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THE SURVIVAL OF EIDER DUCKLINGS (SOMATERIA MOLLISSIMA L.) HATCHED ON COQUET ISLAND (NORTHUMBERLAND) IN 1975

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INDEX

Page;

PART ONE

INTRODUCTION

Recent studies on the reproductive rate of the common eider, Somateria mollissima at Forvie, Scotland, have revealed a fluctuation in the percentage survivals of the ducklings, with many years of very poor survival (less than 4%) being interspersed with years of good survival (20 - 40%) (Milne, 1974).

The overall effect of this survival pattern has produced a steady increase in the adult population, checked only through the low recruitment of young, or the occasional, excessive adult mortality.

The primary cause of the low survival of these ducklings has been attributed to the severe gull predation observed in the large creche systems. These systems are thought to be necessary to enable females and ducklings to utilize different feeding grounds, at the same time of day (Gorman and Milne, 1972). Campbell (1975), working on an eider population on Spitzbergen, has also found a low survival of ducklings which he attributes to gull predation. Unlike the Scottish population, where greatest predation occurred on the water, Campbell found predation greatest between the time of hatching and the time of ducklings leaving the nest. He suggested that the lack of ground cover and the relatively high density of nests on Spitzbergen, compared with that found by Milne (loc. cit.), increased the vulnerability of the ducklings in the nest. He further suggested that, on arrival at the water, the rapid dispersal, away from the nesting ground, reduced the chances of predation amongst the Spitzbergen ducklings, while those in Scotland remained close to the nesting ground, concentrated in creches.

The breeding population of eiders on Coquet Island (Northumberland) is about one fifth of that counted at Forvie and therefore sampling of the Coquet population is not necessary. It forms a discrete unit with breeding areas to the south of the island not being recorded. To the north, apart from a few pairs (maximum of 10) nesting at Dunstanburgh Castle, the nearest breeding ground is located, 30 kms away, on the Farne Islands.

Unlike the Forvie population, after hatching, the majority of these ducklings remain in their separate broods, accompanied by the female. The present study was carried out to investigate the percentage survival of ducklings, hatched on Coquet Island, in 1975. The distribution of mortality, with age, and the feeding behaviour of the ducklings were studied in an attempt to provide a possible explanation for mortality, within single broods, once they have left the island.

PART TWO

STUDY AREA

Coquet island lies approximately 1.5 kms. off the coast of Northumberland, opposite Amble. It forms the most southerly of two large breeding areas known, for the common eider duck, along the east coast of England. The other area is located on the Farne Islands, approximately 30 kms. north of Coquet Island. (see Map. 1.)

Some 30 kms. of coastline, stretching north and south of Coquet, from Castle Point to Snab Point, formed the general study area.

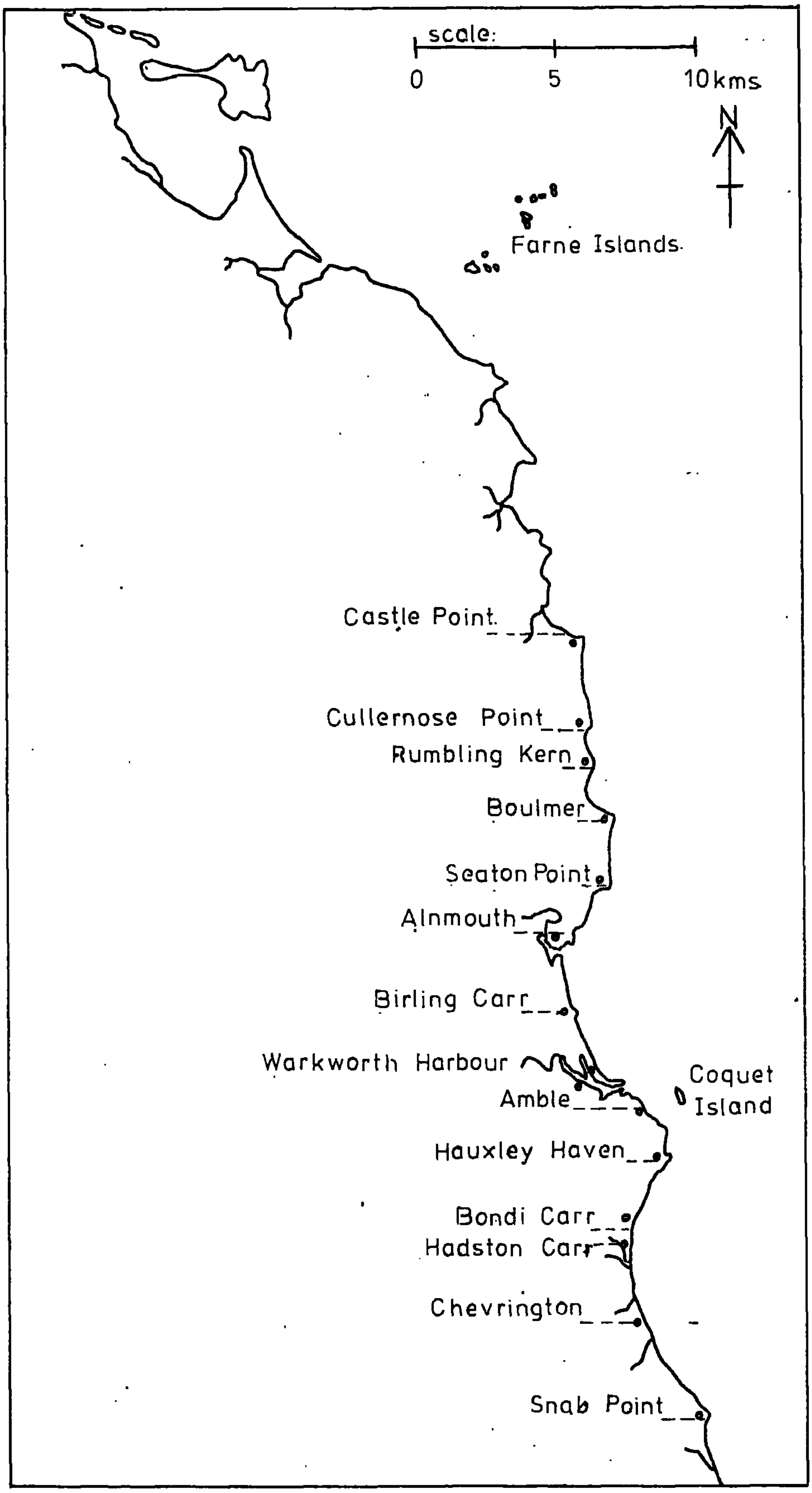
Within this area, an intensive study area was maintained, which stretched from Birling Carr to Bondi Carr and included Warkworth Harbour, the estuary and flood plain of the river Coquet. (See Map. 2).

The estuary is flanked, on the northern side, by a mature salt marsh and dune system, stabilized by a mixture of marram grass tussocks, (Ammophila arenaria.) and lyme grass, (Elymus arenarius). This region provided good coverage for daytime brooding and roosts at night.

The southern side of the estuary is bounded partly by the A1068 and partly by the Amble quayside.

At low tide a large expanse of mudflat (approximately 10ha) is exposed which supports a fauna including Hydrobia spp., Nereis spp., Corophium volutator, Gammaridae, and a dense vegetation of Ulotrichales which is present as an algal mat.

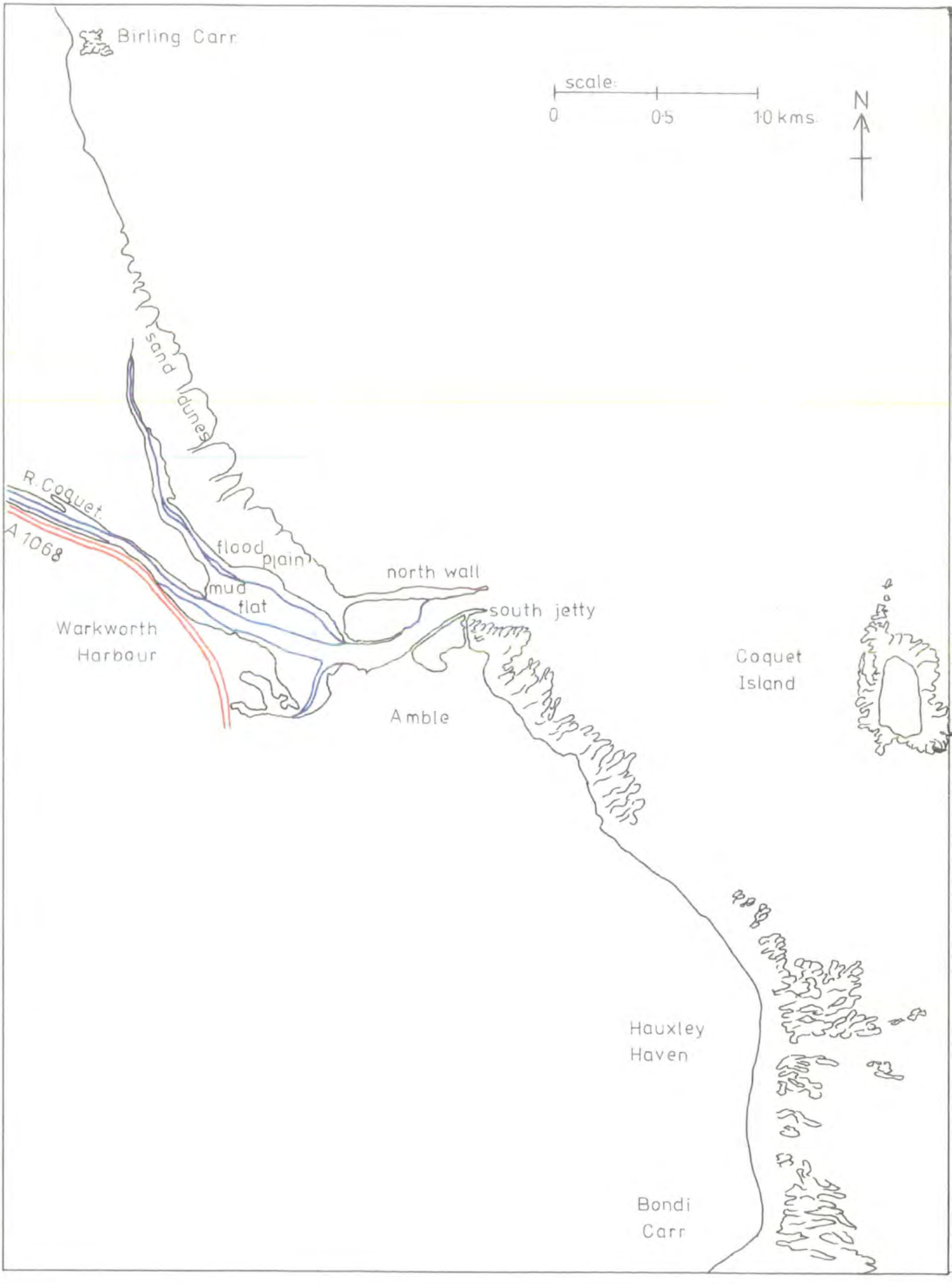
Map 1: Coquet Island and the general study area in relation to the Farne Islands.



key:-

• ~ Observation stations within the general study area.

Map 2: Coquet Island and the intensive study area.



Edible mussels (Mytilus edulis) are also found on the river beds, but not in large quantities.

The estuary opens out into the harbour. Along the north wall of the harbour fallen boulders support a dense vegetation of Fucus spp. Mussel beds are also well established along this wall. Other mussel beds, within the intensive study area, are sited at Birling Carr, Amble, Hauxley Haven and Bondi Carr. These areas provided feeding for the adult eiders, while the ducklings fed, more often, in the estuary and harbour areas.

Fresh water, which the adults and ducklings used for drinking, was available from the river Coquet and from an outlet at Hauxley Haven.

PART THREE.

METHODS

3.1 General Observations.

The study was begun in early May 1975, approximately four weeks before the first ducklings hatched, and was continued until late August 1975, by which time the majority of surviving ducklings hade fledged.

