DIURNAL ACTIVITY AND ENERGY BUDGETS OF GOOSANDER *MERGUS MERGANSER* WINTERING ON CHEW VALLEY LAKE, NORTH SOMERSET: INFLUENCE OF TIME OF DAY AND SEX

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Diurnal activity of wintering Goosander was studied at Chew Valley Lake using instantaneous scan sampling. The sex ratio of 0.48 males per female was relatively consistent through midwinter 1995/1996. Daily energy expenditure calculations, based upon published basal metabolic rates, suggested that feeding activities incurred the second highest energy cost after resting although feeding occurred for only a small proportion of daylight hours (14% for males and 17% females). Males devoted less time to feeding activities than females, although theoretically males need more energy per day, due to their larger size. It was calculated that males need between 175.5 and 216.6 g/fish/hr spent feeding, compared to females requiring between 117.2 and 144.6 g/fish/hr spent feeding. Males are therefore either more efficient at energy conservation or foraging (e.g. taking larger fish with higher calorific value). Assuming an assimilation efficiency of 80%, and the food to have an energy content of 4.0 KJ/g, it was calculated that Goosander at Chew Valley Lake consumed about 10-13% of their body mass in fish per day.

Keywords: Activity Budgets, Daily Energy Expenditure, Goosander

In Britain, wintering Goosander *Mergus merganser* favour inland freshwaters and rivers (Cramp & Simmons 1977), roosting mainly on reservoirs and lakes at night and moving to nearby rivers, or remaining on standing waters, to feed during the day (Underhill 1993, Marquiss & Duncan 1994). Goosander are piscivorous ducks catching fish mainly by surface diving (Cramp & Simmons 1977). In shallow water, they may catch prey without submerging but in deeper water will always dive, usually returning to the surface to swallow prey. Most of their prey is located visually, often by scanning from the surface with eyes and bill submerged (Cramp & Simmons 1977). Thus Goosanders are largely day-active (Nilsson 1970) and hunt singly, in pairs, small groups or sometimes in large flocks, driving fish forward or into shallow water (Mills 1962). This study of wintering Goosander at Chew Valley Lake (CVL), North Somerset, England (51°20'N, 2°37'W) aimed to: 1) document seasonal changes in numbers and sex ratio; 2) describe diurnal trends in behaviour; 3) compare time and energy budgets between the sexes.

Study site and methods

The activities of Goosander were observed at CVL, an important site for many wildfowl

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species, and supporting the fifth largest concentration of wintering Goosander in Britain (Cranswick *et al.* 1997). Goosander at CVL fish chiefly at the northern end of the lake, using the western shore of Denny Island and an adjacent mud bank for loafing (**Figure 1**).

Observations were made from the west shore of the lake and were conducted over all daylight hours on 15 days between 9 November 1995 and 2 February 1996. Instantaneous scan sampling (Altmann 1974) was conducted every hour between 0700 and 1500 hours (dusk till dawn) using a 15-45 x 60 telescope. A total of 195 instantaneous scans were carried out over 60 hours, on a mean of 152.5 birds per scan. During each scan, the behaviour of each Goosander encountered was recorded as one of thirteen behaviours, classified into five daytime activities for analysis:

- Feeding (diving, inter-dive, head-under-search, drinking, alert behaviour)

- Resting (resting and loafing on water or land)

- Comfort activities (bathing and preening on water or land)

- Social behaviour (social interactions, courtship)

- Flying

Goosander were identified as adult males (including small numbers of birds in eclipse plumage), first winter males (female-like plumage but larger size and with white neck and breast) or females (adults and first years were inseparable in the field). Due to a small sample size of first year males, and the inability to separate first year and adult females in the field, data for both ages were combined for analysis.

Scan sample data were analysed as the mean hourly proportions of birds in each activity. Mann-Whitney U-tests were used to investigate differences between the numbers of males and females and the proportion of birds of each sex in the respective behaviours.

Figure 1. Map of Chew Valley Lake, North Somerset, England. Observations were made from Woodford Lodge on the west shore of the lake (marked with a filled square).

