Observations on the time budget and diving ecology of Long-tailed Ducks in Eqalungmiut Nunaat, West Greenland

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Introduction

The Long-tailed Duck *Clangula hyemalis* is an abundant breeding species in the Arctic with a circumpolar distribution. It is primarily an animal feeder with crustaceans and molluscs comprising an important part of the diet. Previous studies in Greenland have shown that spring and summer food consist principally of adult and larval insects (Manniche 1910; Salomonsen 1950). Food is normally obtained by diving from the surface to depths of 3–10 metres, but gill-net casualties have been recorded from depths of up to 55 metres. Mobile and immobile food items are taken (Cramp and Simmons 1977).

Dive data are of crucial importance in the understanding of energy and activity budgets. Dive parameters and energy budget could be influenced by a variety of factors including sex and site related variables. These aspects were examined in further detail during the present study. Evidence of systematic foraging behaviour was also examined.

Study Area

Eqalungmiut Nanaat is located in central west Greenland at 67° 30′N, 50° 30′W. The area comprises 750 square kilometres of glacially scoured plateau, dominated by numerous lakes of variable depth and size. Fox and Stroud (1981) give a full description of the area.

Observations of Long-tailed Ducks, the most commonly observed duck in Eqalungmiut Nunaat, were undertaken at five plateau lakes. They ranged in size from 4 ha (Top Tarn), 6 ha (Hotel), 6.2 ha (Juliet), 6.5 ha (Papa) to 13 ha (Whisky) and lay, successively, at 450, 475, 480, 520 and 550 metres above sea level. Emergent vegetation was either absent as at Whisky or very limited in extent and confined to the lake edge as at Top Tarn.

Methods

Time budget data were collected exclusively at Top Tarn from a position over-

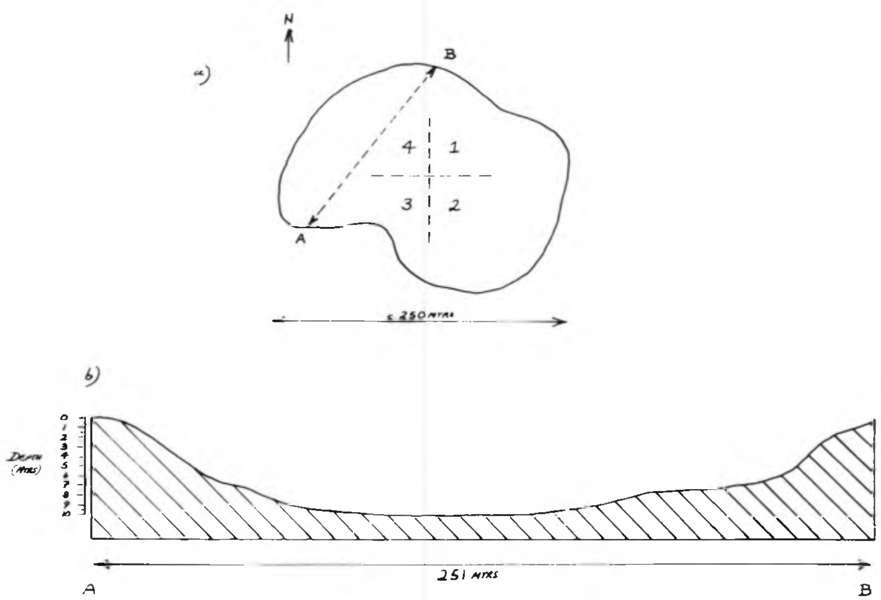

Figure 1. Plan (a) and profile (b) of Top Tarn showing position of quadrants referred to in text. Depth soundings taken every 10 metres.

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looking the lake c.100 metres from the shore. Observations were made during the period 9th–13th July 1984, the site being regularly frequented by a pair of Long-tailed Ducks which had been present at this site since 11th June. The lake was occupied by both male and female simultaneously or by either sex alone. Occasionally both birds were absent. Although copulation was observed on two occasions (9th and 10th July), the status of this pair was uncertain, there being no evidence of egg laying.