Within two days of hatching, the eider ducklings leave Coquet Island and are brought across to the mainland. This behaviour enabled the study to be carried out from the mainland.

Throughout the study period, the intensive study area was searched, daily, for adult and young eiders, using binoculars with X8 magnification, and where necessary a telescope, mounted on a tripod, with up to X30 magnification.

During each census details of the time of day (British Summer Time), tide and weather conditions (e.g. wet or dry, sunny, overcast or misty) were noted. The number of adult males and females, one year old males and females and ducklings, together with their activity and position, within the intensive study area, were also recorded.

In addition to the daily counts a weekly census of adult and young eiders, present within the general study area, was taken to follow the dispersal of eiders from the breeding ground.

The weekly census was always taken when light was good, and, where possible, at high water when most of the eiders were on the water.

Fifteen census stations along the general study area enable its entire coastline to be observed. (See Map.1). When calculating the survival values for ducklings, those found out of the intensive study area were also included. The activities recorded for the eiders were feeding, (whether by diving, dabbling or drinking), resting on land, exposed rocks or floating on the sea.

3.2 Methods for Estimation of Adult Population.

The size of the mature adult population was observed directly from daily counts of birds seen, on the water, within the intensive study area. Birds on the island, "behind" the island (i.e. to the east side of the island), or those within approximately 0.1 km. of the island's shore, were not included in the counts since these could not be distinguished.

Difficulties in counting flocks of eiders were encountered, at Hauxley, when the sea was rough. On such days, waves temporarily concealed groups of eiders, thus increasing the possibility of counting the same group twice, or not at all.

To reduce this error, counts were made from the top of sand dunes (approximately 6.0 m above sea level) to give maximum height to the observer. Counts were repeated and when possible taken on the ebbing tide when the sea was calmer.

Throughout the whole study period there were no more than twelve days with rough seas. This difficulty in counting was not present within the harbour area.

At the beginning of the study period the breeding plumages of the adult male and female eiders made distinction clear. Towards the end of July the adult males went into eclipse plumage and distinction from the females was more difficult. This was particularly found when males and females were present in flocks, out at sea. Good light and a telescope were then essential for counting.

One year old male eiders were distinguished from the mature male by their mottled brown, black and white plumage. The one-year old female eiders were more difficult to distinguish from the mature female, the absence of a speculum on the wing being a characteristic of the one-year old females.

3.3.Methods for estimation of Breeding Population.

The total number of nests on Coquet Island, for 1975, was obtained (J.C.Coulson, pers. comm.) and this figure was used as the number of females breeding.

Where the total number of nests has not been available (e.g. Milne 1974), an approximation of the number of breeding females in the population has been obtained by using the difference between the maximum and minimum of the "dip" in female-numbers occurring in late May when they leave the water to participate in nesting activities.

The number of females left on the water during this period are those which were unsuccessful or non-breeders. The converse of this is not true, the number of females leaving the water include females which associate with the breeders, termed "aunties", and would therefore give an overestimation of the number of breeders.

3.4 Methods for Estimation of Duckling Population.

The majority of ducklings remained in their individual broods, attended by a female and sometimes one or more "aunties". Some broods amalgamated to form small creches (the largest being 34 ducklings) which in some cases were stable and probably formed before or at the time of leaving the island, while others were unstable, breaking down and reforming in different groups.

Full day observations, to study the structures of these creches, were insufficient to reduce the errors involved when calculating the decline in brood size, a technique used for calculating mortality. It was, therefore, necessary to record the numbers of ducklings and allot them to age classes.

The very slow growth of the ducklings made the use of standard age classifications of waterfowl (e.g. Southwick 1953) oversimplified. A scheme was devised based on changes in down colour and size (comparable to adults) observed in a known brood of ducklings. (Table. 1).

The age classes used were seven-day periods, but after the first few weeks difficulty in distinguishing between the classes arose and the age intervals altered to fourteen day periods. After about the seventh week of life some of the surviving broods were recognised individually and these aided in the ageing of unknown broods.

Age class weeks.	Description.
0 - 2	very small ≏ $\frac{1}{8}$ - 1/6 size of adult. dark brown - black down. head markings distinct.
3 - 4	≏ $\frac{1}{4}$ size of adult. down lighter in colour. head markings less distinct.
5 - 6	≏ $\frac{1}{2}$ size of adult. down light brown - no head markings. 1st signs of feathers on flank.
7 - 8	≏ $\frac{3}{4}$ size of adult. down - patchy on head. feathers more predominant.
9 - 10	almost full size of adult female. feathers dark brown - overall colour darker than adult female.

<u>TABLE I</u>: AGE CLASSIFICATION SCHEME.

By allotting the ducklings to these age groups the maximum number of ducklings of each age group, observed in each week can be found and survivals estimated from the totals. This method of counting and ageing does not take into account the number of ducklings which died before leaving the island or those which came to the water and disappeared between counts. The totals found for each age group thus represents an estimate of the minimum number of ducklings known to have survived through each week.

In conjunction with the records of live ducklings, records of dead ducklings were made. Every second day, after high tide, the tide-line, for the whole of the intensive study area, was searched. Records were kept of all the dead birds found, noting the date, state of the bird (whether fresh or old; complete or remains).

The birds were marked (by removing the right leg) and buried, to avoid recounting. Measurements of leg length and age estimation were made for dead eider ducklings.

A series of dawn to dark studies were made, observing particular broods throughout the day, to observe any deaths within the broods and the cause of death.

3.5 Methods of Studying Feeding Behaviour.

The feeding behaviour of adults and ducklings was studied, noting feeding grounds and general feeding times in relation to time and tide. A series of twenty dawn to dark studies were made to record the daily feeding activity, (expressed as the percentage of birds feeding at intervals throughout the day), of a) male eiders, b) female eiders without ducklings, c) female eiders with ducklings
d) ducklings.

A qualitative analysis was made of the faeces of ducklings and females, collected after periods of brooding.

PART FOUR

RESULTS AND ANALYSES

4.1 Adult Population.

The average, maximum and minimum numbers, and ratio of the numbers of males per 100 female adult eiders, observed on the water, throughout the months of May to August, are presented in Table 2.

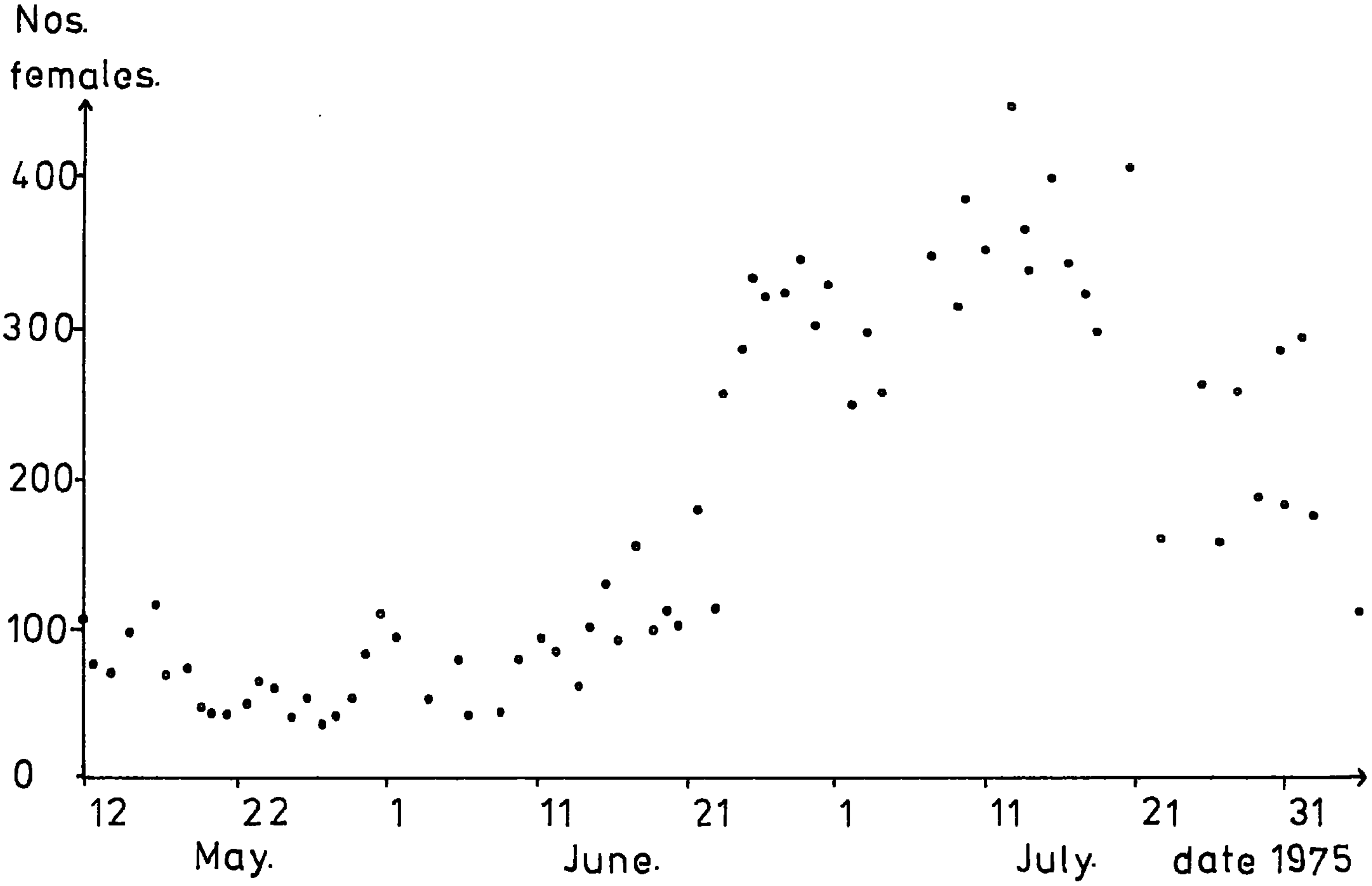
Over the whole study period the maximum number of females observed was 443 and the maximum number of males was 476; a ratio of 107 males per 100 females.

During May, departure of females, to participate in nesting activities on the island, created a "dip" in numbers, which rose again in early June when ducklings were brought to the mainland. (Graph 1a).

