans build their nests in the shallow water on the mud banks and shallows of the lagoon. Most of this activity takes place in parts of Moulting Bay and the number of nests may be a significant proportion of the total, but due to flooding the breeding success frequently is very low (Plate III).

9. Islands at the South End of Moulting Bay

These are five low lying islands close to the eastern shore of the lagoon and are used regularly by breeding swans, but the islands are subject to heavy flooding. They range from 15 square yards to about 1 acre in area.

10. Southern Side of Watson's Bay

The mainland as well as a small island at the southern side of Watson's Bay is used infrequently for breeding. This island, together with (9) above, is subject to human depredations.

11. Lake Island

This is a small islet with a pond in the centre situated on the eastern shore of the lagoon.

THE NEST AND NEST BUILDING.

The first egg may be laid before the nest construction takes place though it is more usual for some start to have been made to the nest before egg laying. In the case of lagoon nests, it is obviously essential to have a nest ready for the egg. The nest is a truncated cone with a hollow cup at the top and it is constructed of various materials. The height of the nest varies considerably on the different sites depending upon availability of material. Where plenty of nesting material is on the site some nests reach 1 metre in height but 70 cm. is a common height. On the other hand, the average dimensions of 37 nests on Cockatoo Island are 14.76 cm. high, base width 94.3 cm. and cup diameter of 14.8 cm. (Plate IV).

Nest building is carried out by the female. The male collects material and brings it to the site and drops it at the edge of the nest. The female then builds it into the structure. The male may rearrange materials occasionally and may move out to the nest after the female has left. The pair have been seen to rest together on the nest.

Lagoon nests are built of the common aquatic weed of the lagoon, *Chara* sp. This is collected by the male and brought to the female who places is in position in the nest. Nest building often takes place about 1½ to 2 hours before sunset and is accompanied by displays on the part of the male. The display made by one male to the female whilst she was nest building consisted of stretching out the neck in front, partly opening the wings and fanning out the tail feathers. The male made a similar display when he climbed on the nest after the female had quitted it.

The nests on Bacon Point and on Bacon Point Island are made either of local materials, i.e., rushes and reeds or of *Chara* or of a mixture of these materials. The nests on Cockatoo Island and Top Bank Island usually are of *Chara* with whatever local material can be gathered. A chronic shortage of nesting material exists on this island.

The nests amongst the Tea Tree are made of bark, rushes, twigs, leaves and flood debris. Some of the nests in this area are well made but others may be only a few centimetres above the general land surface due to a very severe shortage of building materials. These nests are prone to flood damage, even if the water level rises but slightly.

The nest may not be completed when egg laying commences and the enlargement of the nest takes place with the eggs being kept at the surface. In all cases, whenever egg laying is finished and the nest complete, down is laid around the cup of the nest to act as a lining. The eggs are not covered with down as occurs in geese and some ducks. From time to time the lining of down may be partially renewed; and this event always takes place a few days to a week before hatching.

In the early stages of the breeding season the nesting site consists of a number of complete nests, many more incomplete and a large number of scattered eggs which may represent the beginnings of nests or be the eggs of unsuccessful breeders. Some birds lay their eggs on the ground and never build a proper nest but surround the eggs with a low (9 cm.) bank of adjoining material. This is particularly true of Cockatoo Island birds.

The nests are built at varying distances apart, the site being apparently haphazardly selected, some nests being build on the sheltered side of tussocks but others are constructed on open rocky outcrops. The distance between nests may be as close as 1 metre from the edge of one nest to the other. The average distance apart of 33 nests on Cockatoo Island is 162.5 cm. The nests in the Tea Tree are much more widely spaced, the position of the site being governed by the location of trees and creeks.

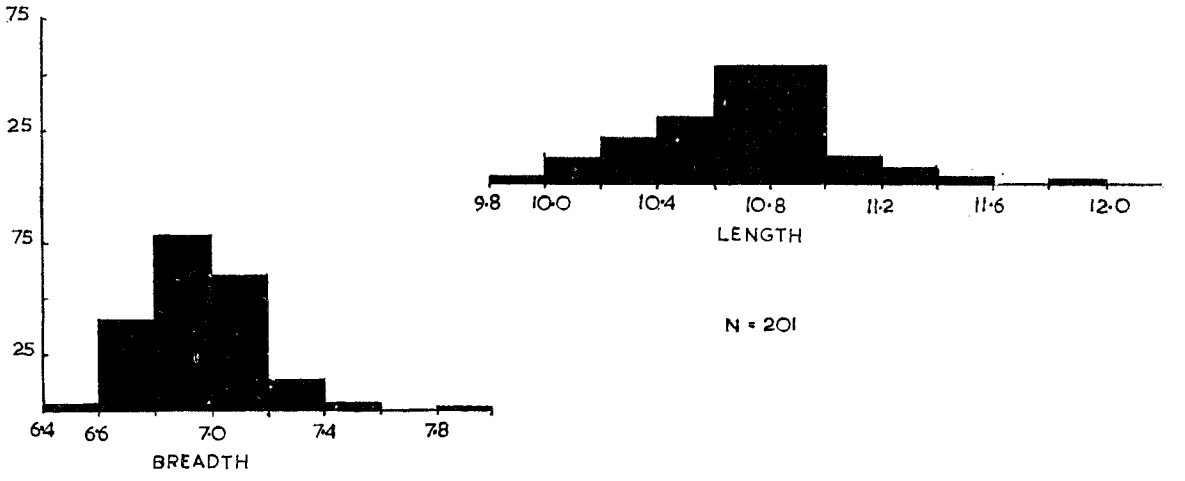

FIG. 2.—Size frequency distribution (in cms.) of eggs of the Black Swan, *Cygnis atrata*, at Moulting Lagoon, Tasmania.

Nesting sites from previous years may be refurnished and used or nests may be re-used in the same season. Material is stolen from other nests and materials from old or abandoned nests are rapidly removed for new work.

Fighting takes place between the males, often on the water. It is doubtful if this is for territorial reasons as the nests are close together but it is likely to be in defence of the mate. The offended male runs over the surface at the offender and just before reaching the opponent he draws his head back to the breast and lunges, endeavouring to catch the offender on the back. If successful he than pulls the offender under water. Generally, the offender is keen to get away from the vicinity. Face to face encounters are unusual. In these fights, the males approach each other holding their heads in a threatening position, wings half open. The birds leap up to 1 metre out of the water, pass each other, striking with the beak as they do so. This is repeated two or more times and the birds eventually settle down a few metres apart. No use is made of the wings in fighting.

The amount of fighting is negligible when the large number of birds in small areas is considered, the general impression being that the Black Swan in nature is a gentle, peaceable bird. This is sharply in contrast to introduced Mute Swans, *Cygnis olor*, on Lake Leake (Tasmania) where vicious fights take place between 18 birds living on several square miles of water.

THE EGG AND CLUTCH

The egg of *C. atrata* varies in colour from a light pale green to a duck egg blue. Freshly laid eggs are covered with a chalky white bloom which wears off the egg in the first few days after laying. The eggs soon become scratched and older eggs may show a light coppery brown hue. Some clutches remain clean but others become very dirty, even shortly after laying.

A sample of 201 eggs range in length from 9.80 cm. to 11.82 cm., with a mean of 10.69 cm. The breadth varies from 6.52 to 7.92 cm., with a mean of 6.98 cm. In 2000 eggs examined in the breeding seasons the smallest egg measured 7.70 cm. by 5.40 cm., and the largest 13.68 by 7.98 cm., with a weight of 496 g. and a volume of 383.5 cc. Sharland (pers. comm.) told me of an abnormally small egg the "size of a table tennis ball" in a nest containing normal sized eggs. The size frequency distribution is shown on Figure 2. The weight of each of 49 eggs ranged from 262.1 g. to 347.2 g., with an average weight of 299.84 g. The volume ranges from 220 to 320 cc. with a mean volume of 252 cc. This is strongly in contrast to the 700 cc. recorded by Romanoff & Romanoff (1949). The shell of the egg is thick, ranging from 0.04 to 0.09 cm. The thickness of the shell varies slightly from place to place on the same egg.

The mean dimensions of the eggs here differ from those of Delacour (1954) and Littler (1910), Delacour giving 11.5 cm. by 6.5 cm. as an average for an unstated number of eggs and Littler recording 10.8 by 6.8 for a clutch of six eggs. It is presumed that the eggs measured by Delacour were obtained from domesticated European birds and might not be representative of the species.

The egg can stand considerable compression without fracture and some flood damaged eggs were found to be sufficiently strong to support a man weighing approximately 190 lbs.

The laying of a clutch is spread over several days and depending upon the number of eggs may take up to 12 days for a clutch of six eggs to be laid. This time is unusually long, a clutch of five eggs taking six or seven days to be laid, but clutches of eight eggs are laid over a period of 10 days. some birds may lay two eggs in a 24-hour period. This may have been due to two females using the nest or to robbing or acquisition of other eggs. The mean clutch size of 579 clutches containing 2,256 eggs from all habitats except lagoon nests is 3.39. More will be said of this later. The largest clutch observed contained 11 eggs, but we have had reports of 12 eggs per clutch. These clutches may be the result of robbing (see below).

Egg laying takes place during both day and night. Observations carried out on Cockatoo Island on 19-21 August, 1962, showed that of 39 eggs laid during this period, 16 were laid between 07.00 and 17.30 hrs., i.e., during the daylight, and 23 were laid between 17.30 and 07.00 hrs.