Only at Top Tarn, were lake depths and profiles investigated in any detail. However, a common feature of many of the plateau lakes was the presence of a "stepped" profile in which a shallow peripheral terrace shelved steeply to the lake bottom (Figure 1).

At Top Tarn posture and activity were recorded instantaneously every two minutes according to the following categories: alert; head-submerged; head-on-back (resting); diving; wing-flapping; copulation; preening; swimming; flying. Postures were based on the classification of Inglis (1977). The 'Alert' category included 'head-low', head-up' and 'extreme head-up', representing an increasing level of alertness. Instantaneous scans give objective samples of behaviour and thus approximate to percentage time spent in specific postures and activities (Altmann 1974).

Top Tarn was subjectively divided into quadrants and the position of the birds on the lake noted at each scan (Figure 1). Meteorological data, including temperature, humidity, wind-strength and direction, precipitation and cloud cover were recorded hourly there. All times are given as Greenland Local Time, i.e. GMT+ 3 hours.

Dive times and dive intervals were recorded opportunistically. Most birds generally dive for less than 60 seconds (Butler and Jones 1982). Dives in excess of 60 seconds were rarely recorded and were excluded from the analyses on the basis that they probably comprised two consecutive dives. Dive intervals were timed from the point of emergence from a preceding dive to the point of submergence. Intervals in excess of 60 seconds were considered to constitute the end of a feeding bout and were not included in the analyses.

Results

Activity records were obtained at Top Tarn for the male bird on the 9th, 10th and 12th July and covered the periods 0130–0400, 0830–1700 and 1800–2130. The female data were obtained on the 9th, 10th and 13th July during the periods 0600–0730, 1100–1630 and 1800-0500. Gross time allocation over the period of the study is shown in Table 1. The male bird spent significantly more time alert and less time resting than the female (X^2=15.69, df=1,P<0.001 and X^2=13.19, df=1,P<0.001 respectively, arcsine transformed data). All other differences were not statistically significant.

Using pooled data for the male and female for the period 9th-13th July, diurnal changes in behaviour were examined. Observations were distributed over a 24 hour period except for 0500–0600 and 1700–1800 (Table 2, Figure 2). Of all feeding activity 87% occurred during the period 0100-1300, whilst 68% of the time spent alert occurred between 1300 and 2400. Nearly all (96%) of the time devoted to resting was noted between 1100 and 2400.

Table 1. Gross time allocation of male and female Long-tailed Ducks, Top Tarn, 9th–13th July.

Activity	No. Records (%) Male	Female	X^2	df	P
Feeding	143(22)	145(19)	1.26	1	>0.20
Resting	172(26)	264(35)	13.19	1	<0.001
Alert	303(46)	269(36)	15.69	1	<0.001
Swimming	82(13)	73(10)	2.56	1	>0.10
Preening	271(4)	63 (8)	1.13	1	>0.20
Flying	3(.5)	4(.5)	0.33	1	>0.50
Copulation	1(.1)	1(.1)			
Total Records	651	748			

Table 2. Diurnal behaviour as % Time, of male and female Long-tailed Ducks, Top Tarn, 9th–13th July. All times given as Greenland Local Time i.e. GMT+3 hours. Note – indicates bird out of sight or absent.

Time	Diving		Alert		Resting		Preening		No. Records	
	M	F	M	F	M	F	M	F	M	F
0000–0100	–	0	–	84	–	16	–	3	–	31
–0200	40	88	60	12	0	0	0	0	25	25
–0300	24	45	72	41	0	0	0	10	29	29
–0400	33	57	64	27	0	0	3	10	30	30
–0500	–	43	–	10	–	20	–	7	–	30
–0600	–	–	–	–	–	–	–	–	–	–
–0700	–	30	–	42	–	6	–	21	–	33
–0800	–	20	–	47	–	7	–	27	–	15
–0900	77	–	23	–	0	–	0	–	13	–
–1000	60	–	40	–	0	–	0	–	30	–
–1100	60	–	40	–	0	–	0	–	30	–
–1200	0	73	37	3	57	17	3	3	30	30
–1300	0	100	7	0	90	0	0	0	30	30
–1400	0	0	7	3	93	95	0	2	60	60
–1500	0	0	62	17	23	70	15	13	60	60
–1600	13	0	80	63	0	25	7	12	60	60
–1700	27	0	68	98	0	0	5	2	60	45
–1800	–	–	–	–	–	–	–	–	–	–
–1900	0	0	70	63	27	33	0	3	30	30
–2000	3	0	17	17	73	77	3	3	30	30
–2100	7	0	70	38	20	34	3	24	30	29
–2200	8	3	85	89	0	0	0	3	13	29
–2300	–	0	–	17	–	83	–	0	–	30
–2400	–	0	–	43	–	47	–	10	–	30