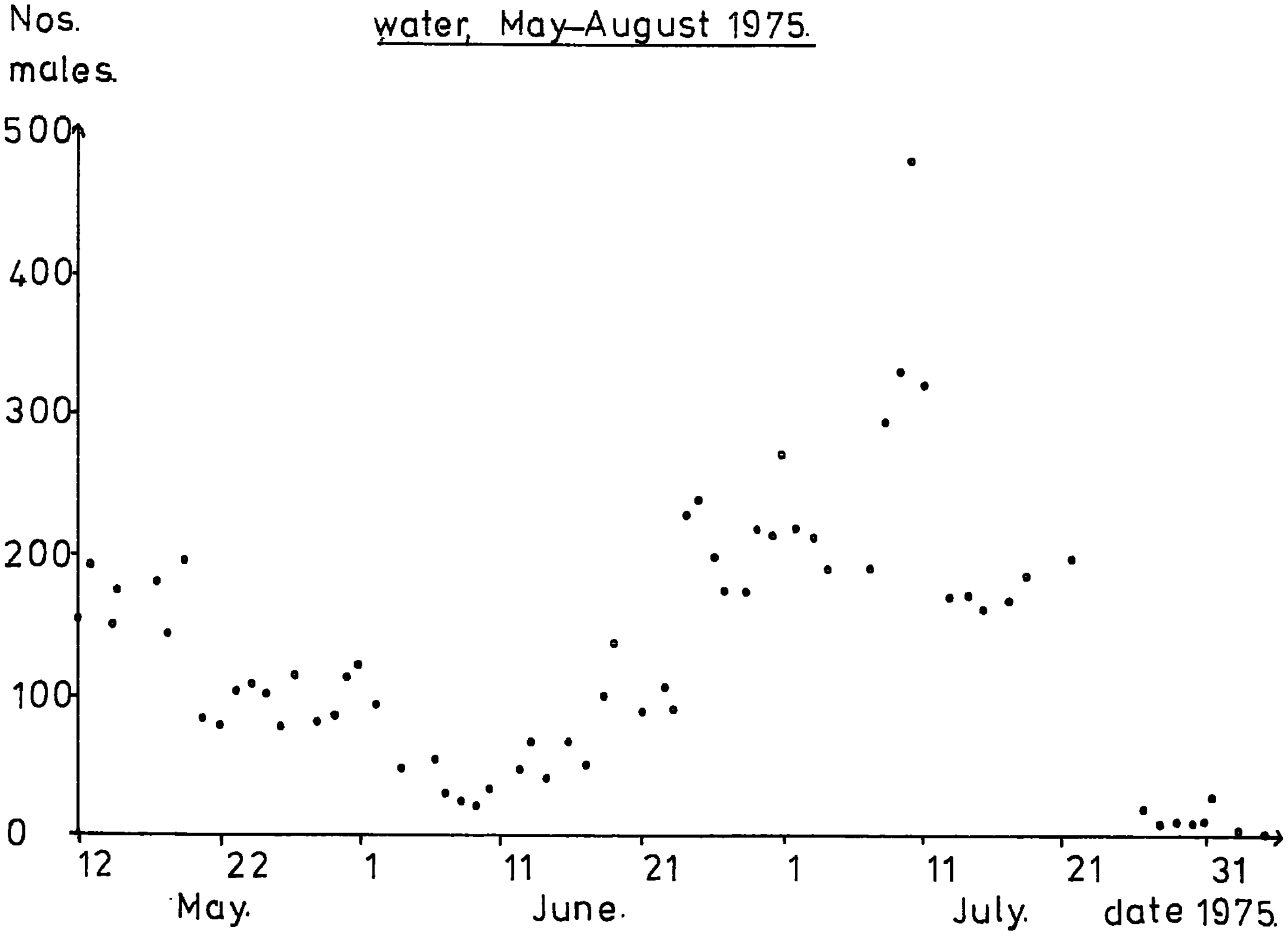
A further drop in numbers appeared in late July, when the females observed tended to be those with surviving broods, or "aunties" associated with the broods. The non-breeders and unsuccessful breeders had moved away from the breeding area by mid-August.

"The "dip" in the number of females was followed in early June, by a drop in the number of adult males seen on the water, (Graph 1b), which rose again by mid-late June. Towards the end of July the number of males dropped suddenly. Large numbers of males disappeared from the breeding area within the same day, flocks of 100+ being observed further north in the general study area. By the end of the study period no males were seen in the graph 1(a-b).

1a) Number of adult female Eiders counted on the water, May–August 1975.



1b) Number of adult male Eiders counted on the water, May–August 1975.



DATE 1975	Maximum Numbers			Minimum Numbers			Average Numbers		
	Nos males	Nos. females	Ratio m/100f	Nos male	Nos females	Ratio m/100f	Nos males	Nos females	Ratio m/100f
12 - 31 May	34	33	103.0	196	113	173.5	120±11	63±6	190.5
1 - 23 June	18	31	58.1	136	178	76.4	64±7	89±8	71.9
24 - 25 June-July	64	85	75.3	476	443	107.4	206±18	290±18	71.0
26 - 14 July-August	7	69	10.1	28	291	9.6	15±3	182±22	8.2

TABLE 2: Numbers of adult male and female eiders observed on the water - 12 May - 14 August 1975.

intensive study area.

The difference in the behaviour of male and female eiders is shown in the variation of the sex ratio, (expressed as the numbers of males per 100 females seen on the water), throughout May to August (Graph 2).

Four distinct phases are present. During early-mid May the sex ratio was high. This represents the period of incubating when the females remained on the island, and the males stayed within the breeding area.

Between mid-May and early-June, the ratio decreased as the hatching period progressed and females left the island with their broods. The males remained in the breeding area during this period. Towards mid-June the number of males per 100 females, was fairly constant but low, ranging from 50 - 90 males/100 females. This can be accounted for by the daily disappearance of some males from the breeding ground, presumably going north to feed, flocks being observed further along the coastline. The remainder of males stayed around the island until late July, when they went into eclipse plumage, and then left the study area, the sex ratio falling to zero by mid-August.

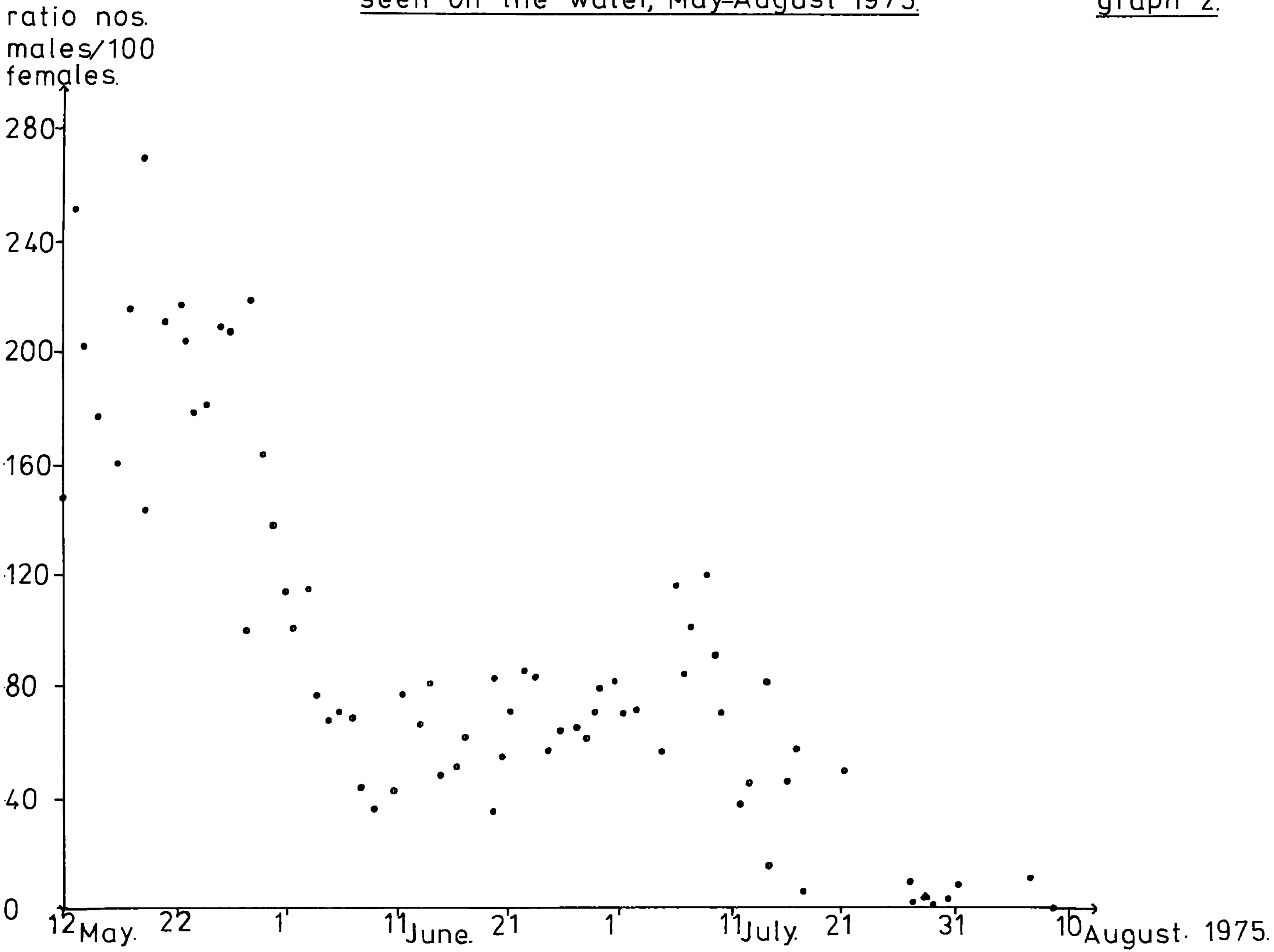
The total number of one-year old eiders observed did not exceed twelve at any one time. Seven males and five females were distinguished from the adult eiders.

4.2 Breeding Numbers.

The number of nests made on Coquet Island was 240 (J.C.

Ratio of the number of males per hundred female Eiders seen on the water, May–August 1975.

graph 2.



Coulson pers. comm.) and this figure was taken to equal the number of breeding females. Thus some 54% of maximum number of females observed were breeding.

The difference between the maximum and minimum of the "dip" observed in the numbers of females in May, gave an estimate of 412 females leaving the water. The number of unsuccessful breeders and non-breeding "aunties" included in this estimate therefore, produce a considerable error of some 200 females.

4.3 Duckling Population.

The potential duckling population was estimated from the nest number on Coquet and the average clutch size recorded for 1975.

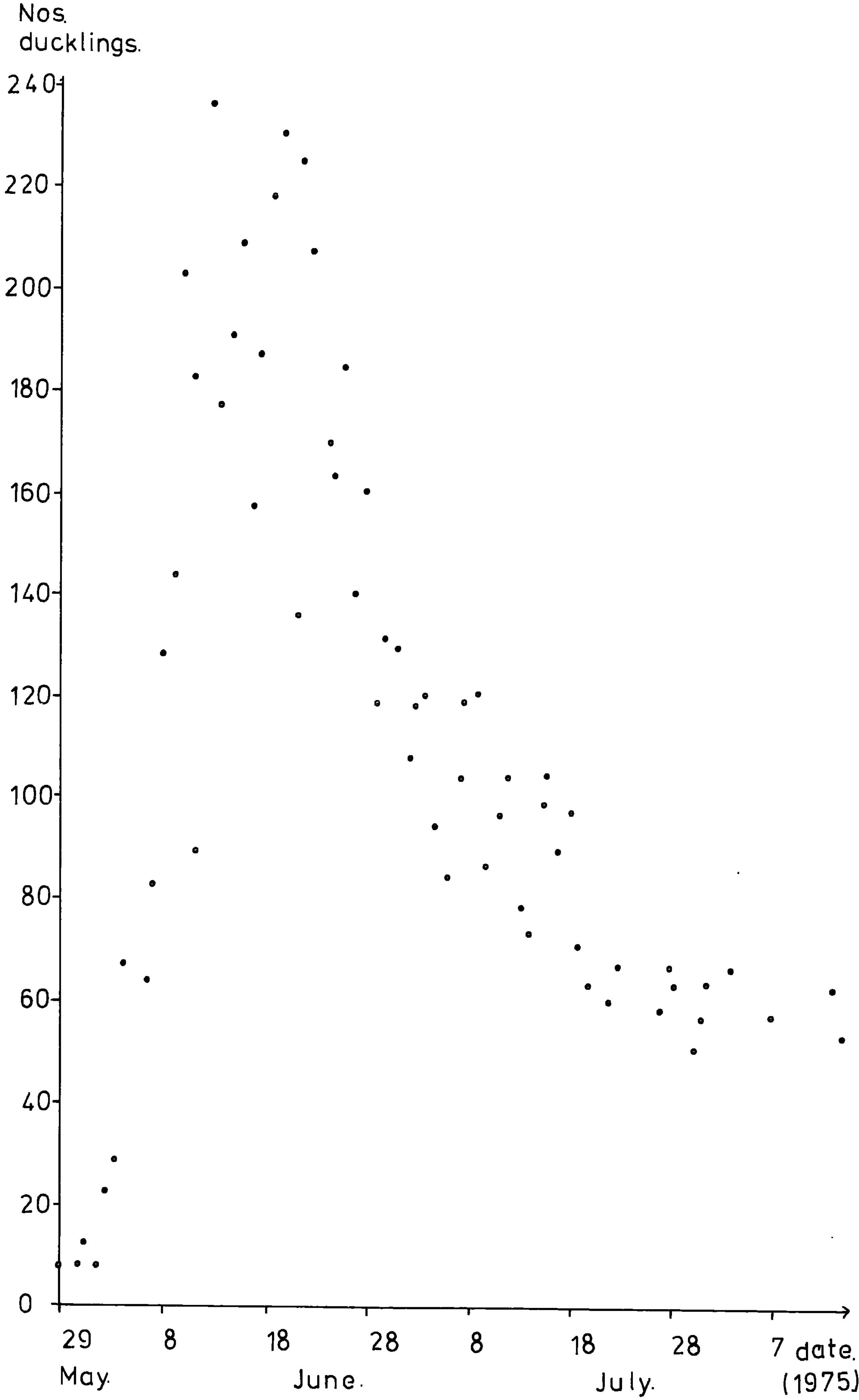
Nest Number = 240 (J.C.Coulson pers.comm).
Average clutch size = 3.83 (J.C.Coulson pers.comm).
Potential duckling number = 919.