Nest robbing by Black Swans takes place, several nests containing eggs which originally had been marked in adjoining nests or had been lying on the nearby ground. On one occasion a bird was seen to move an egg into its nest from nearby ground. Some exchange of eggs takes place during incubation.

INCUBATION

Incubation is shared by the parents (Heinroth & Heinroth, 1959) and the non-sitting partner frequently is found close to the nest. Whilst on the nest, the females remain passive but now and then stretches the neck to lunge at other nearby females who respond similarly.

Sitting commences at 42± 1 days prior to hatching so that some eggs in a clutch are incubated for up to four days longer than the most recently laid egg. Thirty-six days was the shortest incubation period noted.

HATCHING AND GROWTH OF CYGNETS.

The hatching of all the eggs of a clutch takes place over approximately 24 hours irrespective of the time of laying of the egg. During this period the first young to hatch remain on the nest pending the hatching of the remainder of the clutch upon which the mother several hours later leads the brood to water. The cygnet is very precocious and is capable of swimming strongly within a few hours of hatching, but the nest is not normally quitted until at least four hours after hatching. Generally, within 24 hours all the young have taken to the water. There is very little variation from the normal lavender grey colour of the cygnet, except the down may be slightly darker in some birds. The mean weight of 84 cygnets on hatching was 186.74 g.

Human interference with the nesting sites causes the cygnets prematurely to leave the nest and move about the site and may cause an early entry into the water. However, the cygnets swim strongly and the parents await them about 20 metres off shore and then escort them away.

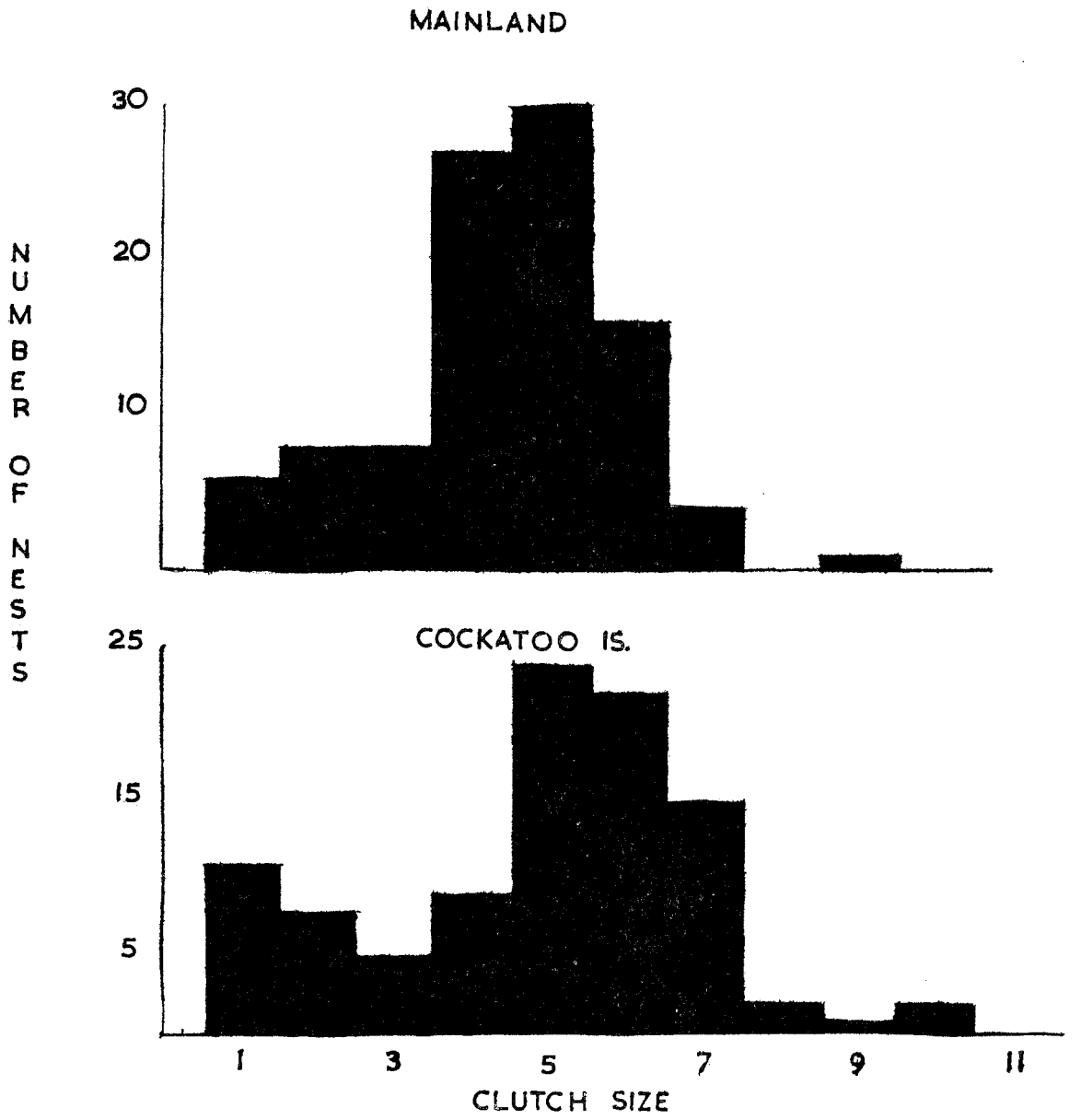

FIG. 3.—Clutch sizes of Black Swan at 520 sites in Moulting Lagoon, 1961.

The growth of juvenile plumage was noted from re-captures during banding operations. The later nestling stages have a greyish brownish tinge to the lavender grey colour of the feathers. The head is the first portion to lose the nestling feathers and this is followed in sequence by the breast, the anterior dorsal surfaces and the belly. During this, the tail becomes more distinct, but the wings are still feeble. The rump is the last part to lose the down. The beak becomes reddish purple and the eye is a light to dark brown with a black pupil. The wings and pinions develop later and the power of flight takes much longer than the development of the feathers.

The juvenile bird is lighter in colour than the adult and frequently the neck bears a few nestling feathers still adhering. The neck in young juveniles is often bicoloured, with an upper light portion separated from the lower dark part by a sharp demarcation line.

There is very great variation in the growth rate of the young bird in the wild. Forty-six cygnets captured from seven to 52 days after initial capture showed a weight gain varying from 3.0 gr./day to 44 gr./day. Seventeen cygnets gained weight at between 0-10 gr./day, 14 between 10-20 gr./day, nine between 20-30 gr./day, seven from 30-40 gr./day and two over 40 gr./day. The weights of young birds re-captured during banding show great variation in the rate of increase from the average. Some birds gain weight very slowly, others extremely quickly and any satisfactory technique to estimate the growth rate has to be designed with this variable in mind.

The time from the appearance of the first feather to the flying stage is about 60 days, though this period varies both within each brood and between broods. Flight is attained slowly, some birds requiring four months from the loss of nestling feathers to flight. One bird was incapable of flight about 11 months after hatching. Most juveniles achieve flight by about six months of age.

MOVEMENTS OF YOUNG

Immediately after the cygnets leave the nest the parents take them away from the immediate vicinity of the nesting sites. In Moulting Bay, the birds move away from the Tea Tree-Bacon Point area towards the very shallow banks on the eastern side of the lagoon, and much of the early life of the cygnet is spent there. From time to time, some cygnets and parents move out of Moulting Lagoon into Watson's Bay. Although the number of birds in Watson's Bay is not usually more than several hundred, there is a considerable turnover of individuals in the population, since banding on subsequent days yields few re-captures.

Not many swans with broods proceed further down the lagoon towards Pelican Bay. A few birds with young have been found there but the great concentration of birds is on the shallows mentioned. Within the lagoon, the birds work upwind into the sheltered localities. However, patches of very shallow water with few waves carry a large number of birds irrespective of wind direction except during gales when the weather shore is sought.

MOULT

There are always a few birds moulting at any time of the year, but in the main moult takes place after breeding during October-November. The project has not shown the proportion of the population that moults every year since relatively few adult birds have been captured as moulters and this shows that all the Black Swans in Moulting Lagoon do not moult there. Non-breeders moult during the latter part of the breeding season before the parent birds have started their moult. This moult of non-breeders may, during bad breeding seasons, be longer than the so-called main moult. The moult, when observed, is complete and the bird is unable to fly due to the loss of, or damage to flight feathers.

NUMBER OF BLACK SWANS

For reasons outlined above it is impossible to estimate the total number of Black Swans in Tasmania, but for game management purposes it is necessary to know the major fluctuations in the population. For this reason Moulting Lagoon and Port Davey were selected as areas for annual counts.

The absolute number of Black swans in Moulting Lagoon was estimated by counts on an aerial survey on 18.12.1961 when some 4000 birds were seen. This was checked by photographs and a total of 4320 birds was counted; the comparative totals are shown in Table 2.

TABLE 2

Black Swan Survey of Moulting Lagoon
11.12.61

	Count	Photograph	Averaged Total
King Bay	200	170	
Swan River	700	500	
Watson's Bay	1000	1350	
North end of Moulting Bay	1100	1200	
Moulting Bay (South end)	1000	1000	
	4000	4320	4150

Subsequent ground observations showed that the number of Black Swans in the area varied greatly from day to day and sporadic aerial surveys of this nature are of questionable value and this work was abandoned.