During this period three peaks of resting behaviour are apparent and these show an inverse relationship with peaks of alert behaviour. Preening behaviour was distributed evenly throughout the day.

For both males and females there were significant differences in dive times between sites (Table 3) (ANOVA, $F=13.19$, $df=2, 345$, $P<0.001$ and $F=13.15$, $df=3,256$, $P<0.001$, respectively). There were also significant differences in dive intervals between sites (ANOVA, $F=86.4$, $df=1, 321$, $P<0.001$ and $F=5.2$, $df=2, 130$, $P<0.01$ respectively).

At Top Tarn and Whisky, the only sites at which both male and female data were collected, male dive times were significantly longer than those of females ($t=14.86$, $P<0.001$ and $t=7.13$, $P<0.001$ respectively). Male and female dive intervals for

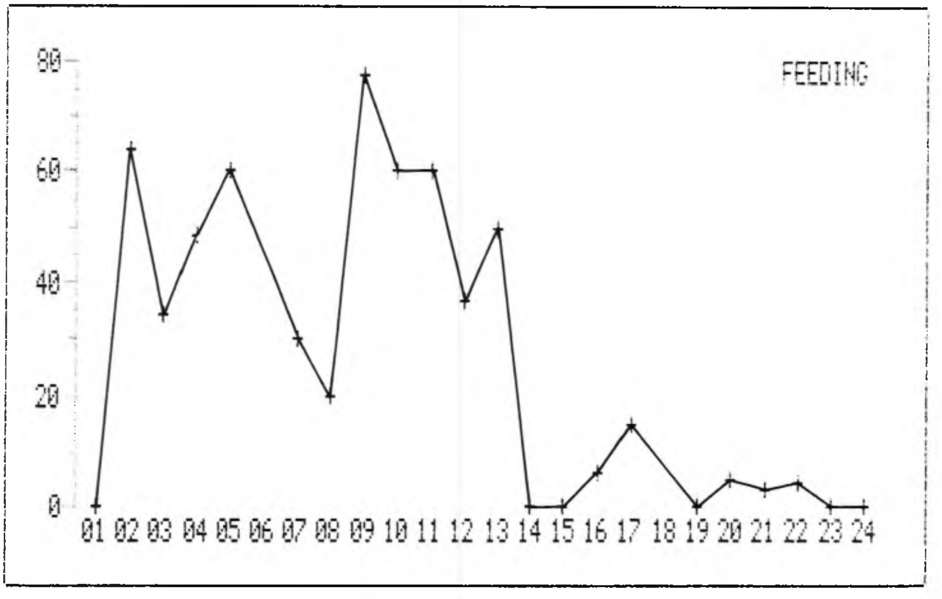
Table 3. Dive Duration and Dive Interval (seconds) of male and female Long-tailed Ducks at five sites.

Site	MALE			FEMALE		
	X	SD	N	X	SD	N
DIVE DURATION						
Top Tarn	32.8	4.6	237	25.9	4.1	147
Whisky	36.1	6.1	87	29.5	2.1	12
Papa	34.8	7.1	24	–		
Hotel	–			22.3	5.7	69
Juliet	–			27.4	7.6	32
DIVE INTERVAL						
Top Tarn	7.8	5.0	240	7.4	3.4	112
Whisky	14.0	5.5	82	10.7	6.3	9
Hotel	–			9.8	2.7	11

the same sites did not differ significantly ($t=1.04$, $P>0.1$ and $t=1.49$, $P>0.1$ respectively). Dive times and dive intervals were weakly correlated ($r=0.309$, $P<0.01$, $n=103$, pooled data for male and female from three sites).