The number of sucessfully hatched ducklings was estimated by allowing for egg losses through nest desertion by the incubating females, possible egg predation, infertile eggs. The overall loss through these causes was estimated not to exceed 10% of the potential number of eggs (R.Gomes. Warden. pers. comm.). Thus an estimated 827 ducklings hatched successfully.

4.4 Survival of Ducklings.

The daily records of eider ducklings, of all ages, are shown on Graph 3. The first ducklings were observed on 29 May 1975, from which date "duckling observation weeks" were

Number of ducklings counted on the water, within the intensive study area, May-August, 1975. graph 3.



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Age intervals weeks	1	2		1/2	3/4	5/6	7/8	9/10	11/12
Obser- vation beginning: weeks									
29 May I	68			68					
5 June II	182	43		203					
12 June III	196	117		230	28				
19 June IV	93	123		198	84				
26 June V	42	60		93	94	19			
3 July VI	21	39		60	63	55			
10 July VII	13	19		30	76	46	19		
17 July VIII	15	5		15	50	26	28		
24 July IX	7	7		11	15	43	21	16	
31 July X	3	5		8	5	30	18	28	
7 August XI	1			1	10	15	20	12	16
14 August XII					1	4	14	3	16
21 August XIII								18	12
28 August XIV									0
									18
Totals:	641	418		917	426	238	120	77	62

TABLE 3: Maximum numbers of eider ducklings, of the same age category, observed in each observation week, including the regrouping of age categories 1 and 2.

begun. Fourteen (I - XIV) observation weeks were made.

The total number of ducklings observed, on any one day, did not exceed 240. Towards the end of the study period 62 ducklings were still alive, of which 46 were older than ten weeks.

Table 3 gives the minimum numbers of ducklings observed within each age category, for each observation week. The minimum number of different ducklings observed, from the mainland, throughout the study period, was estimated to be 641. Thus an estimate of 186 ducklings disappeared during their first three days of life before being counted. (Three days being an estimate of the maximum time taken between hatching and reaching the mainland).

From the survival numbers of ducklings recorded, an age-specific survival table was constructed for the first three weeks of the ducklings' lives (Table 4) (Southwood, 1966)

l_x

Age interval (x) weeks	Survivors ((x) at start of each x. min. estimate.	Survival rate (qx) from (x) to (x+1)	Log Survivors Log_{10} (lx).
0 - 2	917	0.46	2.96
2 - 4	426	0.56	2.63
4 - 6	238	0.50	2.38
6 - 8	120	0.64	2.08
8 - 10	77	0.81	1.89
10 - 12	62	-	1.79

TABLE 4: Survival numbers and rates for the first twelve weeks of life of the ducklings.

The age interval used (x) was fourteen days. The number of individuals surviving (lx) at the beginning of each age interval were the minimum values estimated from the daily observations - (see Table 3). The estimates for one and two week old ducklings were regrouped, from the original data, to give the minimum estimation over the fourteen day interval.

From these two sets of information, the survival rate (qx) for each age group was determined. A survivorship curve, for the ducklings, was drawn (Graph 4). This describes the fall-off in numbers of survivors (lx) of known years (x). The shape of the survivorship curve obtained describes the distribution of survival with age.

In this study the curve obtained shows an initial, rapid drop in numbers surviving in their first few weeks of life, followed by a more steady fall in numbers over the next five-six weeks. By the ninth and tenth weeks of life, the drop in numbers tends towards zero.

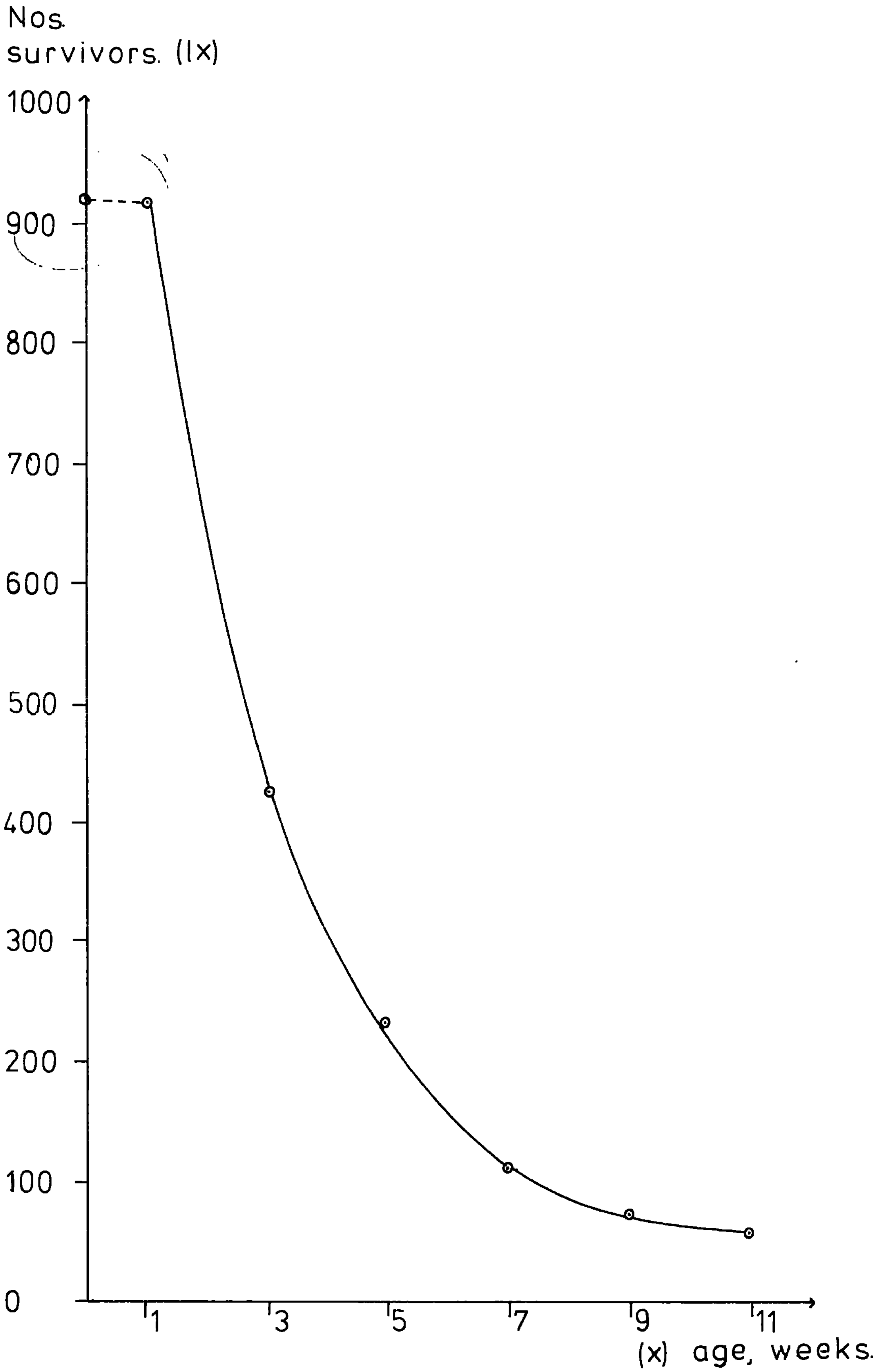
The value of 919 (estimated potential duckling population) when plotted on the survivorship curve, illustrates the difficulty encountered in successfully allotting ducklings to their correct age groups. The rate of survival (qx) as opposed to the actual numbers surviving, appears to have two rates, dependent on the age of ducklings.

Up to the fifth and sixth weeks of life, the survival rate appears to be constant, having an average value of 0.51 ± 0.04 of the total surviving through a fourteen day interval.

Survivorship curve for ducklings

0–12 weeks of age.

graph 4.



After the sixth week of life, the survival rate appears to change, increasing with increase in age of the ducklings. Thus during the first six weeks of life, the survival rate appears to be independent of the age of ducklings, while the increase in survival after the sixth week, is dependent upon age.

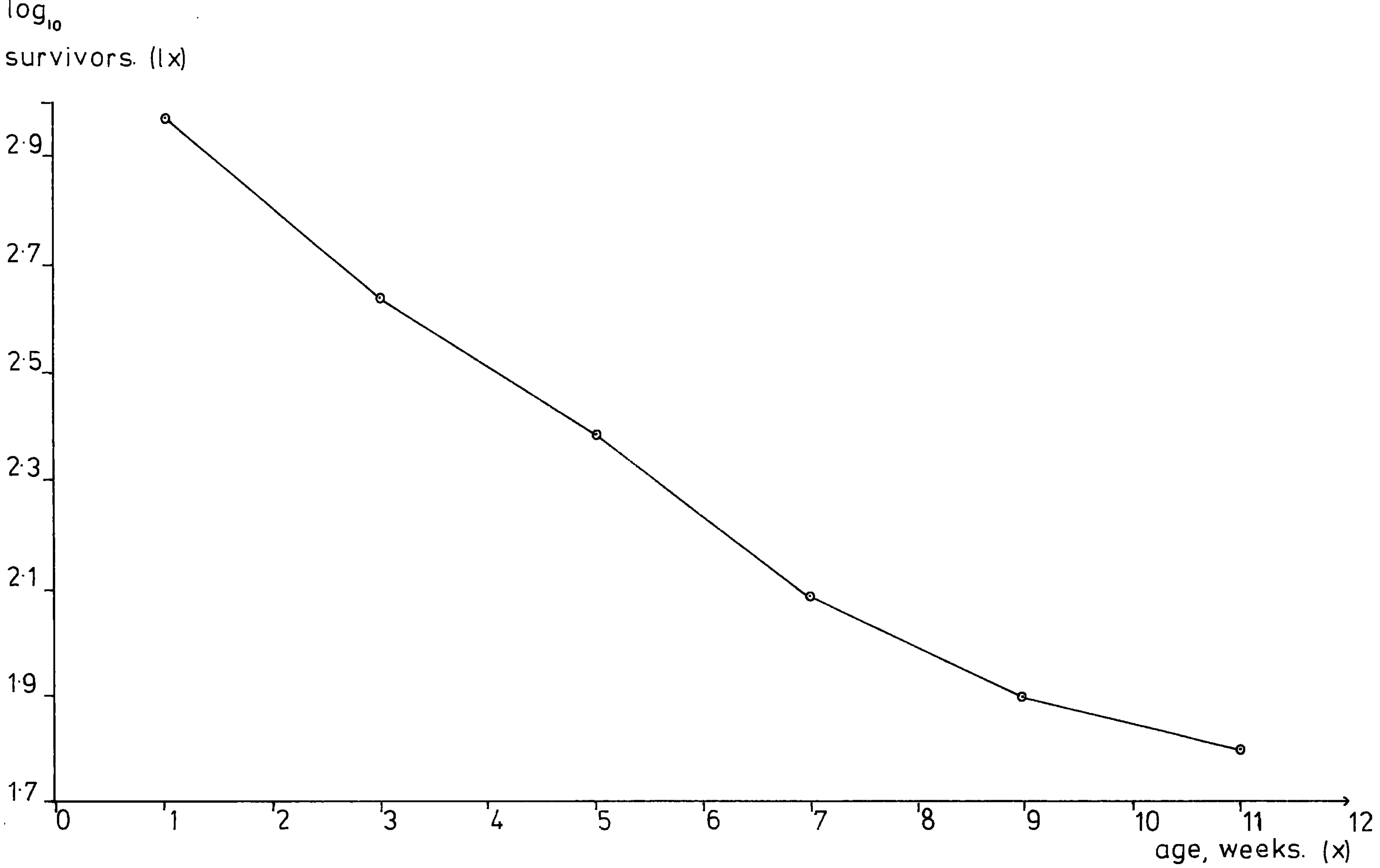
This pattern of survival differs from that found by Milne (1974)., who found in, years of well synchronized hatching (e.g. 1962) a rapid decline in duckling numbers in the first week of life, followed by a flattening off in mortality. In years of protracted hatching, however, Milne found a slower decline in numbers after hatching (e.g. 1961).