For comparative purposes and in order to assess the value of Port Davey as a Black Swan breeding reservoir an aerial survey of Black Swan numbers there was carried out (Table 3).

The Port Davey area did not play a major role in the breeding of Black Swans in the years 1961-64. Early reports (Lord, 1927) tell of thousands of Black Swans in Port Davey but Green and Mollison (1961) record a flock of 200 in Bathurst Harbour in 1952 and " dozens " in Hannant's Inlet in November, 1959. Clearly, assuming the early reports are correct, there has been some considerable reduction in numbers in this area since the late twenties. It also is apparent that Port Davey is a resting and feeding site but is not important in breeding.

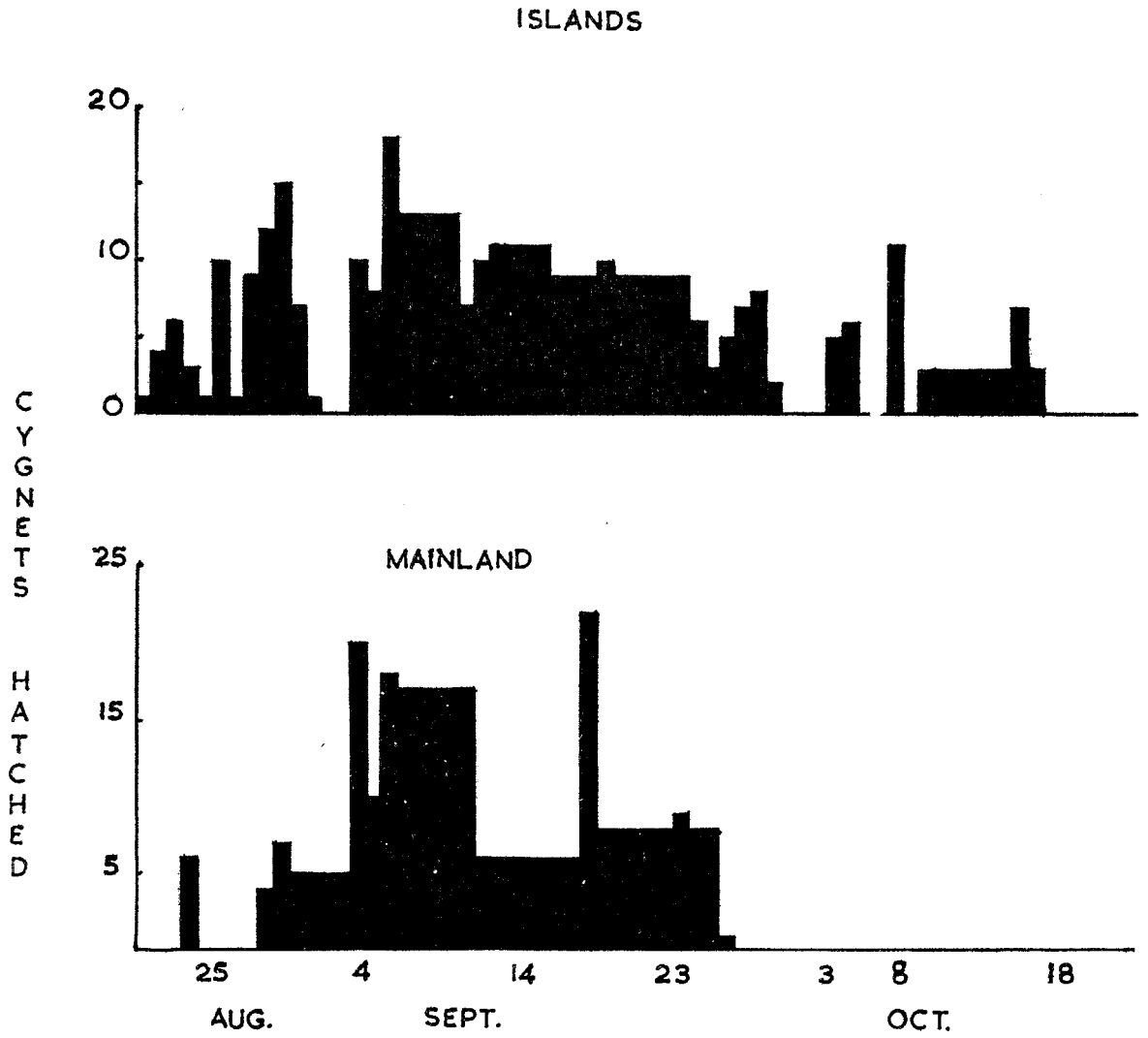

FIG. 4.—Hatching dates in 1961 for mainland and Island Black Swan breeding sites at Moulting Lagoon, Tasmania.

TABLE 3

Aerial Survey of Black Swan Numbers, Port Davey

	27.11.61			19.11.62			29.11.63	8.11.64
	Adults	Cygnets	Total	Adults	Cygnets	Total	Cygnets	Cygnets
Old River	93	6	99	42	0	42	....	....
Moulter's Lagoon	0	0	0	4	0	4	....	....
Bathurst Harbour	13	0	13	34	0	34	....	....
Celery Top I.	10	0	10	0	0	0	....	....
Swan Island	0	0	0	0	0	0	....	....
North Bay	300	6	306	383	0	383	....	....
Narrows	4	0	4	4	0	4	....	....
Joe Page's Bay	47	2	49	89	7	96	....	....
Spring River	100	11	111	0	0	0	10	....
Hannant's Inlet	332	2	334	200	0	200	....	9
Kelly Basin	310	2	312	132	7	139	....	....
Davey River	130	2	132	125	12	137	....	....
	1339	31	1390	1013	26	1039	10	9

By way of comparison the number of Black Swans on Cameron's Inlet on the eastern side of Flinders Island on 6th March, 1962, was counted from the air as over 3,000 birds. The inlet at the time was being used as a drought refuge and food was almost nil but the importance of this waterway as a refuge cannot be underestimated.

A total of 1,053 Black Swans were counted on 12th May, 1963, on the North-West Coast between Woolnorth and Smithton. This area clearly is of importance to this species.

FOOD

Swans are herbivorous but some animal protein is eaten along with the food since gastropods of several species and crustacea are common on the weeds most usually eaten. The Black Swan has no crop and the gizzard is relatively massive and crushes all food materials, rendering recognition difficult. These Black Swans must be shot during early morning feeding and the gizzard contents examined immediately.

The principal food of the Black Swan in Moulting Lagoon is *Chara* species with *Nitella* and *Ruppia* species of importance from time to time. *Salicornia* is eaten occasionally. There was no evidence of food scarcity at any time.

In areas of greater salinity, the food is mainly *Zostera* with *Cymodocea* being of secondary importance. Swans which inhabit shallow areas of salt water appear to feed almost exclusively upon *Zostera* spp.

Black Swans may feed on pasture grasses and on oats if food is scarce in the lagoon or if opportunity for terrestrial feeding is attractive.

THE 1960 BREEDING SEASON

The main breeding in Moulting Lagoon in 1960 took place on Bacon Point, Bacon Point Island, Top Bank Island and Cockatoo Island. Observations were made mainly on Bacon Point Island with subsidiary observations on the other three localities. About 30 nests were constructed and used on Sabinas Island but these were not visited by the author. In addition, a number of nests were constructed in the shallows of the lagoon.

The brief history of the 1960 season was that hundreds of eggs were noted washed out of nests by floods on 18th July and the surviving eggs were hatching on 2nd August. A further laying took place in August and this too was washed out by floods. More eggs were laid in November and December and a successful hatch appeared from this late laying.

GONAD DEVELOPMENT

Regular samples of six birds each were shot in Watson's Bay and Little Bay. The gonads were measured then fixed in Bouin's Fluid. The development of the gonads, based upon testis volume and oocyte size is shown in Table 4.

TABLE 4

Gonad sizes of 38 samples of Black Swans from King Bay, Moulting Lagoon. Testis volume in cc. and oocyte sizes in cm.

	MALE			FEMALE		
Date	No.	Total vol. of both testes	Av. vol.	No.	Vol.	Oocyte size
2.5.60	2	2.30	1.10	4	4.10	0.38
24.5.60	4	6.20	3.15	2	3.50	0.60
25.7.60	3	31.60	9.62	4	8.20	1.03
16.8.60	2	10.00	6.88	3	7.00	0.67
23.8.60	—	—	—	6	26.8	1.13
26.9.60	2	23.00	11.5	6	5.00	0.71

In determining these measurements, the six largest oocytes in each ovary were measured and each sample was averaged on individual mean measurements.

These figures show the development of the gonad but only in one case was a larger egg (5.35 mm.) found in the gonad and the testis in no instance showed a mature condition. The evidence shows that the population sampled in King Bay was in the pre-breeding stages of gonad maturation. At the same time birds were actively mating and laying on the breeding sites. Thus, final stages of maturation take place in the breeding area and there is very little, if any, movement of the population out of the area during the breeding phase.

In general, the right testis is larger than the left but the reverse holds true in many Black Swans.

THE FIRST LAYING

The first visit to the lagoon was on 2.8.1960 when a clutch of five was observed hatching. From later knowledge, this clutch must have been laid between 28th June and 16th July. Local residents state that this laying date was abnormally early, and late July and August is the more normal time. This was the only surviving clutch of the June laying which hatched. The known mortalities are shown in Table 5.