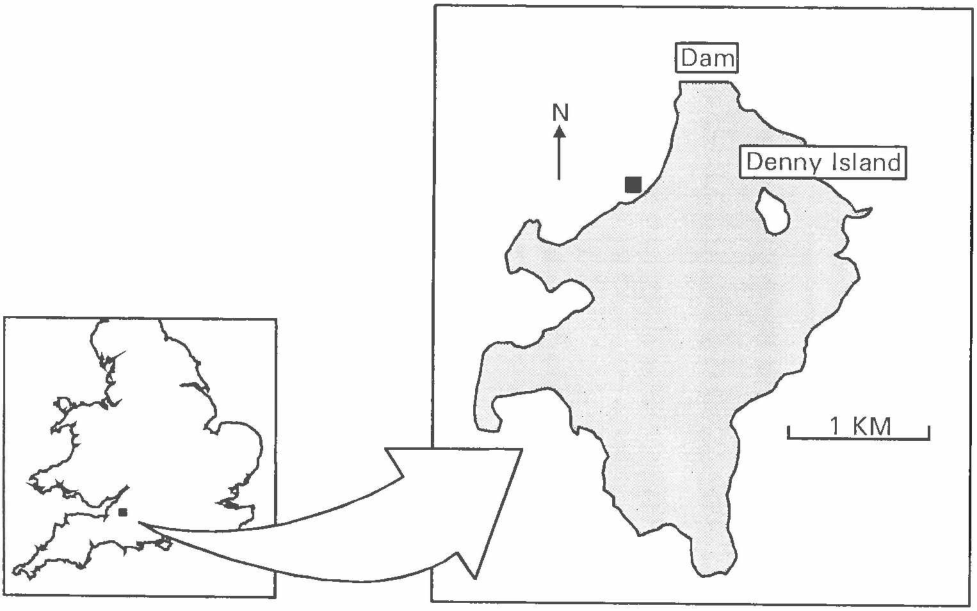

Table 1. Published basal metabolic rate (BMR) coefficients used in energy budget calulations for Goosander at Chew Valley Lake, North Somerset, England.

Behaviour	BMR Coefficient	Species	Reference
Feeding	3.2 x BMR	Tufted Duck	Bevan & Butler (1992)
Flying	10.0 x BMR	White-fronted Goose	Owen (1972)
Resting on land	1.4 x BMR	Black Duck	Wooley & Owen (1978)
Resting on water	2.0 x BMR	Tufted Duck	Bevan & Butler (1992)
Comfort/Social	1.8 x BMR	Black Duck	Wooley & Owen (1978)

Spearman Rank correlations were used to investigate relationships between behaviours and time. To reduce the problem of pseudoreplication (Hurlbert 1984), comparisons between sexes used means per day (*n*=15 days) and comparisons with time of day used means per hour (*n*=10 hours).

Daily energy expenditure (DEE) was calculated using activity budget data, determining the Basal Metabolic Rate (BMR) using the Aschoff-Pohl equation:

BMR=307.5 Body Mass$^{0.734}$ (Aschoff & Pohl 1970) and multiplying the time spent in each behaviour by BMR coefficients from previous metabolic studies in waterfowl **(Table 1)**. Although BMR coefficients are used from three different waterfowl species (Tufted Duck, Black Duck and White-fronted Goose), these are the most applicable to the wintering Goosanders observed during the current study (R.M. Bevan, *pers. comm.*), especially with regard to the relative metabolic costs of each activity.

The BMR of male and female Goosanders was calculated as 448 KJ/day and 353 KJ/day, respectively, assuming a mean weight of 1,671 g for males and 1,205 g for females (Cramp & Simmons 1977). No nocturnal observations were conducted, but as Goosander are visual feeders (Nilsson 1970), we assumed they rested throughout the night. Whether or not birds roosted on land or water may have had a significant effect on energy estimates as resting on water is more costly than resting on land (Bevan & Butler 1992). Calculations of DEE therefore took both scenarios into account.

Daily Food Intake (DFI) was calculated from DEE, assuming an assimilation efficiency of 80% (Feltham 1995) and the energy content of food to be 4.0 KJ/g (Kieckbusch & Koop 1993, Hislop *et al.* 1991, Sidwell 1981, all cited in Grémillet *et al.* 1995).