A plot of the log of survivors against the age, was drawn to describe the survival rate with age (Graph 5). The curve obtained implies an initial low, but constant, rate of survival which, with age, flattens off giving a second higher rate of survival. The flattening-off appears between the fourth and sixth weeks of life. 7+

The type of survivorship curve obtained resembles a cross between a type II and type III survivorship curve (after Deevey, 1947) and its importance will be discussed later.

The overall percentage survival for the first twelve weeks of life was estimated to be 7.50 ± 0.91%.

Semi-log survivorship curve for ducklings 0–12 weeks of age. graph 5.



4.5 The Effect of Hatching Period on Survival.

The effect of date of hatching on the survival of ducklings was also considered.

The hatching period was concentrated into the first VI observation weeks (29 May - 10 July), by which time 94% of the ducklings had been seen. The remaining 6% were spread over the following five observation weeks (10 July - 14 August), suggesting a more protracted hatching period, such that a period was reached when the addition of new broods was balanced by mortality. This created a flattened peak in the numbers of ducklings observed (see Graph 2).

Cohorts of ducklings, hatched within the same observation week, were followed through their lives. Table 5 gives the percentage survivals from one age interval to the next and the overall percentage survivals, for weeks one to twelve of life, for each cohort.

Individual marking of the ducklings was not possible and the use of age categories was again necessary for ageing the cohorts.

From Table 5 it appears that those ducklings, hatched during the first III observation weeks, show a similar pattern with low percentage survivals increasing towards 100% survival with increase in age of the ducklings.

Cohorts hatched during observation week IV appear to have had a poor survival pattern throughout their lives, while cohorts hatched during observation weeks V and VI showed a high initial survival which decreased with

Age Groups	1/2 - 3/4	3/4 - 5/6	5/6 - 7/8	7/8 - 9/10	9/10-11/12	Overall % survivals for each cohort
Weeks of first Observation I	41.1 ±5.4	67.8±8.3	100	84.2± 8.3	100	23.5
II	41.3 ±3.1	65.4 ±4.4	50.9±6.3	100	57.1 ±8.9	7.8
III	40.8 ± 3.1	48.9 ± 4.4	45.6±7.0	57.1±10.4	100	5.2
IV	31.8± 3.1	41.2 ± 5.4	69.2±8.9	16.6± 8.3	0	0
V	81.7 ± 3.1	56.5 ± 5.4	46.5±7.0	90.0 ± 6.3	100	19.3
VI	83.3± 4.4	60.0 ± 6.3	46.6±8.3			Not complete
VII	50.0 ± 8.9	100				Not complete
VIII	33.3 ±1.4	80.0±17.8				Not complete
IX	90.9 ± 8.3					Not complete
X	12.5±11.4					Not complete

TABLE 5: Percentage survivals[1] (from one age group to the next) of eider duckling cohorts hatched during different observation weeks.

1. Standard errors calculated using the formula $SE^2 = \frac{p.q.}{\sqrt{n}}$ where $p = 1-q$
   p = probability of surviving to $(x+1)$
   n = number of ducklings surviving (x).

increasing age of the ducklings.

Ducklings hatched after observation week VI were few in number, which is reflected in the high standard error values carried by the percentage survival figures.

The number of weeks of survival also varied within the different cohorts; e.g. ducklings hatched in the first three weeks have some ducklings surviving to their tenth week and beyond, while the cohort hatched during week IV had no ducklings surviving beyond their sixth week of life.

Cohorts hatched after observation week VI were not followed beyond their fifth week of life, when the study ended. Of these ducklings however, few survived to their fifth week.

The difference in survivals of the cohorts may have been caused by a number of factors, both dependent and independent of age and date of hatching of the ducklings; e.g. weather conditions, predation, food availability, disease.

By considering the survival values for all-aged ducklings, observed during the same observation week, temporary, age-independent factors affecting survival would appear to have an adverse effect on all ducklings.

From Table 5 there appears to be no trend showing a good, or bad, week for survival.

The survival in the first five weeks increases with increasing age of ducklings, while after week V the survivals fluctuate showing no pattern with increase of age.

The week of hatching, however, does appear to have an effect on the overall survival for the cohorts.

The survival of cohorts hatched during weeks I - IV decreased with the later hatching date, towards zero survival in week IV. The overall survival of ducklings hatched in week V increased to 19.3%.

Cohorts hatched after week V cannot be compared since data are not complete beyond the eighth week of life of those ducklings. Thus weeks I and V appear to have produced the greatest overall percentage survivals.

4.6 Dispersal from Breeding Ground.

Weekly counts made north and south of the intensive study area showed that on no occasion were ducklings found to the south of the breeding area. (Table. 6).

Immediately to the south of the study area lies Druridge Bay, approximately 8 kms. of open sandy bay. This offers no protection for ducklings, throughout its length, only one area of rocks being present (Hadston Carr. 1 km. south of Bondi Carr), and these are exposed only during spring tides.

It is suggested that the lack of protection makes dispersal away from the breeding area to the south unfavourable.

During observation week III, fourteen ducklings were seen at Dunstanburgh Castle. These ducklings were in their first week of life and considered too young to have travelled some 18 kms. in their first few days, but were probably hatched along that part of the coast.

Date 1975	4 Stations South. South.	Study Area	Alnmouth	Seaton Point	Boulmer	Rumbling Kern	Cullernose Point	Castle Point North
25 May	0	0	0	0	0	0	0	0
1 June	0	8	0	0	0	0	0	0
8 June	0	128	0	0	0	0	0	0
15 June	0	192	0	0	0	0	0	14
22 June	0	226	0	12	0	24	0	19
29 June	0	181	0	58	0	0	5	10
6 July	0	84	0	0	0	19	9	4
13 July	0	149	0	5	0	52	17	11
20 July	0	63	0	0	00	10	10	8
27 July	0	93	0	0	0	19	8	5
2 August	0	37	0	00	0	10	4	9

TABLE 6: Dispersal of duckling north and south of the intensive study area, shown by the numbers recorded in each area.

Apart from these few, the first ducklings seen north of the breeding ground, were sited during observation week IV, at Seaton Point and Rumbling Kern. After week V more ducklings were seen to gather around Rumbling Kern and Cullernose Point.

On no occasion were ducklings seen at Alnmouth and Boulmer. Both of these areas are open stretches with sandy bays and rocky shorelines, easily accessible to the public. The areas around Cullernose Point and Rumbling Kern are more sheltered bays, accessible by cliff paths. These areas may have provided more protection from weather and human interference.

4.7 Mortality.

Apart from those ducklings observed further along the coastline, ducklings disappearing from the intensive study area were assumed dead, the total figure being established as 765. Tidal walks recovered 17 ducklings of which 10 were complete and 7 were the remains of legs and ripped down.

The leg lengths of the duckling recoveries were measured (Table 7) and used as an age criterion, comparing the leg lengths of whole ducklings, whose ages were estimated from size and down colour, with the leg lengths of the remains of ducklings.

From the data it appears that all the dead ducklings were in their first two weeks of life. All the recoveries were made during observation weeks III to IV.

	Date 1975	Leg Length cms.	State of remains	Estimated age. Weeks
1	13/6	6.6	complete. fresh	1/2
2	13/6	6.5	complete. fresh	1/2
3	15/6	6.9	remains leg and down	(1/2)*
4	15/6	6.4	complete. fresh	1/2
5	16/6	7.0	remains legs	(1/2)
6	17/6	6.8	complete. fresh	1/2
7	19/6	6.7	remains legs and down	(1/2)
8	19/6	6.9	remains legs and down	(1/2)
9	19/6	6.8	complete. fresh	1/2
10	20/6	6.5	complete. fresh	1/2
11	22/6	6.8	remains	(1/2)
12	23/6	6.4	complete. fresh	1/2
13	29/6	6.7	remains legs	(1/2)
14	29/6	6.9	remains	(1/2)
15	30/6	6.5	complete. fresh	1/2
16	30/6	6.9	complete. fresh	1/2
17	2/7	7.0	complete. fresh	1/2

TABLE 7: Dead ducklings found during the study.

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*( ) age estimated from leg length whole remains whose ages were classified according to down and size.

Observations of three of these deaths were made. In two of these incidents death occurred after the ducklings had become separated from their broods. After a period of anxiety and searching the ducklings were washed ashore, and died soon after. Neither duckling attempted to feed whilst searching for their groups.

The third observation made was an attack made by a mature Herring gull (*Larus argentatus*) on a single duckling, estimated to be two weeks old. The duckling was resting on exposed rocks while the female was diving. The gull attacked from the air. Once the duckling had been taken the female moved further out to sea to join a flock of diving females.

No other successful attacks by gulls were seen despite a minimum of 2 hrs. observation each day. Attempts of predation were observed by mature and immature Lesser black-backed gulls (*Larus fuscus*) and Herring gulls.

The attempts consisted of the gulls circling about and swooping down over broods of ducklings while they were feeding. When this occurred the attendant females stretched their necks upwards and made gutteral sounds, at which the ducklings ran into tight groups around the females. If several broods were close together they often formed a temporary creche, protected, on all sides, by females who continued to thrust their beaks towards predators.

When the predators left, the creches broke down and the ducklings resumed feeding in their individual broods. Four gull attacks were observed in the estuary and seven attempts were seen at Hauxley.

4.8 Feeding Behaviour.

Ducklings were brought to feeding grounds by the females who remained with them whilst feeding.

Three main areas were used by the ducklings; the exposed mud flats and shallow waters of the estuary; along the harbour walls; the shallow waters at Hauxley. The first two of these areas were used more often where broods remained separated. Very few single broods were seen feeding, at Hauxley where two large creches, one of 34 ducklings with 5 females and the other of 25 ducklings with 4 females, were usually present. These creches fed at low tide, dabbling at the water's edge while the attendant females often came out of the water and preened.

Towards high tide these ducklings were taken out to sea where they remained pecking at the surface water while the females dived.

Periods of brooding took place on the exposed rocks at Hauxley and occasionally back on the shore of Coquet Island.

Ducklings brought into the harbour to feed, fed mostly on the incoming and ebbing tides, dabbling among the fronds of algae and Fucus spp. attached to the boulders.

At high and low tides the ducklings either rested along the harbour wall or were taken further into the estuary to feed and rest. Occasionally ducklings were taken back out to sea.

Apart from the ducklings that came and went with the tides, those taken into the estuary tended to be the younger broods. One-two week old broods fed on the exposed mud flats, sifting through the mud and shallow waters, the females accompanying them out of the water. After about ten days of life ducklings were seen diving for short periods. Brooding on the banks of the estuary was frequent throughout the day, but for short periods at a time.

Ducklings older than about six weeks were rarely seen in the estuary but tended to stay in the harbour, or just outside the harbour where they dived for food in the deeper water. By weeks seven and eight they fed out at sea.