TABLE 5

Number of eggs destroyed by floods in Moulting Lagoon and found on 2.7.1960.

Area	No. of eggs
Cockatoo Island	336
Top Bank Island	102
Bacon Point Island	40
	478

This figure represents the minimum and does not include the large number of eggs washed off the nesting sites which could be seen lying on the bottom of the lagoon.

Egg-laying had re-commenced on 2nd August and 30 nests on Bacon Point Island were in use.

Some of these eggs hatched but the great majority were washed away in a flood on 16th-18th September.

Sporadic breeding by a few pairs took place in October and November, but this was overshadowed by a major egg-laying near the entrance to the Apsley River which took place towards the end of December. These eggs hatched in early February and by 25th February there were a large number of small cygnets in the lagoon.

The details of the August breeding were examined on Bacon Point Island by visits at irregular intervals and Table 6 summarises the results.

TABLE 6

Details of Bacon Point Island Hatching, August, 1960.

No. of nests	109	No. of eggs	494
No. of nests used twice	7	No. of eggs	17
	116		511

Clutches hatched 100%	7
Clutches hatched less than 100%	109
No. of cygnets hatched	61
(or possibly	67)

Reasons for failure of egg to hatch:

1. Addled	6
2. Predated	39
3. Bad mother	24
4. Robbed *ex* another nest	1
5. Broken	0
6. Fallen from nest	5
7. Nest abandoned	25
8. Robbed by another swan	0
9. Incomplete hatching	0
10. Dead cygnet in egg	0
11. Flooded nest	348
12. Eggs buried in nest	0
13. Post natal cygnet death	0
	448

In the above table some of the reasons for egg failures are self-explanatory but others require some elucidation. A bad mother refers to the bird that lays an egg or eggs but makes no attempt to nest build or to incubate the eggs. This is different from the case where a nest is constructed and eggs laid but subsequently abandoned after some incubation (7). There were no eggs noted during the observation period that could be described as infertile, all the addled eggs examined had undergone some development and there was no evidence of infertility.

It is quite clear that the greatest mortality of eggs was due to floods and any other mortalities were of a secondary nature, with predation, nest abandonment and bad mother being the main causes of failure to hatch. Of these, predation may have been unduly high on account of the number of nests which were flood damaged and eggs subsequently predated. Care was taken to ensure that eggs noted as predated were taken from nests containing warm eggs, i.e., used nests, but some error may have occurred. Predation may have been heavier than normal due to our presence on the area allowing the predators better facilities, but flood damaged or abandoned eggs were attacked more frequently than fresh warm eggs.

THE 1961 BREEDING SEASON

The sites used this year contrasted with ones used in 1960. Of last year's breeding sites, only Cockatoo Island and Top Bank Island were used by numbers of birds. Nests also were constructed in the shallows of the lagoon as in 1960. However, the greatest nesting activity was on a stretch of swampy ground, much intersected with narrow water channels situated about 150 yards to the south of the opening of the Apsley River.

Egg-laying commenced on or about 12th July and the first cygnets hatched on 20th August. Greatest laying activity took place in the first two weeks of August. The number of eggs laid on the various sites is given in Table 7.

Egg-laying took place sporadically after the main laying and the latest eggs laid in the study areas were on 16th October on Cockatoo Island. However, it is known that swans have an attenuated breeding season and from the size of one clutch of cygnets banded in February, there must have been some late laying in November. Littler (1910) gives the breeding season as August to December generally, January sometimes.

The number of eggs laid in 1961 is shown in Table 7.

TABLE 7

Number of Black Swan eggs laid at breeding sites in Moulting Lagoon, 1961. The figure in brackets is an estimated total based on the mean clutch size.

Area	First Usage of nest	Second	Third	Total	Total sites	Mean clutch size
Cockatoo Is.	539	155	2	696	152	4.578
Top Bank Is.	100	0	0	105	—	—
Bacon Point	115	5	2	536	122	4.400
"Lagoon"	0	0	0	(362)	93	—

The distribution of clutch sizes is shown in Fig. 3. The mainland clutch sizes follow a normal distribution but those of the islands depart significantly from the normal at more than 1% level. The mean clutch sizes do not differ significantly on a test but a variance ratio test shows a significant difference at the 0.1% level. Thus, the two populations laying on the mainland and Cockatoo Island statistically are significantly different. This difference may be attributed to young females breeding for the first time and laying on the island as being the most convenient place, and also to a preference for the presumably safer and terrestrial predator-free islands.

The hatching data and breeding success are shown in Tables 8 and 9.

TABLE 8

Hatching data for Bacon Point and Cockatoo Island (in italic type) for the 1961 breeding season.

No. of nests	110	*109*	Eggs laid	494	*513*
No. of nests used twice	10	*43*	Eggs laid	37	*181*
No. of nests used thrice	4	*6*	Eggs laid	5	*2*
Total	124	*158*		536	*696*
Clutches hatched 100%	58	*43*			
Less than 100%	53	*72*	No. of cygnets hatched	316	*419*
Reasons for failure of eggs to hatch:					
1. Addled	17	*21*	9. Incomplete hatching	0	*1*
2. Predated	53	*43*	10. Dead cygnet in egg	1	*1*
3. Bad mother	19	*25*	11. Flooded nest	31	*2*
4. Robbed *ex* another	0	*3*	12. Egg buried in nest	0	*5*
5. Broken	0	*2*	13. Post natal cygnet death	1	*2*
6. Fallen from nest	1	*2*			
7. Nest abandoned	51	*48*		174	*150*
8. Robbed by another bird	0	*7*			

The peak of egg-laying occurred during the first week of August but substantial numbers were being laid in the observed 112 nests at Bacon Point in 16th August (34 eggs). However, the number being laid fell rapidly after that date with the second laying appearing on 5/9 and extending to 23/9. The peak of hatching occurred in early September, but was more attenuated on the islands than on the mainland (Fig. 4).

TABLE 9

Breeding success of Black Swans in Moulting Lagoon—1961.

Total number of nests	715
Mean clutch	4.489
Potential hatch	3209
Percentage hatch	63%
Actual hatch	2021 cygnets (429 broods)
Less immediate post-natal deaths	8
Production	2013 cygnets
Mead brood size of 102 broods	3.70
Mean brood size at hatch	4.82
Mortality	1.12/brood
Net production	2013 less 480 = 1530 cygnets

THE 1962 BREEDING SEASON

During this season the breeding sites used were more widespread and more birds participated in the breeding than in either of the previous years. All of the sites were again used but in addition, a number of sites hitherto unutilised during the present survey had nests on them and some birds returned to Bacon Point Island (Table 10).

TABLE 10

Sites used in the 1962 breeding season at Moulting Lagoon, together with the number of eggs laid.

Location	Nests	Eggs	Mean clutch
Cockatoo Is.	100	579	5.790
Top Bank Is.	26	112	4.308
Bacon Point Is.	4	23	5.600
Bacon Point	43	194	4,512
South side of Watson's Bay	56	Eggs stolen	—
Island near above	10	47	4.700
Sabinas Is.	47	232	4.936
South Is.—			
No. 1	119	607	5.100
No. 2	61	303	4.970
No. 3	37	193	5.210
No. 4	18	95	5.270
No. 5	52	258	4.960
Tea Tree	454	1861	4.101
	1021	4504	4.410

The first nests were noted on 2nd August and the first eggs were found on Top Bank Island and Cockatoo Island on 6th August. This was later than in previous years and the birds were slower in reaching the peak of egg-laying (Fig. 5) which did not occur until 19th-20th August.

The weather apparently was suited to swan breeding and no flooding took place. The main cause of mortality was abandonment of the nests with predation being the next most important factor (Table 11).

TABLE 11

Hatching data for Black Swans at two sites in Moulting Lagoon in 1962.

	Mainland	Cockatoo Is.
No. of nests	42	89
No. of sites used twice	0	11
Total No. of eggs	190	464
Clutches hatched 100%	21	45
Clutches hatched less than 100%	21	33
No. of cygnets	131	342
Reasons for failure to hatch:		
Addled	5 = 2.6%	12 = 2.6%
Predated	13 = 6.8%	17 = 3.7%
Bad mother	3 = 1.8%	15 = 3.2%
Robbed *ex* another	0	0
Broken	0	1 = 0.2%
Fallen from nest	0	0
Nest abandoned	33 = 17.4%	57 = 12.7%
Robbed by another bird	0	0
Incomplete hatching	0	0
Dead cygnet in egg	0	0
Flooded nest	4 = 2.7%	0
Egg buried in nest	0	0
Post natal cygnet death	0	0
	58	102

TABLE 12

Breeding success of Black Swans in Moulting Lagoon in 1962.

Total No. of nests	1021	
Mean clutch size	4.410	
Potential hatch	4504	
Percentage hatch	71.826	
Actual hatch (estimated)	3235	734 (broods)
Less immediate post natal deaths (estimated)	25	
Production of cygnets	3210	
Mean brood size at hatching	5.344	
Mean brood size	4.454	
Brood mortality	0.890	
Brood casualties	553	
Net production	2657	

COMPARISON OF 1960-1964 BREEDING SEASONS

The breeding data for the various localities is set out in Table 13.