Dive frequencies were noted at Top Tarn. The male dived 357 times in 246 minutes (87 dives/hour). The female dived 88 times in 58 minutes (91 dives/hour). The

Figure 2(a). Diurnal changes in Feeding, and Preening, behaviour. Pooled data for male and female Long-tailed Ducks, Top Tarn, 9th–13th July. No data for periods 0500–0600 and 1700–1800. Data derived from instantaneous scans (n=1399).



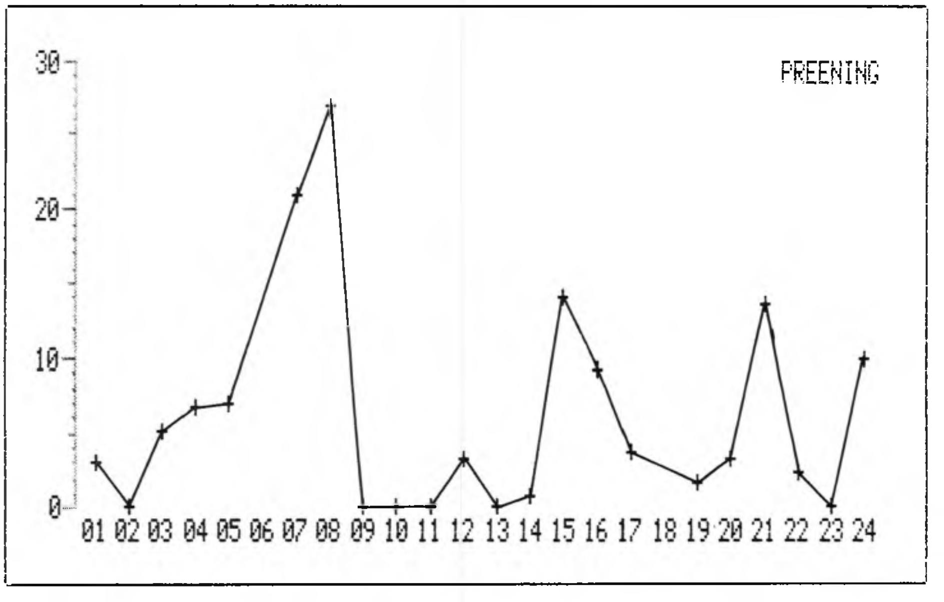
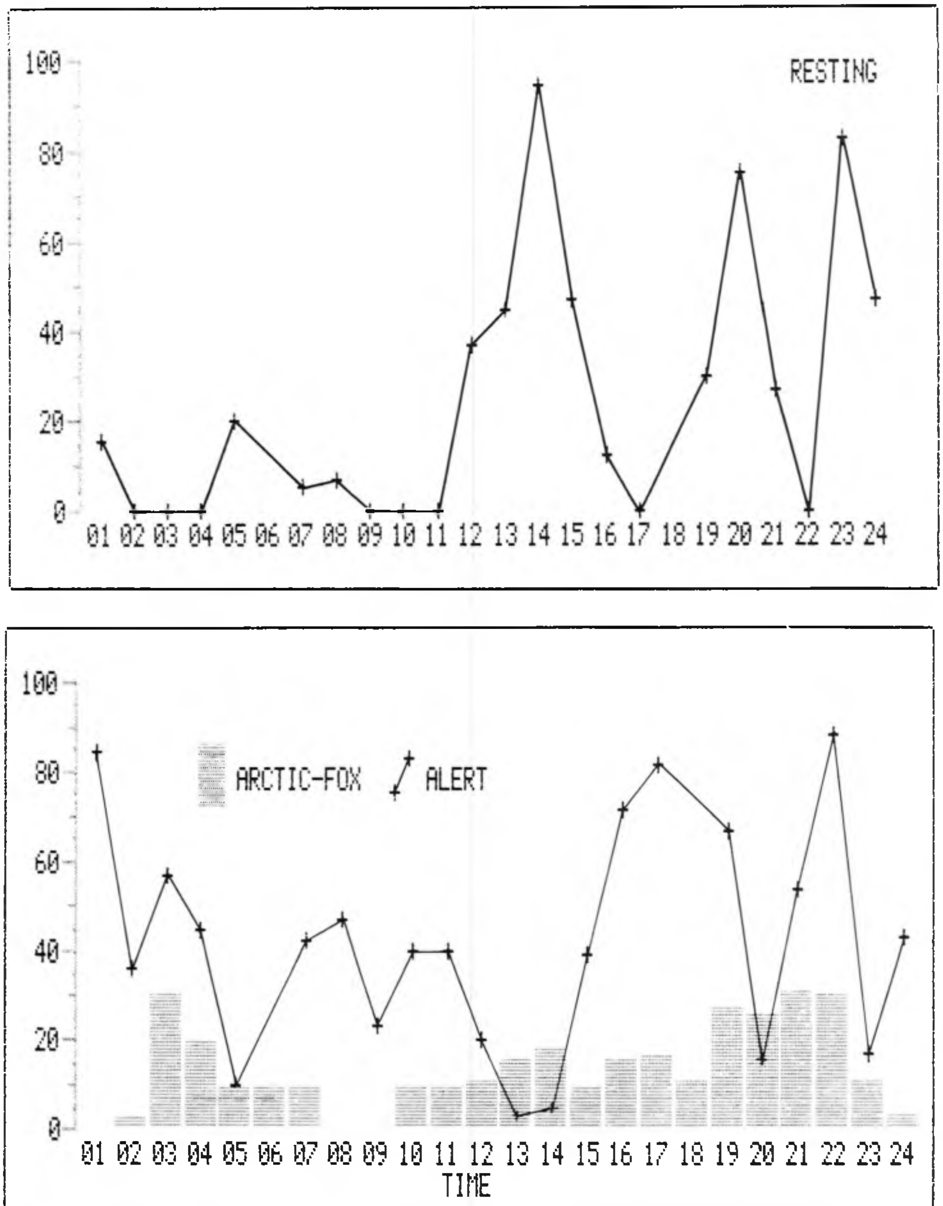