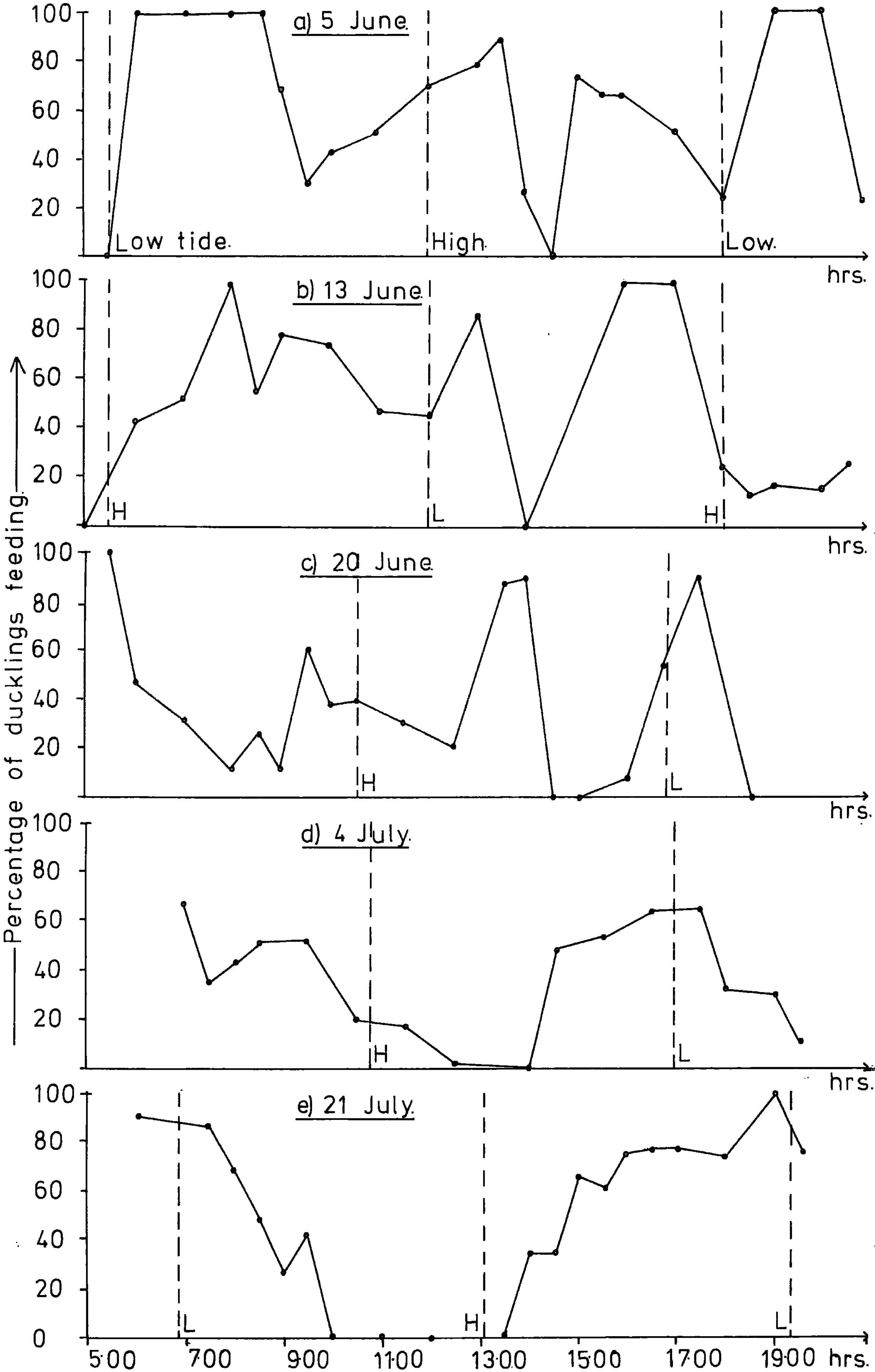
Samples of duckling faeces revealed various plant material remains and appendages from small crustaceans e.g. Gammaridae, Corophium sp. were found in large numbers.

Detailed observations of ducklings feeding patterns, throughout complete days, were made. In the younger ducklings, (between one - four weeks of age), two peaks of feeding activity were seen, one in the morning and one in the evening. (Graph. 6 a.b.c.). The timing of these peaks appeared to be affected, in the evening, by a high tide (13 June) when ducklings tended to feed earlier (16.00 - 17.00 hrs) than when a low tide occurred in the evening. e.g. 5 June. feeding was between 19.00- 20.00 hrs.; 20 June feeding was between 17.30 - 18.30 hrs.

Similarly, the morning peak of activity was delayed

Variation in feeding activity, of ducklings, with tide and time

graph 6(a–e).



when a high tide occurred in the morning. (13 June).

On all three days feeding was observed throughout the day by some ducklings, a smaller peak of activity occurring just before 14.00 - 15.00 hrs., after which ducklings were seen resting.

Older ducklings seen feeding in the estuary showed a more marked pattern of feeding, with a period of feeding in the evening, divided by long resting periods. (Graph 6.d.e).

The patterns of feeding observed in females, attending broods, closely resembled that of the ducklings.

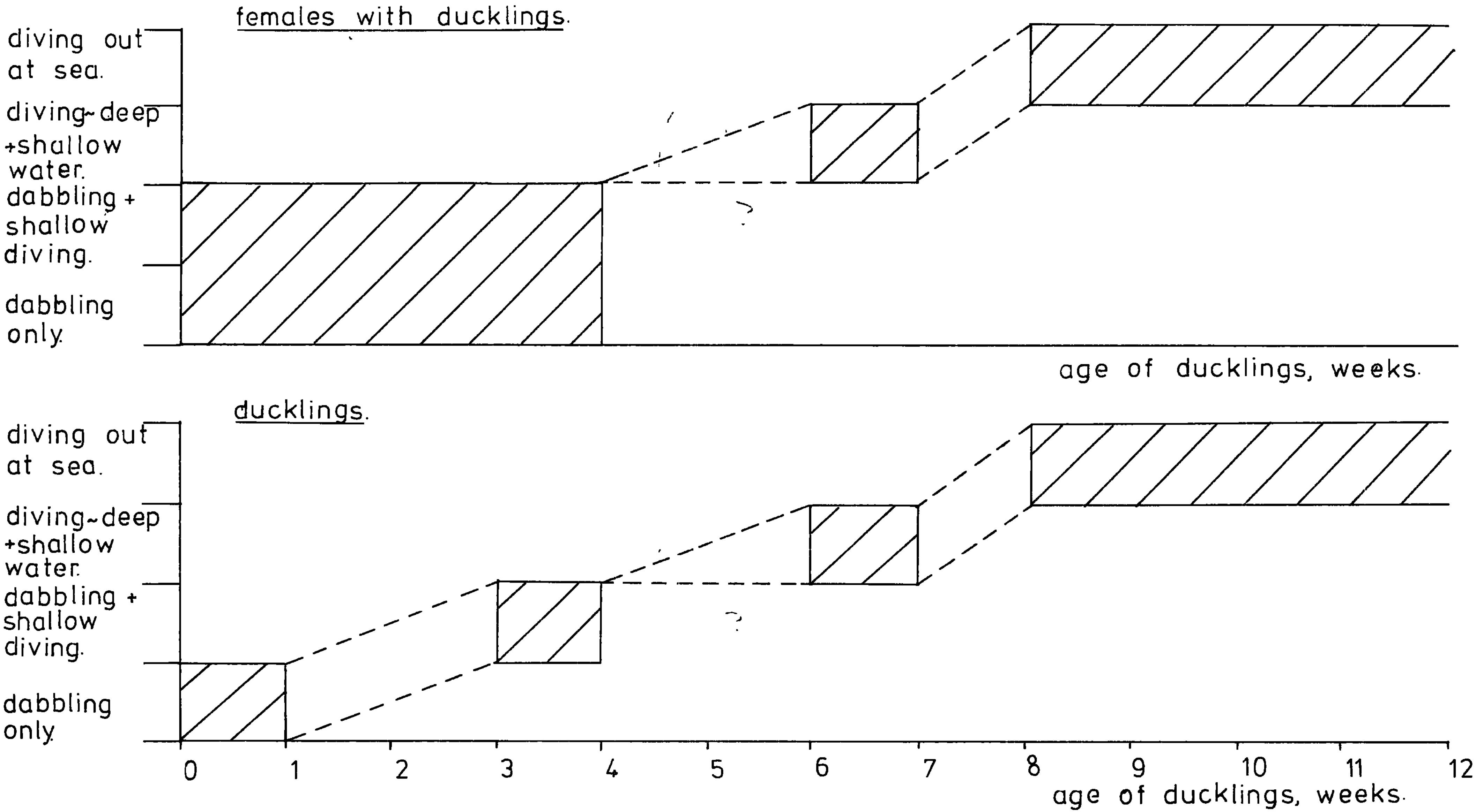
When the ducklings were young and feeding in shallow waters, the females fed by dabbling or up-ending. On several occasions, females feeding on the incoming tide in the harbour area, were seen to scratch, with their feet, at the newly covered sand. After scratching they dabbled, sifting through the upturned sand. Ducklings often took advantage of this type of feeding, following the females and dabbling for disturbed food. Some females were also seen to dive for food, before their ducklings were diving.

From field observations, a schematic diagram has been constructed to illustrate the type of feeding behaviour observed in the different aged ducklings and their females. (diagram 1.). Feeding behaviour has been divided into four categories; dabbling only; dabbling and diving in shallow water; diving in shallow and deep water, but not dabbling; diving out at sea.

The hatched areas represent the age when it was observed

Schematic diagram to illustrate variations in the feeding behaviour of adult females and their ducklings.

diagram 1.



that a particular feeding behaviour was characteristic to the majority of ducklings of that age, and the age of ducklings when their females fed in a particular way. Thus, for example, all ducklings less than one week old fed by dabbling only and by their third week of life the majority fed by diving in shallow waters. The females of these aged ducklings fed by dabbling, and diving in shallow water.

The division between one feeding pattern and the next, is not sudden but occurs over a period of time. This transition period has been represented by joining the hatched areas.

Three transition periods were observed for the ducklings. The first was between weeks one and three of their lives. The survival of ducklings during this transition is not likely to alter very much since both types of feeding occur in the same area. Thus if the ducklings were inefficient in diving for food they could revert to dabbling without having to separate from their brood.

Similarly, the transition between diving in deep and shallow water, and out at sea will not affect the survival rate greatly, the ducklings having successfully learnt to dive, have only to adapt to deeper waters.

The transition from dabbling and shallow water diving to diving in and around the harbour, where the water was shallow and deep (respectively), presents more of a problem to the ducklings.

Since it is likely that more energy is used during diving than dabbling, unsuccessful diving attempts would decrease the energy reserves of ducklings and make further diving attempts difficult. If the ducklings, during this transition, are taken out into the harbour, the opportunity to dabble is not present should their diving attempts be unsuccessful. The survival rate during this transition will therefore depend upon the age at which ducklings are taken into the deeper waters.

For the majority of ducklings this transition occurred between weeks four and six of their lives.

Only two transitions were observed for the females, diving in shallow water, up-ending and dabbling being observed as soon as the females brought the ducklings to the mainland. The two transitions both required a movement to different breeding grounds.

In the early part of June females with broods fed actively in the morning and evening. High tides coinciding with the morning peak caused a delay in feeding, while a high tide in the evening created an earlier peak in activity. (12 June) (Graph 7.b.).