TABLE 13

Black Swan breeding date for sites in Moulting Lagoon, 1960-1964. *The Lake Is. site was not discovered until* 1964.

	1960	1961	1962	1963	1964
Watson's Bay Is.	....	....	56 nests	....	....
Sabinas Is.	110 est.	....	232	686	3034
Southern Is.	....	....	287	834	1128
Cockatoo Is.	....	....	579	622	515
Top Bank Is.	....	....	112	136	161
Bacon Pt. Is.	....	....	23	52	216
Bacon Point	....	....	194	747	2370
Tea Tree	....	....	1861	1391	784
Apsley Marshes	....	....	(in above)	....	113
Lagoon nests	....	....	....	94	612
Lake Is.	....	....	....	....	101
	....	....	1021	4562	9034

The location of the main breeding effort alters each year but the Tea Tree, Bacon Point, the Southern Islands and, possibly, Sabinas Is. always being important. The reason for this change of site is not known.

THE BROOD

Few cygnets die on the nesting area but a mortarity occurs after the young birds leave the nest. The mean size of 100 broods on hatching in 1962 was 4.82 whereas the mean of 100 broods counted from the air was 3.48 and of 62 captured during the banding operations the mean was 3.93 (average of these last two being 3.7), showing that there was a mortality rate of 1.12 birds per brood.

Interference with the brood does not affect their acceptability to the mother nor does the scattering of the brood due to banding activities prevent the parents from collecting them together, since broods were re-captured intact a day after their original capture. However, in the later stages of the pre-flight period a large number of young were taken which apparently were living separate from either parents or the rest of the brood. This is not the result of banding operations but due to a greater independence of the young at later pre-flight stages and to the breaking up of the brood as some achieve flight.

PREDATORS

The adult Black Swan has not been observed to be attacked by any other birds and must be regarded as free from predators. The main predation takes place during the egg stage and also during the early pre-flight life of the cygnet.

The predation on the eggs is mainly carried cut by the Australian Raven, *Corvus coronoides* (Gould), large numbers of this species being seen around the nesting sites. The ravens take eggs from abandoned nests or those dropped by "bad mothers" and the predation from actively used nests is not great. The Swamp Harrier, *Circus approximans* (Forster) is a similar predator. The importance of lambing in adjacent properties in relation to Black Swan breeding should not be overlooked. Large numbers of Ravens are attracted to either the lambing or swan nesting, depending upon which takes place first. In 1960 there were few Ravens at the islands but large numbers in the lambing paddocks whereas in 1961 the reverse held true.

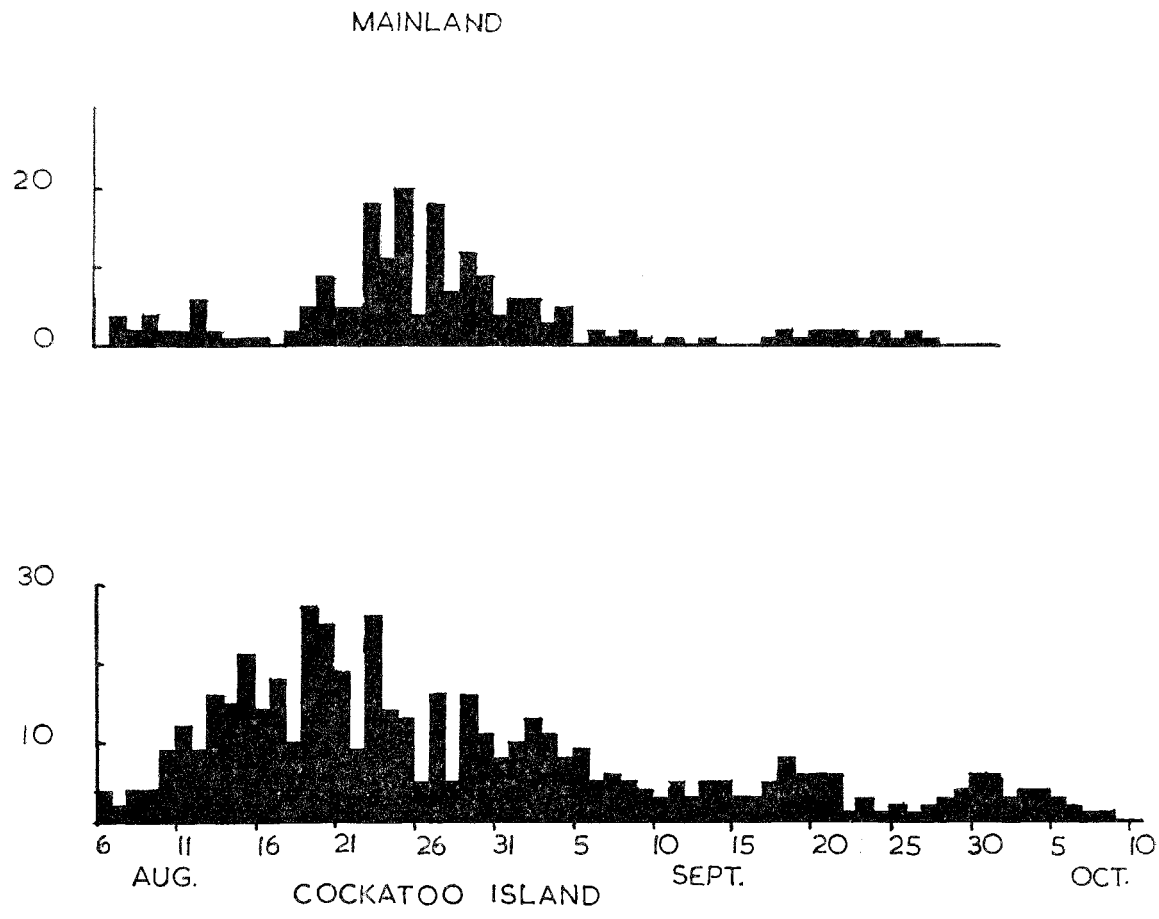

FIG. 5.—Black Swan egg-laying on Cockatoo Island and mainland, Moulting Lagoon, 1962.

Other lesser predators on eggs are the Rat, *Rattus norvegicus* and the Yellow-bellied Swamp Rat, *Hydromys chrysogaster* (Geoffrey). These is no doubt that the Native Cat, *Dasyurus quoll* (Geoffrey) would take eggs given the opportunity but no *Dasyurus* were observed in the nesting area. Frequent pads of the Tasmanian Devil, *Sarcophilus harrisii* (Boitard) occur in the area and these animals undoubtedly would devour such eggs and cygnets as were presented to them. The cygnets usually swim beside the parents but rarely the young are carried on the back of the parent bird. The cygnet is thus liable to predation by hawks should it stray too far from the parent birds. The young cygnet is the prey for the Sea Eagle, *Haliaetus leucogaster* Gmelin. This species has been seen to remove eggs from the nests and one individual was seen to take a live cygnet from Cockatoo Island. The arrival of a Sea Eagle causes great turmoil amongst the adult Swans. Swamp Harriers, Gulls and Terns also kill cygnets, the latter only doing so whilst the cygnets are on the water.

A parasitological and pathological examination was carried out in the laboratory on all swans shot. The only parasite found was *Drepanidotaenia bisacculina*. This is remarkable in that no less than 16 species of Cestode are recorded by Lapage (1961) from the Black Swan together with 19 other endoparasites. The restricted area from which the specimens were collected may be important in this regard and may explain the absence of other species, though banding returns show that individuals may travel very widely.

The number of *Drepanidotaenia* in each Black Swan was counted and the infestations ranged from zero to 500. There was no correlation between the number of worms and the condition of the host, the bird with the heaviest infestation being in "poor" condition, while one with only 50 fewer parasites was described as "very fat". Other birds with no parasites were in 'poor' condition.

The worms varied greatly in size but all the segments in different individuals had reached the same sexual maturity. The same feature was noted by Southwell and Kirshner (1937).

The pathological examination revealed that some birds showed fatty degeneration of the liver and one bird had cirrosis of the liver together with areas of necrosis. In this same bird, the spleen was enlarged with areas of fibrosis and bad scars.

BANDING

A small number (128) of Black Swans were banded at Moulting Lagoon in 1960 and these were ringed with C.S.I.R.O. bands. Further banding work has been carried out and by July, 1965, 4,315 Swans have been banded. The emphasis of banding has been placed upon birds of the year, although moulters have been taken as the opportunity presented itself. The data collected were used for statistical estimations of the cygnet production in 1962 and 1963 using both positive and negative regressions. From this calculation, the number of cygnets at the commencement of the banding was 2,200 and that estimated at the conclusion of the banding was 1,250 (Table 14). The populations estimated from the banding operations differ but slightly from those in Table 9, especially in the estimates made at the commencement of banding.