Results

Maximum daily counts of both male and female Goosander increased rapidly during November, less so during December and remained relatively stable at about 200 birds during January, although the number of visits during this month was low (**Figure 2**). Significantly more female than male Goosander were present at CVL during the study (W=149.5, *n*=15 days, *P*=0.0006) with a mean sex ratio of 0.48 males per female. This remained constant over the course of the study despite the increasing numbers of birds present as the gradient of the regression line through the sex ratio data (y=0.00006x + 0.475) did not differ significantly from zero (t=0.10, *n*=15 days, *P*=0.92).

Goosanders at CVL spent most of their time resting (60-65%) with only 15% of the day (about 1$^1/_2$ hours) spent feeding and performing comfort movements (**Table 2**). A significantly higher proportion of females (16.8%) than males (14.2%) were observed feeding (W=3107.0, *n*=10 hours, *P*=0.006) while

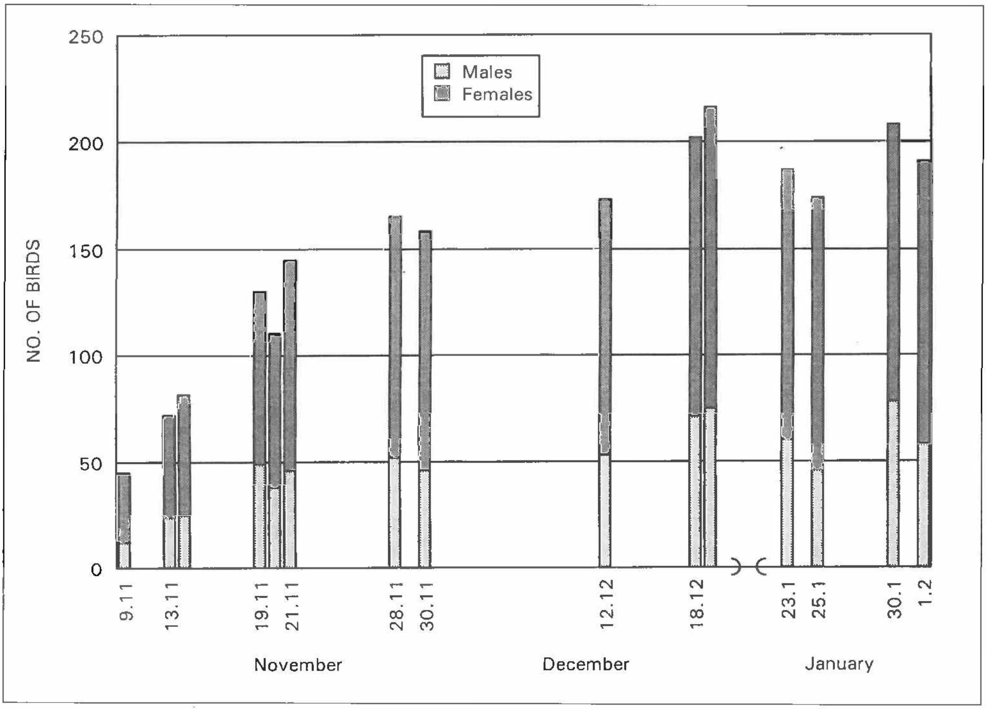

Figure 2. Maximum counts of male and female Goosander at Chew Valley Lake, North Somerset, England, November 1995-February 1996. Note breakpoint in x-axis.

significantly more males rested (W=4012.0, *n*=10, *P*=0.012) and were involved in social behaviour (W=4150.5, *n*=10 hours, *P*=0.006). Males and females did not differ in the time spent flying or in comfort activities.

The proportion of birds feeding was greatest at sunrise, decreasing steadily through the day, (males *r*=-0.733, d.f.=8, *P*<0.05; females *r*=-0.806, d.f=8, *P*<0.01, **Figure 3**) whilst the proportion of birds resting gradually increased

Table 2. Diurnal time budget of Goosander at Chew Valley Lake, North Somerset, England, November 1995-February 1996. Figures are means (± 1 S.E.) from 195 instantaneous scans carried out over 60 hours on a mean of 152.5 birds per scan.