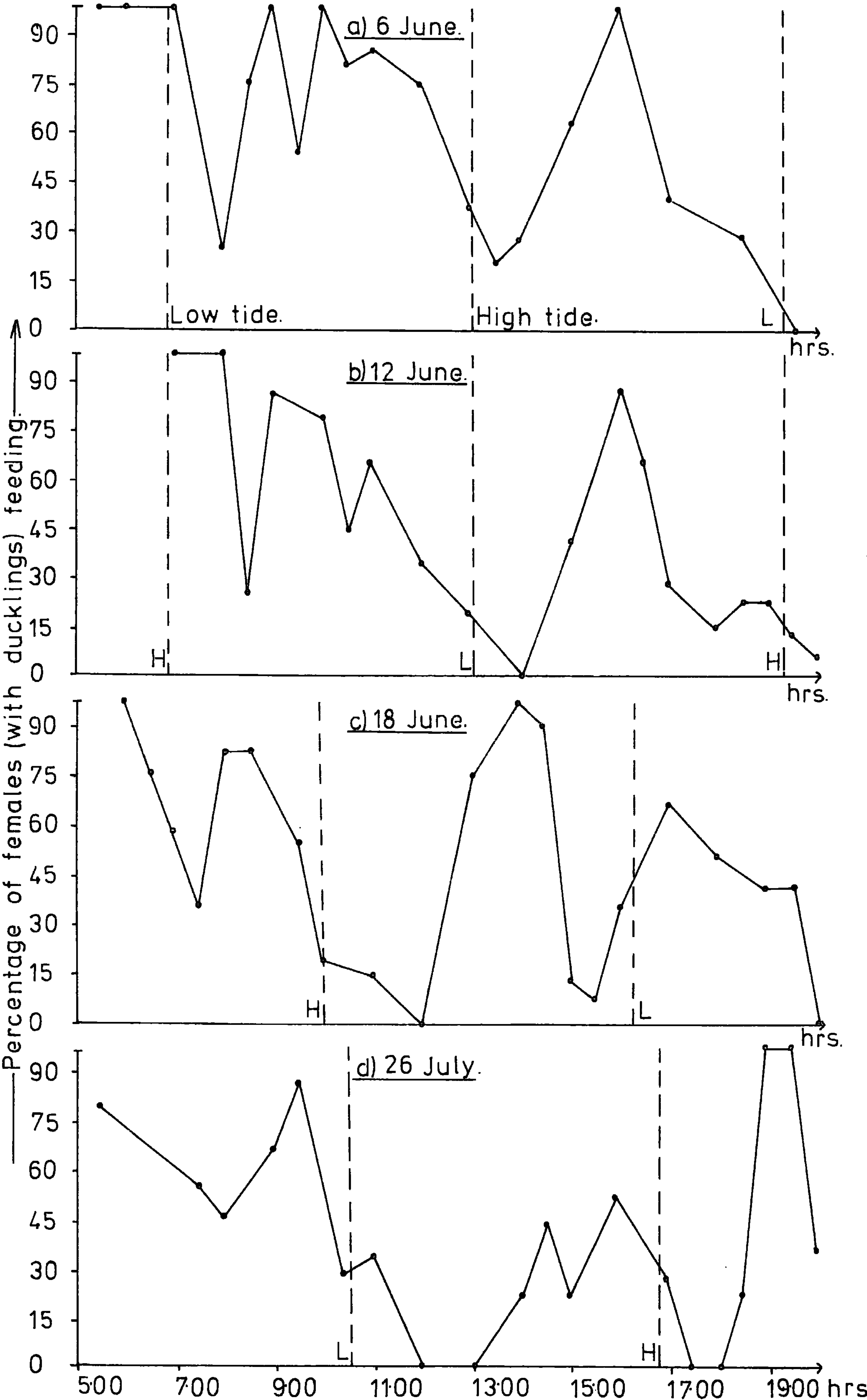
Between the two peaks of activity, females fed throughout the day, with short rest periods between 12.00 - 14.00 hrs., (Graph 7.b.c.) apparently irrespective of tides.

On 6 June (Graph 7a), females (whose ducklings were less than two weeks old) fed more continuously throughout the day, there being no time when all females stopped feeding.

Towards the end of July females were diving more

Variation in feeding activity, of females (with ducklings), with tide and time.

graph 7(a-d).



frequently, when their ducklings were also diving. Their feeding pattern then took the form of three periods of activity (26 July. Graph 7d.), one in the morning, one in the afternoon and one in the evening. During the afternoon period only about 50% of the females were feeding at any one time.

This later pattern of feeding resembles, more closely that observed in females without ducklings. These latter females showed a distinct two-peaked feeding pattern (Graphs 8a.b.c.d.), and were observed feeding in flocks, out to sea, where their activity was affected by the tides.

Diving was not common during high or at low tides. e.g. 23 May, where a low tide coincided with the evening peak and delayed feeding in some females. On 21 July, however, an early low tide brought the feeding peak forward.

Feeding of the males varied throughout the study period. (Graphs 9a.b.c.).

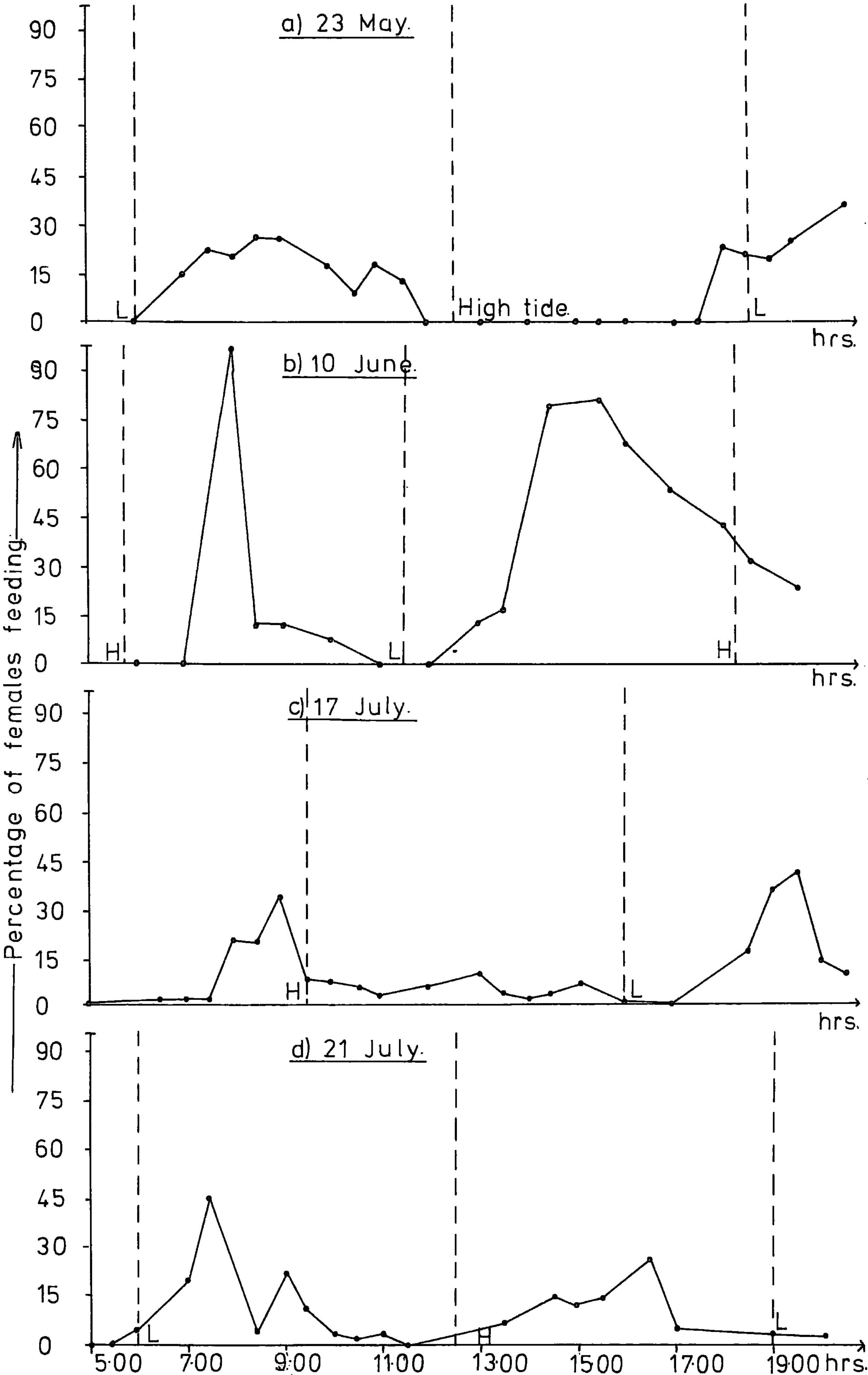
During May and the early part of June males stayed within the intensive study area, diving in flocks, mid-way between Coquet Island and the mainland.

Feeding was more frequent on the ebbing and incoming tides than at high or low tide. (15 May: 22 May).

Towards the end of June, males disappeared from the water at low tide, some returning to rest on the island, others leaving the intensive study area. Males that remained in the area had a period of feeding activity in the afternoon. e.g. 17 July when feeding occurred after the low tide.

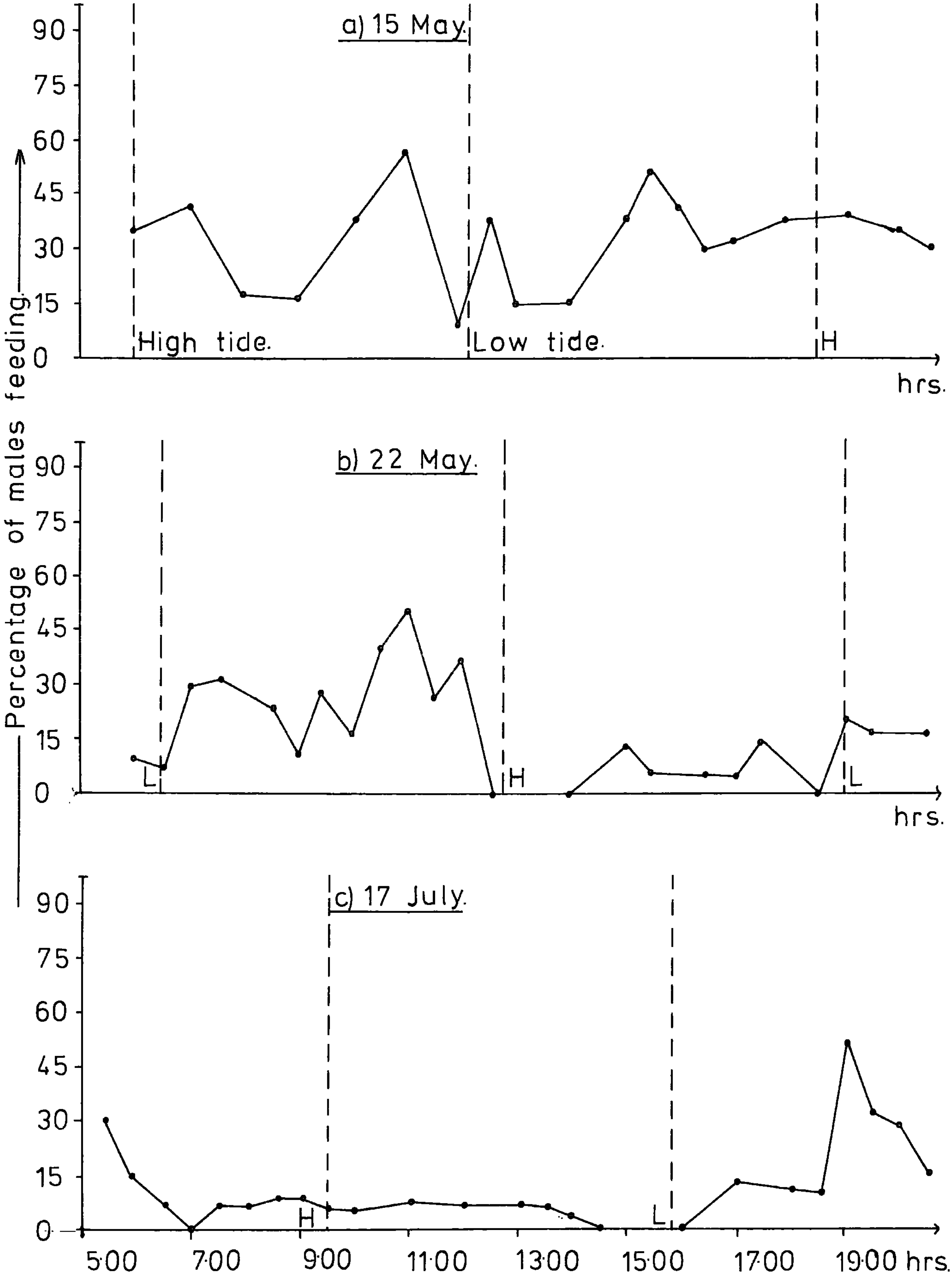
Variation in feeding activity, of females, with tide and time.

graph 8(a-d).