TABLE 14

Trellis diagram for regression calculation of population of cygnets of Black Swans, Moulting Lagoon, 1962.

		t_2	t_3	t_4	t_5
t_1	65	0	11	8	4
t_2		97	12	13	5
t_3			67	12	1
t_4				106	7
					70

In table 14 the data are grouped into 5 lots, namely t_1—28th Nov. to 1st Dec., 1961, t_2—12th Dec. to 13th Dec., 1961 t_3—9th Jan. 1962 to 10th Jan., 1962, t_4—6th Feb. to 7th Feb., 1962 and t_5—23rd Feb., 1964. The time intervals separating these lots are thus 11, 26, 26 and 16 days respectively. The figures within the trellis represented the number of each group re-captured at the date of operations. The sample was standardised to 100, then

$$r+ = \frac{y^2 + y^3 + y^4 \ldots yn-1}{y^1 + y^2 + y^3 \ldots yn}$$

where y^2 = No. of t_1 birds re-captured on occasion 3

$$\text{and } a_o = \frac{y^1 + y^2 + y^3 + y^4 \ldots yn-1}{r+}$$

$$N^t1 = \frac{10.000}{a_o}$$

The estimated production of cygnets in 1963 also was calculated from the re-capture data (Table 15). It will be seen from these estimates that the population varied from 6,702 to 576 and only on three occasions, namely 11th January, 9th and 22nd February, did the estimated population agree with that found by direct observation, the mean of the estimated populations on these dates being 2,759. If the data are statistically standardised the error in the estimation becomes greater. However, it is to be expected that the number of cygnets will fall during banding operations as further birds become capable of flight.

The difference between the statistically estimated population of cygnets and that gained by direct observation primarily is due to non-random sampling of population which in turn is attributed to the nature of the waterways (Table 1). This error is increased by the changes in wind direction which cause unpredictable movements in the bird flocks. Human activities in the area including the banding operations, further accentuate the non-random nature of the sample. The behaviour of the young also increases the statistical error since mixing the population apparently does not occur constantly and all samples taken later in the year are affected, flying young, leaving the population. It is apparent that the close correlation between known cygnet production and that estimated from re-capture data in 1961 was fortuitous and could have been misleading.

Recoveries of dead banded birds show that about 3% of the cygnet crop dies before achieving flight. This figure is very low.

The returns from shooters have shown that birds banded at Moulting Lagoon have been shot on the North-East Coast of Tasmania as well as on lakes in the Central Highlands. The absence of band returns from the North-West, South and West merely reflects the small amount of shooting in those areas. It can be deduced that some of the Black Swan population moves about this State, which is in contrast to earlier belief (Sharland, 1958). However, the frequency of re-trapping of some individual Black Swans at Moulting Lagoon leads to the conclusion that some birds are fairly static in habits and in the case of one bird it appears likely that it is incapable of flight, having been caught without pinions on four occasions in 12 months.

One banded Black Swan was returned from Flinders Island and two from New South Wales (Corowa and Cowra respectively). No bands have been recovered from Victoria. The extent of the movement of Black Swans to the Mainland of Australia is not known.

MANAGEMENT PROBLEMS

The problems which are of concern to Tasmania are associated with keeping the Black Swan population up to a reasonable level, rather than controlling the numbers. This is in contrast to the situation in Victoria where the Swan population has to be controlled to minimise pasture damage. The New Zealand Black Swans, which are an exotic species, are controlled only in areas of large numbers. Pasture damage occurs sporadically in Tasmania and is only local in nature and is controlled by the issuing of special permits to destroy or frighten the offending birds.

TABLE 15

Trellis diagram for Moulting Lagoon, 1963, based upon re-captures of 1962-bred Cygnets.

Date	8/1	11/1	22/1	2/2	9/2	22/2	15/3	30/4	9/5	16/5	23/5	30/5	6/6	21/6
Pop. Size	6702	2751	1433	1395	2679	2839	998	1042	1840	920	576	956	—	—

	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_{13}	t_{14}	t_{15}	r_t	T_t
t_1	90	2	2	8	10	6	7	9	9	5	6	10	4	3	2	1	1207
t_2	33	1	2	13	14	1	4	3	11	4	6	7	3	1	69	4	1117
t_3	47	5	0	3	6	6	4	6	4	1	6	9	2	59	9	27	1084
t_4	115	0	3	1	6	0	11	7	6	2	8	1	61	27	27	14	1037
t_5	76	2	0	1	4	2	7	5	5	2	1	77	37	39	37	14	922
t_6	246	0	2	0	6	2	5	4	1	0	89	52	24	66	34	13	846
t_7	74	1	0	4	5	1	8	5	1	70	27	24	66	34	13	15	600
t_8	88	0	2	1	4	1	6	0	88	14	37	39	37	14	13	15	526
t_9	70	1	0	1	8	4	0	74	37	39	37	14	13	15	13	15	438
t_{10}	89	0	0	2	3	1	246	39	37	14	13	15	13	15	13	15	368
t_{11}	77	2	1	0	0	76	52	24	66	34	13	15	13	15	13	15	279
t_{12}	61	1	1	0	115	24	66	34	13	15	13	15	13	15	13	15	202
t_{13}	59	0	0	47	66	34	13	15	13	15	13	15	13	15	13	15	141
t_{14}	69	0	33	34	13	15	13	15	13	15	13	15	13	15	13	15	72
t_{15}	13	90	13	15	13	15	13	15	13	15	13	15	13	15	13	15	13

TOTAL BIRDS CAPTURED

CAPTURES

RELEASES

$$N = \Sigma T \frac{N}{\Sigma R}$$

(a) OPEN SEASONS

The Black Swan was the subject of open seasons for many years but from about 1923 until 1958 there were no open seasons. The recent open seasons are given in Table 16.

TABLE 16

List and duration of open season on Black Swan in Tasmania, together with licences issued and bag limits. The kill is estimated allowing each hunter half a bag limit per one day only. This method of kill estimation is based on the fact that most shooting takes place on opening day and on the observations of inspectors when inspecting bags and it is probably an underestimation.

Year	Licences	Duration	Bag Limit	Estimated Kill	Breeding
1958	330	11 days	6/day	990	Poor
1959	1384	8 days	4/day	2768	Very poor
1960	....	closed	....	....	Fair
1961	1406	3 days	6/day	4218	Poor
1962	....	closed	....	....	Good
1963	527	3 days	6/day	266 (400)	Good
1964	836	9 days	4/day	800	Good
				9042	

Most of Moulting Bay was closed in the 1963 season and the number of birds killed (266) is an accurate count based upon bag checks and the figure of 400 is the estimated total for the whole of the State.

The re-opening of seasons, with large kills in 1958 and 1959 resulted in a reduction in the number of Swans in the Moulting Lagoon area and initiated the present investigation. The estimated kill of 2,768 in 1959 followed by the large kill of 4,218 in 1961 resuted in the closure of the season since the latter figure was greatly in excess of the estimated production of 1,530 young Black Swans for that year.

Concern was felt that the Black Swan season occurred at a time when pairing of the adults had taken place and also that most of the shooting took place over the breeding areas of the Swans. It was decided in 1963 to open the season only for areas of relative unimportance to Black Swan breeding, i.e., all of Moulting Bay was closed. In addition, the season was shortened. These measures had the result of bringing the kill down to well below the estimated production for 1963. The same policy was followed in 1964. The significant result of these measures was that the breeding success of the Black Swans increased greatly from 2,657 in 1962 to 3,650 and 7,250 in 1963 and 1964. It is clear that the shooting over the breeding areas is not a desirable feature and should not be permitted.

The apparent success of the restriction of shooting over the breeding grounds led to a more positive approach to the shooting and the season was lengthened in 1964 to enable shooters to take a larger proportion of the crop. In future years the survey of the breeding success should be continued and used as a basis for determining the duration and bag limit of any future season.

During the examination of specimens in 1960 one pellet was found encapsuled in the gizzard and during banding operations two birds were found with broken wings which could have been the result of gunshot wounds. These birds were in good condition.

The shooting pressure upon the Black Swans was assessed during band returns from shooters as an index. The returns of bands from Swans shot in an open season can be used to indicate the shooting pressure upon the species (Table 17.) The samples are too small at present for valid comparisons and the shooting pressures will be the topic of a future contribution.

The rate of exploitation of each year group is low, 1961 being the only year in which the number of bands reached 10%, though it must be remembered that the total number of banded Black Swans was low. The Black Swan population can stand exploitation at this level and as long as the annual kill does not exceed the production there should be no difficulty in maintaining the numbers.

The percentage return of bands from each year is remarkably constant, with the exception of the initial small number of bands in 1960. It is apparent that the population is being shot indiscriminately and over a period there is not a large percentage of any year group being killed.

(b) BREEDING

It has been shown that the Black Swan breeds during the austral winter and thus the nests are prone to the effects of flooding during the winter rains.

The three breeding seasons, 1960-64, are sharply different in the effect of this factor on the success of breeding of the Black Swan. The major cause of the failure of breeding in 1960 was flooding which was responsible for the destruction of 68% of the eggs laid during the early laying. Flooding was responsible for only 5.8% of the egg mortality in one locality in 1962, and a negligible number of nests suffered from this cause in 1963, though early eggs in 1964 were washed off the Lagoon nests and the South islands (Fig. 6).

TABLE 17

Return of bands from Black Swan shooters in Tasmania.