Figure 2(b). Diurnal changes in Resting and Alert behaviour. Data as for 2(a). Also shown, hourly occurrence of active Arctic Foxes observed in Equalungmuit Nunaat, 7th–18th June.



difference was not statistically significant ($\chi2$=0.08 P=0.5 to 0.8).

The proportion of time spent feeding in the four sectors of Top Tarn were determined. The male divided his time 18%, 37%, 31% and 14%, the female 36%, 30%, 24% and 10%. The differences between sectors and sexes were not significant (Chi= squared test, arcsine transformed data).

Discussion

Diurnal Behaviour

As can be seen from Figure 2 prominent patterns of diurnal behaviour can be distinguished. There is a problem of causality however and it is not possible from the limited data available to determine precisely the controlling factors involved.

The diurnal fluctuations in alert behaviour are of particular interest. It is possible that vigilance levels vary in response to changes in predator activity during the day. Arctic Fox *Alopex lagopus*, Peregrine Falcon *Falco peregrinus* and Gyrfalcon *Falco rusticolus* were in the area during the study. With the exception of Arctic Fox, there were insufficient predator records to permit meaningful interpretation. The Arctic Foxes of the area, however, were the subject of a separate study which included monitoring of radio-tagged individuals.

The hourly occurrence of active Arctic Foxes observed in Eqalungmiut Nunaat during the period 7th–18th June 1984 is shown in Figure 2 d) together with the diurnal pattern of alert behaviour of the Long-tailed Ducks at Top Tarn. The data suggest a possible correlation of alert behaviour and Arctic Fox activity (Spearman's Rank Correlation Coefficient, $R=0.40$, $n=22$), although the relationship was not significant (Student's "t", $t=1.97$, $P<0.1$). Stroud (1981) suggested a similar relationship with respect to vigilant behaviour in breeding Greenland White-fronted Geese *Anser albifrons flavirostris*. Clearly, however, it is important not to dismiss alternative explanations. For example, Long-tailed Duck behaviour may reflect changes in diurnal availablility of prey and may have little to do with Arctic Fox activity *per se*.