Variation in feeding activity, of males, with tide and time.

graph 9(a-c).



Faecal analyses for some adult eiders, revealed remains of mussel shell and pieces of the exoskeleton of crabs. Remains of small crustaceans were also found in the faeces collected from females with ducklings.

PART FIVE

DISCUSSION.

The overall survival of eider ducklings, to fledging, for 1975, was low (7.50 ± 0.91%) and represents an average of 0.26 ducklings per breeding pair. The same figure was found for the colony at Forvie, where duckling survival, over a ten-year period, was 9.8%. (Milne and Reed, 1974). (Table 8).

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p

The type of survival observed for the Coquet Island population represents a mixture of a type II and type III survival curve (after Deevey, 1947). The initial survival rate being constant, but low (0.51) for the first five-six weeks of life (type II), after which the rate increased with increase in duckling age, such that those ducklings which survived beyond their sixth week of life had a relatively high expectance of further life (type III). This pattern of survival differs from that found by Milne (1974), where duckling survival was found to be low for the first week of life (a maximum of 0.45 for 1961 and '62), after which it increased with duckling age.

The result of the low duckling survival, at Coquet, is that there will be very little recruitment to the adult breeding population in 1977. Similarly, from the 1974 duckling population, a maximum of twelve one-year old ducklings were observed. If it is assumed that one-year old ducklings do not stay away from the breeding area, then the survival rate for 1974 was again low, and recruitment to the 1976 breeding population will be low.

	Coquet Island population 1975.	Forvie population 1961 - 70 (Milne, 1974).
Hatching success	90%	63%
% survival of ducklings to fledging.	7.5%	9.8%
Nos. duckling surviving per breeding pair.	0.26	0.26
% survival over 1st few weeks.	51% constant for weeks 1 - 6	45% in 1st week (1961 and 1962).
duckling loss through gull predation	low (1% observed)	high.
% ducklings involved in creche system.	13% (low)	high.

TABLE: 8. A summary of breeding success found on Coquet Island (1975) compared with that found at Forvie (1961 - 1970) by Milne, (1974).

If the eider population is to remain constant, or increase in size, then the low duckling recruitment must be balanced by a high survival rate for the adult population (or low emigration), or the number of immigrants must increase. Alternatively, the years of low fledging output could be interspersed with years of high fledgling output, as observed for the Forvie population (Milne, 1974).

For the Coquet population, the survival rate for the breeding eiders is about 0.92 and the number of breeding mean p.a.? ducks 350 (J.C.Coulson pers. comm.). Thus some 60 ducklings will be required to maintain the population provided no emigration occurs. In 1977 therefore, any increases in the adult population will not be the result of its own reproductive output.

The date of hatching of eiders appears to have favoured the overall success of ducklings hatched early in the season.

Milne (1974) has suggested that late nesters, at Forvie, were the inexperienced young birds, which fed less efficiently prior to egg laying and therefore gained a lower pre-laying weight and this produced fewer and smaller eggs.

Evidence from Kittewake (Rissa tridactyla) breeding behaviour (Coulson) has suggested that a decline in clutch size towards the end of the laying period is the result of the breeding state of the bird. Thus the early breeding Kittewakes were the fittest for breeding, the later breeders less efficient but not necessarily the youngest.

For eider ducks, the pre-laying feeding strategy would therefore be important, the more efficient birds laying earlier.

The efficiency of the earlier laying birds may have resulted in the high rate of survival of their ducklings, however, data on egg size and hatching date were not available for the Coquet eiders.

High mortality of eider ducklings has been observed in many populations, the causes of death often being attributed to predation by gulls and crows, particularly at the egg stage. (e.g. Ahlén and Anderson, 1970; Milne, 1974; Milne and Reed, 1974; Campbell, 1975).

In this study, an estimate of a 10% loss of eggs, though gull predation, infertility and nest desertion, was made. This figure was low compared to egg losses of 21% in Scotland (Milne, 1974), 20% on Spitzbergen (Campbell, 1975) and as high as 70% off the coast of Maine (Bourget 1973) and 73% on Spitzbergen (Ahlén and Anderson, 1970), being recorded for various sub-species of the common eider.

Compared with these studies, gull predation on Eider's eggs, on Coquet, was considered unimportant.

About a hundred pairs of herring gulls and lesser black-backed gulls were breeding on Coquet. Carrion crows (Corvus corone) were rarely seen in the study area, and on no occasion were any seen flying to Coquet.

Evidence of gull predation on hatched ducklings, that had left the island, suggested that it was an unimportant mortality factor during the day.

During a minimum of 2 hrs. daytime observation throughout June and July (i.e. a minimum of 122 hrs. observation), only one successful and eleven unsuccessful gull attacks were observed. Possible gull predation at night was not studied.

Despite the similarity in the survival rate of ducklings of Coquet with those of Forvie, the cause of mortality is not the same. (see Table 8.).

The recovery of ducklings assumed dead, was very low, 3%, all of which were in their first two weeks of life. Of the recoveries 41% were the remains of ducklings which had either been killed for food or eaten after being washed ashore e.g. by carrion crows.

No observations of the latter were made and avian predation was low when ducklings were on the water. Observations of other predators e.g. fish, fox, were not observed during the day.

Tidal walks were not made beyond the intensive study area, therefore any ducklings washed ashore in these areas were not recorded. Similarly, ducklings that left the intensive study area and died inbetween the weekly census' made, were not recorded.

If the large number of ducklings missing had left the study area, then a corresponding decrease in the number of females would be expected. Numbers of females were not observed to decrease until the beginning of July, while the greatest mortality of ducklings was observed in their first few weeks of life.

Dispersal and subsequent death may, therefore, account for a small proportion of the disappearances of ducklings, but does not account for the large numbers disappearing early in the study period.

The remainder of the tidal recoveries (59%) were complete ducklings, the death of two of these was observed after separation from the parent, followed by anxiety and possible starvation.

Separation as an aid to death, either through subsequent starvation and increased chances of predation, may have been important in this study during late July - August. During this period thick, sea-frets came inland with the tides, reducing visibility to a few metres. The rate of mortality during July and August was low and therefore, while separation and death may have been experienced during the sea frets, they do not account for the earlier, low survival rates observed in the younger ducklings.

Evidence, for death through lack of food, is not conclusive from this study, however, qualitative analyses of the feeding behaviour of the ducklings and adult eiders are useful when considering the possible causes for the change in survival rate, observed after weeks five/six of life.

Ducklings observed in one locality (Hauxley), formed small, but permanent creches. The total number of ducklings involved in these creches did not exceed 13% of the total number of ducklings observed, and therefore feeding behaviour observed within these systems was not characteristic of the majority of the duckling population.

It is interesting to note, however, that the creches were found only in this one locality where ducklings and their females came together, along the same stretch of exposed shoreline, (approximately 40m), at low tide to feed. At high tide, the ducklings were taken out to sea, where only the females dived for food.

This behaviour, within the creche, is different from that observed within the Forvie creches (Milne and Gorman, 1972) where ducklings and females feed in different areas, at the same time of day, females spending, on average, 4 days with their broods.

Temporary creches were observed in the estuary area, when gull attacks were attempted. If individual broods were feeding close to one another on the mud flats, and avian predators were observed, the ducklings amalgamated, dispersing soon after the predator had gone. (This was observed in three out of the four attacks observed in this area). Temporary creches were not seen at any other time in the study area.

Apart from the small proportion of ducklings forming creches, the feeding behaviour of the remaining ducklings and their females was found to vary with age of the duckling.

The female remained with her brood, well into their ninth week of life and beyond. The feeding behaviour of the female was found to closely resemble that of her ducklings, feeding being more or less continuous throughout the day, when the ducklings were young and decreasing in the middle of the day as the ducklings grew.

When the ducklings were in their sixth and seventh weeks, a two-peak daily activity was established, similar to that observed in non-breeding females.

When the ducklings were too young to dive efficiently, faecal analyses revealed remains of various crustacean in their diet. The high calorific requirement of the ducklings (found to equal that of adult females by their third week of life, Cantin, Bédard and Milne, 1974), would therefore necessitate continuous feeding throughout the day, to fulfil their requirements.

The females, were feeding on mussels, crabs and crustaceans and continous feeding was required presumably to enable them to recoup weight losses encountered during their long periods of incubation, without food.

It is suggested therefore, that as the ducklings, at Coquet, grew they became more efficient in diving for mussels. Thus their food requirements were fulfilled more quickly as they became more efficient, such that two daily peaks of activity were sufficient.

It is further suggested that the inefficiency in feeding technique, prior to diving, may explain the lower survival rate observed within the first six weeks of a duckling's life.

This low survival rate corresponds to the time of life when ducklings fed by dabbling and diving in shallow water. The increase in survival rate occurs around the weeks seven and eight of life, by which time ducklings are diving in deep water, having learnt to dive successfully, their survival rate increases.

To support these ideas further work on the type of of food consumed and the efficiency in obtaining the food, in terms of energy expenditure and energy intake, would be necessary.

From this work therefore, it has been found that while the high duckling mortality at Coquet, was not caused by day time gull predation, feeding behaviour studies have led to the tentative suggestion that, the efficiency of feeding techniques and type of food consumed may be the important factors in duckling survival.

ACKNOWLEDGEMENTS

I would like to thank Dr. J.C.Coulson who supervised this study and provided data on the breeding biology of the Eider on Coquet. I am also grateful for his advice and constructive criticism throughout the preparation of this work. I would also like to acknowledge R.Gomes (Warden on Coquet Island) for his estimate of egg losses on Coquet.

SUMMARY

The maximum number of adult eiders observed within the study area was 919, 476 male, 443 female.

The number of breeding females was 240 (54% of the maximum number of female). Estimation of the breeding numbers, from the departure of females from the water in May, was 412 and included some 200 unsuccessful and non-breeding ducks.

From the nest total (240) and average clutch size (3.83) a potential of 919 ducklings was calculated. Allowing a 10% egg loss through infertility, predation, and nest desertion, gave an estimate of 827 successfully hatched ducklings.

A minimum of 641 different ducklings were observed, thus some 186 disappeared before being counted. At the end of the study period 62 ducklings were alive, representing an overall percentage survival of 7.5%, thus recruitment to the adult population in 1977 will be low.

A suvivorship curve was plotted for the first twelve weeks of life. The type of curve obtained was a cross between a type II and type III curve (after Deevey, 1947).

The rate of survival for the first six weeks of life was constant, (0.51). After the sixth week of life the rate of survival increased with increase in duckling age, to 0.81 by week ten.

94% of the ducklings hatched between 29 May - 10 July, the remaining 6% between 10 July - 14 August.

Cohorts hatched during weeks I and V had the greatest overall percentage survivals for the first twelve weeks of life. (23.5% and 19.3% respectively).

An estimate of 765 ducklings died. Tidal walks recovered 17 ducklings, 10 complete and 7 the remains of predation.

One successful and eleven unsuccessful gull attacks were observed during a minimum of 122 hrs. observation.

Gull predation, during the day, was found to be unimportant both for the egg stage and duckling mortality.

Feeding behaviour of the ducklings was found to vary with age, a schematic diagram, based on field observations, was drawn to illustrate the change in feeding behaviour of the ducklings, and their females, with increase in duckling age.

Creche formation occurred in 13% of the total duckling population, the remaining staying in their separate broods.

The efficiency of feeding techniques, used by the ducklings, is discussed as a possible mortality factor in the survival of ducklings.

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