Banding		Recoveries in years following banding					Total Recoveries	
Year	Number	1960	1961	1962	1963	1964		
1960	128							
1961	....	24					24	10.9%
1962	735			CLOSED SEASON				
1963	946	0	7	9			16	1.7%
1964	1000	1	13	13	11		37	3.7%
1965	1634	0	10	18	25	72	125	7.06%
Totals	4315	25	30	40	36	72	202	4.6%
Bands recovered		11.7%	4.08%	4.2%	3.6%	4.4%		

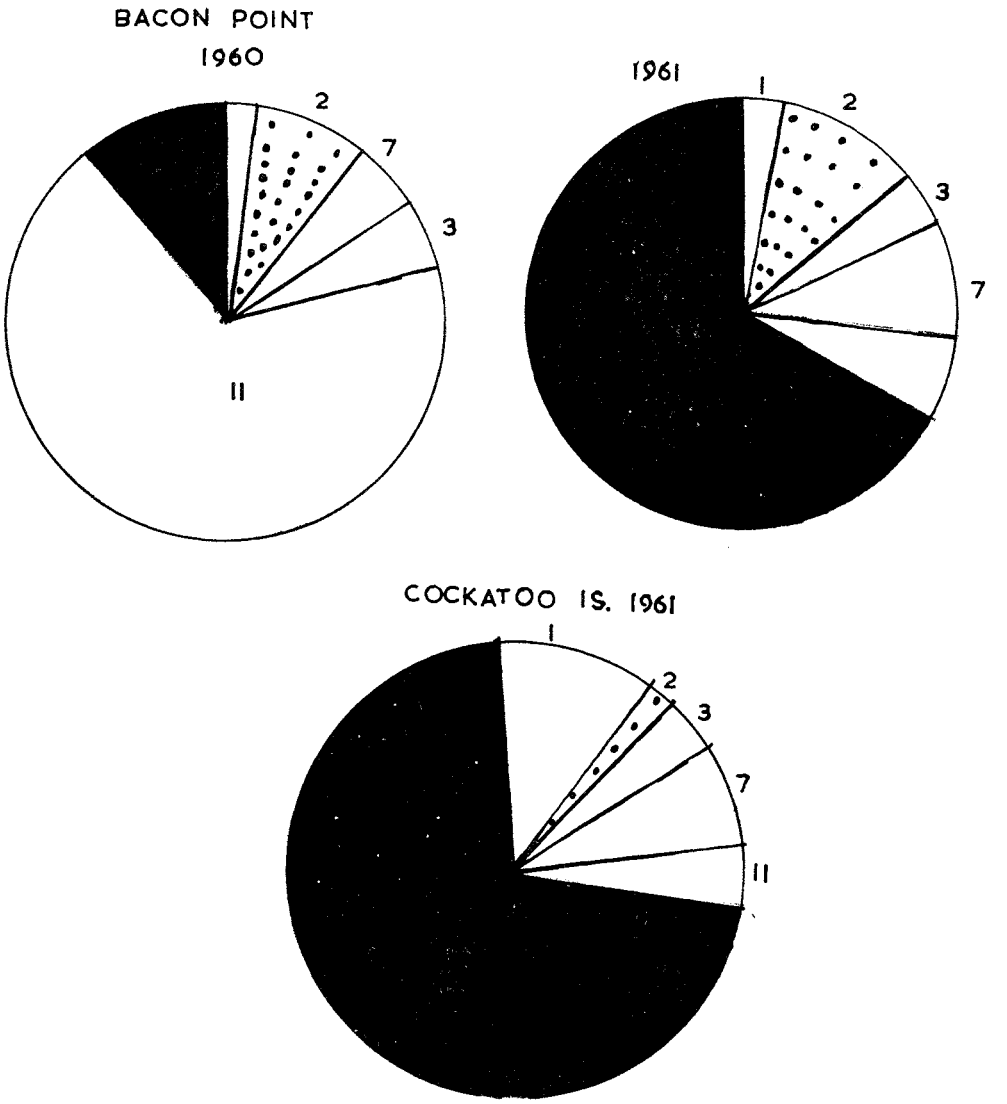

FIG. 6.—Causes of Black Swan egg mortality, Moulting Lagoon, Tasmania, in 1960-61. 1—addled eggs; 2—predated; 3—bad mother; 7—abandoned; 11—flooded; black—successfully hatched.

The floods result from precipitation in the extensive watersheds of the Apsley River combined with south to south-westerly winds and high tides, both coincident with wet weather, which back up the seas at the restricted entrance to the Lagoon. A tide gauge was maintained in the lower Apsley Marshes from 3.5.61-16.10.61 and the normal level of the river was about 9" Recorder Datum (R.D.). The maximum height reached by the water was 6' 4" R.D. and 5' 0" R.D. was exceeded twice. The rise in level may be rapid, a rise of 3' 3" being recorded in 23 hours and small rises of more than 3" per hour were frequent. This latter was associated with the maximum flood of 6' 4". It must be stressed that the winter of 1961 was abnormally dry and these floods were very low and only a small percentage of the eggs were affected. Whenever major flooding occurs the whole nesting area is inundated as in 1960, these floods being estimated to be at about 8' 0" R.D. It is clearly impossible to control these floods and other methods of nest protection have to be used. The raising of the general level of the nesting sites presents difficulties in the mechanical handling of large quantities of materials over muddy shallow water and the most satisfactory method is in the provision of floating nesting sites.

The general pattern of breeding shows that Swans commence egg-laying earlier on the islands and the clutch size laid there is larger than on the mainland. This indicates a preference for islands as breeding sites and the birds even build their nests on the low-lying swamps, this reflecting the shortages of island nesting sites. The provision of suitable floating nest sites, such as rafts, motor tyre tubes, fulfils the apparent preference for island habitats and also is necessary to overcome the flood problem. However, in view of the ability of Black Swans to breed again after floods, it is doubtful if such measures would serve any useful purpose.

(c) GENERAL

The Black Swan is a heavy bird, adults averaging 15 lbs. in weight and the effort of climbing on to an island is accompanied by much scratching with the feet. This causes a reduction in the shoreline of islands and over a period of twenty years Top Bank Island has been reduced to about one-third of its original area. This process has taken place on other islands and the destruction of habitat has reduced the area available for breeding. The placing of stones around the edges of the islands can arrest this erosion.

Some degree of egg-management is currently being practised. There are always a number of eggs lying on the surface of the islands and these are not incorporated in nests and furnish a source of food for scavenging predators such as water rats and crows. These eggs if placed in nests of low clutch size are acceptable to the brooding bird and an increase in the effective clutch size can be obtained by this method. Only one egg is placed in each nest and each egg has to be placed in a clutch which has not commenced incubation. Disturbance of the nest causes little upset to the breeding birds and does not cause undue nest abandonment. Undoubtedly some nests were abandoned as a result of our activities in 1960-61 but the 1963 season, when the examination of the nests were less frequent, saw few nests abandoned by the birds. The Black Swan is not an easy species in which to inhibit breeding and any breeding disasters within the normal breeding season are countered by a subsequent egg-laying.

The relation between open seasons and the subsequent efficiency of breeding has occupied much effort. The shooting season takes place in April, this month being considered suitable because the young birds of the year are able to fly by that time and there are no nests being constructed for breeding. The gonad examination showed that development of the gonad may commence in February and pair formation takes place in March-April, but nest building does not commence until July. The period of the open season thus interferes with pair formation and may break established pairs. The traditional main hunting areas are King and Little Bays in the southern part of the Lagoon and Moulting Bay, the northern end of which is a Sanctuary where hunting is forbidden. These hunting grounds, particularly in Moulting Bay, coincide with much of the breeding area of the birds and consequently the April season not only disrupts pair formation but the shooting and disturbance takes place over the breeding sites. After the 1958, 1959 and 1961 open seasons, the breeding was poor, but in 1960 and 1962 when there was no shooting, the breeding was fair to good (Table 16). This was believed to be due to the effects of the shooting. It was decided in 1963 to hold a short open season but as an experiment to close Moulting Bay, Little Bay and Watson's Bay to shooting so that the paired birds would be protected and only the non-breeders and a minimum number of breeders would be liable to shooting. The 1964 restricted season was followed by the best breeding observed to date and, following similar restrictions in 1964, even better breeding results were obtained. The climatic factors associated with the 1963 season did not fulfil the conditions one might expect for good breeding, being abnormally dry with low rainfall, and local residents agree with this conclusion. It is hoped to persevere with this unpopular disruption of traditional shooting to check further the validity of this conclusion.

Illegal egg-taking by poachers takes place from time to time, especially on the islands at the south end of Moulting Bay and the island at the southern side of Watson's Bay. It is not possible to assess the extent of this depredation but it is not believed to be great and is controlled by policing. The theft of eggs from nests is not serious as long as all the eggs are removed, as the birds will, after some delay, lay again. It is the practice however to leave one egg in a misguided attempt at conservation. This should be discouraged.

SUMMARY.

1. A list of the main breeding areas in Tasmania is given and the nest, nest building, egg and clutch are described. The mean dimensions of 201 eggs are 10.69 x 6.98 cm. and the average weight is 299.84 g., with a mean volume of 252 cc. The clutch size of 579 clutches in 1962 was 3.89.

2. The incubation period was 39± 2 days and notes are given in the growth rate of cygnets which

may gain weight at a rate of 30g/day, and some young can fly at 60 days from the appearance of the juvenile plumage, though many birds take longer.

3. Aerial surveys to estimate the number of Swans were carried out successfully for small numbers of birds and showed the Port Davey area to be insignificant as a breeding source in 1961-62.

4. Details of the breeding season 1960-62 in Moulting Lagoon are given and floods were found to be the main source of mortality and egg loss. Other factors form a small percentage of the total and inadvertent interference with the nests may render a considerable proportion of these eggs liable to predation or nest abandonment.