Dive times

Male dive times were significantly longer than those of females. This may reflect different sex related feeding strategies or alternatively may be a consequence of physiological differences in diving ability. The latter has been shown to be closely linked to body size in vertebrates (Butler and Jones 1982). The mean weight of males and females determined in late May-June from arctic Alaska was 788g ($n=20$, range 621-880) and 657g ($n=5$, range 510-794) respectively (Cramp and Simmons 1977). The observed differences in male and female dive times are therefore as would be predicted on the basis of body size.

For both males and females there were significant differences in dive times between lakes. These differences may be correlated with site specific variations in lake depth and topography. Alford (1920) and Dewar (1924) examined a range of diving ducks and concluded that dive duration increased with water depth. A similar relationship was observed for the Long-tailed Duck by Ingram and Salmon (1941) and in seven species of diving bird by Dow (1964). Dive duration of wintering Black Ducks *Anas rubribes* was significantly longer in deeper water (Brodsky and Weatherhead 1985). Details of lake depth were not obtained during the present study other than on Top Tarn but it is likely that the observed differences in dive times between sites is to some extent a reflection of water depth. Site related variations in the abundance and availability of potential prey items may also be of importance as could innate differences between breeding, non-breeding, mature and immature birds.

Dive intervals

The between-site differences in dive interval implicates some or all of the factors discussed above in relation to dive times. The tendency for longer dives to be associated with longer dive intervals is presumably a reflection of the recovery time required at the surface for oxygen and carbon dioxide exchange. Lillo and Jones (1982), investigating involuntary dives, did show that the time taken for pre-dive levels of ventilation to be restored varied directly with the length of the previous dive. A similar positive correlation between dive time and dive interval was noted by Dow (1964) and Morrison *et al.* (1978). Brodsky and Weatherhead (1985) found that for Black Ducks much of the variation in dive interval was explained by windchill rather than dive duration.

Dive Frequencies

The results suggest that the female at Top Tarn may have compensated for shorter dive times by increasing dive frequency. This possibility is supported by the finding that there was no significant difference between the proportion of time spent feeding (as calculated by instantaneous scans) by the male and female. Given a mean calculated time devoted to feeding of about 5 hours per day the male and female would be expected to undertake 435 and 455 dives respectively. Assuming that the female is physiologically constrained by smaller size from undertaking dives as long as those of the male then the data imply that food intake of the female could be enhanced by increased dive frequency.

Sector use

All sectors at Top Tarn were used for feeding but to varying degrees. Observations suggested that the female circulated around the lake in a systematic manner during feeding bouts, travelling in an anticlockwise direction. A typical circuit on the 10th July was completed in 105 minutes. Systematic use of the lake by the male was less obvious. Presumably this pattern of feeding is a consequence of local resource depletion and/or disturbance to both potential prey and bottom sediments. Circulation around the lake may be a means of maintaining optimum feeding rates. Similar systematic exploitation of food resources has been described for Pied Wagtails *Motacilla alba* (Davies 1976), Pied Flycatcher *Ficedula hypoleuca* (Bibby and Green 1980) and Amakihi *Loxops virens* (Kamil 1978).

Summary

Aspects of the time budget and diving ecology of Long-tailed Ducks *Clangula hymalis* were studied in July 1984 at five plateau lakes in West Greenland.

Examination of diurnal behaviour showed that peak vigilance levels may be correlated with peak Arctic Fox *Alopex lagopus* activity, although the two variables may be independently related to other factors. Males spent significantly more time alert and less time resting than females.

For both sexes dive times and dive intervals varied significantly between sites. Male dive times were longer than those of females, probably as a consequence of physiological differences in diving capacity associated with body size, but dive intervals were not significantly different. Dive times and dive intervals were positively correlated.

Females appeared to compensate for shorter dive times by increasing dive frequency and one female exploited the resources of the lake systematically, probably in response to local resource depletion and disturbance.

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