5. The breeding success for 1961 and 1962 is tabulated and was 1,330 and 2,657 cygnets respectively. The data gained during banding operations gave a statistical estimate of 1,250 and 2,759 respectively.

6. The principal predation occurs at the egg stage and is carried out mainly by ravens and hawks with mammals being an unimportant subsidiary. The time of lambing on adjacent properties can be important in reducing avian predators, particularly ravens.

7. The open seasons and game management problems are interrelated and show that shooting over the breeding ground has an adverse effect on breeding and an experimental season of shooting with the breeding grounds closed was followed by a successful breeding season.

8. Swans prefer to use island nesting sites and the population using islands statistically is significantly different from that using the mainland. Auto-destruction of habitat is taking place on the islands due to the scratching by birds as they leave the water.

9. Egg management can be used as a means of increasing the effective clutch size.

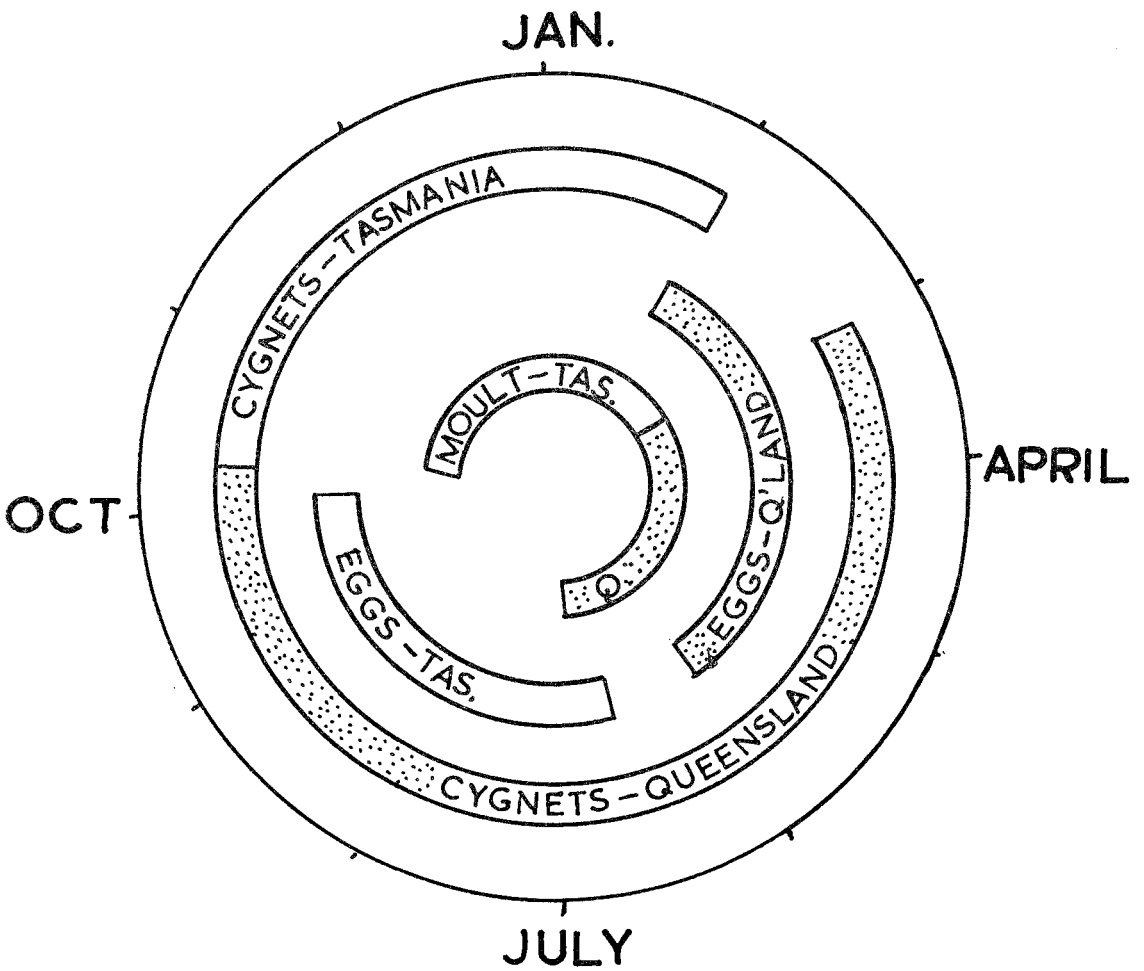

FIG. 7.—Comparison of annual activity of Black Swans in Tasmania and Queensland.

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ADDENDUM

Since the above was written, a paper by Lavery (Wildlife in Australia, 2, pp. 23-5) gives some comparisons with the Queensland Black Swan population. It is apparent that the Queensland birds are lighter in weight than those in Tasmania, Lavery quoting 10 lbs. for the female and 12 for the male. It is also apparent that the breeding success is lower, only about 4 young hatching from 7 eggs per nest. This is attributed to predation by crows. The provision of extra habitat at Bowen has resulted in a large increase in Swan numbers.

The annual activity cycle of the Queensland Swans is sharply different from that in Tasmania (Fig. 7). Egg-laying and the consequent presence of cygnets is almost six months out of phase with the Tasmanian birds. Although the physical presence of rainfall does not stimulate breeding it is clear that both the Tasmanian and Queensland populations of Black Swans breed at times during which the seasonal rains are likely to be encountered, though this is less likely to be important in the Tasmanian population where the rainfall is more equably distributed throughout the year. Drought refuge flocks, important in Queensland, are not identifiable as such at Moulting Lagoon but can be seen at Flinders Island. It appears that the moulting season is much longer at Moulting Lagoon, extending through most of the year but with a peak occurring at post breeding whenever the parent birds undergo moult.

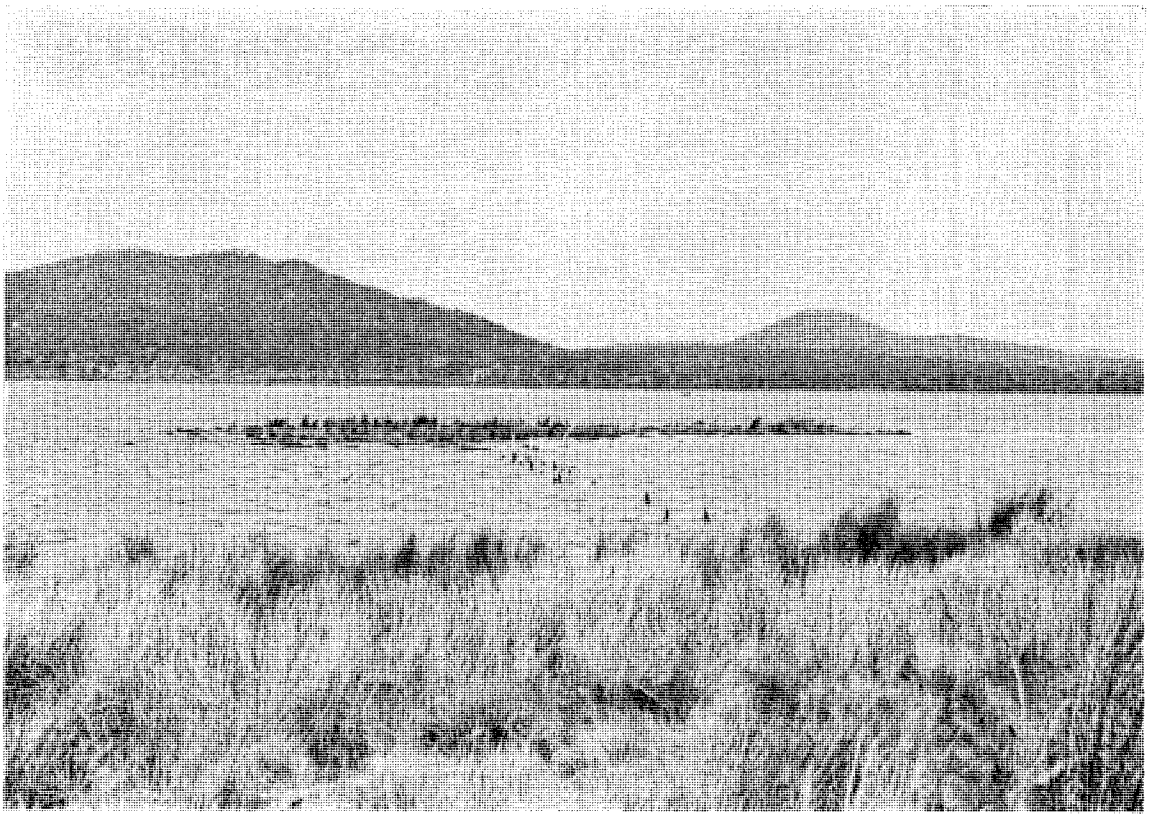

PLATE I.—Top Bank Island, Moulting Lagoon, September, 1960. Although very prone to flooding, this island is not the first breeding site to suffer inundation.

PLATE II.—General view of Black Swan breeding on part of Cockatoo Island, August, 1961, showing nests and nest markers.

PLATE III.—A Lagoon nest constructed of *Chara*, off Top Bank Island, August, 1961.

PLATE IV.—Nest of Black Swan, Cockatoo Island, August, 1961. The three eggs in the background are those laid by a "bad mother".