Behaviour	**Male**		**Female**	
	% of day	**Hrs/day**	**% of day**	**hrs/day**
Feeding	14.2 (1.86)	1.28 (0.21)	16.8 (1.97)	1.51 (0.22)
Resting on land	37.5 (1.54)	3.38 (0.17)	39.8 (1.78)	3.58 (0.20)
Resting on water	27.7 (1.57)	2.49 (0.17)	22.8 (1.64)	2.05 (0.18)
Comfort movements	16.7 (1.52)	1.50 (0.17)	18.4 (1.68)	1.67 (0.19)
Social activities	3.5 (0.52)	0.32 (0.06)	1.9 (0.63)	0.17 (0.07)
Flying	0.4 (0.18)	0.04 (0.02)	0.3 (0.09)	0.03 (0.01)
Total	100	9.00	100	9.00

Table 3. Calculated Daily Energy Expenditure (DEE) in KJ for Goosanders at Chew Valley Lake, North Somerset, England, November 1995-February 1996.

	Male		Female	
	Roost land	Roost water	Roost land	Roost water
Feeding	76.5	76.5	71.0	71.0
Resting on land	480.5	88.4	382.2	73.6
Resting on water	93.0	653.3	60.2	501.0
Comfort/Social	61.2	61.2	48.7	48.7
Flying	7.5	7.5	4.4	4.4
Total	718.7	886.9	566.5	698.7

over the course of the day (males r=0.787, d.f.=8, P<0.05; females r=0.859, d.f.=8, P<0.01). Comfort movements peaked around mid-day as birds moved from water to land. Flying and social activity showed no trends with time.

Male Goosanders at CVL had a calculated DEE of 718.7 or 886.9 KJ, depending on whether they roosted on land or water (**Table 3**), which was equivalent to a DFI of 224.6 or 277.2 g of fish, representing 10.5–13.0% of their body weight (**Table 4**). The DEE of female Goosanders was 566.5-698.7 KJ, with an equivalent DFI of 177.0-218.3 g, representing a similar proportion of body mass as males (9.7-12.0%).

Discussion

The maximum of 217 Goosander on 19 December 1995 was the highest ever count at CVL (Avon bird reports) and follows significant increases in Goosander numbers, both regionally and nationally, over the past three decades (Kirby *et al.* 1995). The sex ratio was relatively constant at 0.48 males per female throughout this winter. Similar ratios have been recorded in Wales during the breeding season in recent years (Underhill 1993, Griffin 1990).

Male Goosander need to obtain significantly more energy per hour than females because of their larger body size. To achieve this, males could either spend longer feeding, catch more fish per unit time, take larger fish or take species with higher calorific value than females. Larger diving ducks have a potentially greater capacity for oxygen storage (Butler & Jones 1982), and are also more powerful, descending faster than smaller ducks of similar morphology (Lovvorn *et al.* 1991). Thus, in theory, male Goosander could be more efficient than females when diving. This study suggested that this indeed was the case as, despite their greater energetic requirements, males spent less time feeding and accordingly must have ingested energy at a higher rate than females.

It was estimated that Goosanders in this study required some 9.7-13% of their body mass in food every day. This is considerably lower than found in previous studies of Goosander in Scotland (Feltham 1995) and of Common Merganser *M. m. americanus* in North America (Latta & Sharkey 1966, Miller 1973). The lower energy costs at CVL may be a result of a number of different factors, for example the weather at CVL was relatively mild during the 1995/96 winter which may have reduced the Goosanders' metabolic costs. However, Goosander at CVL undoubtedly spent little time engaged in high energy cost activities, flying very little and remaining at the lake to feed and roost. This contrasts with the behaviour of birds feeding on rivers in Scotland and Wales which tend to fly to nearby lakes and reservoirs to roost (Marquiss & Duncan 1994, C.Wells *pers. comm.*). Foraging in running water may also be energetically more expensive than in lake situations. Goosander at CVL may also gain by foraging synchronously in large groups, which is thought to increase individual feeding

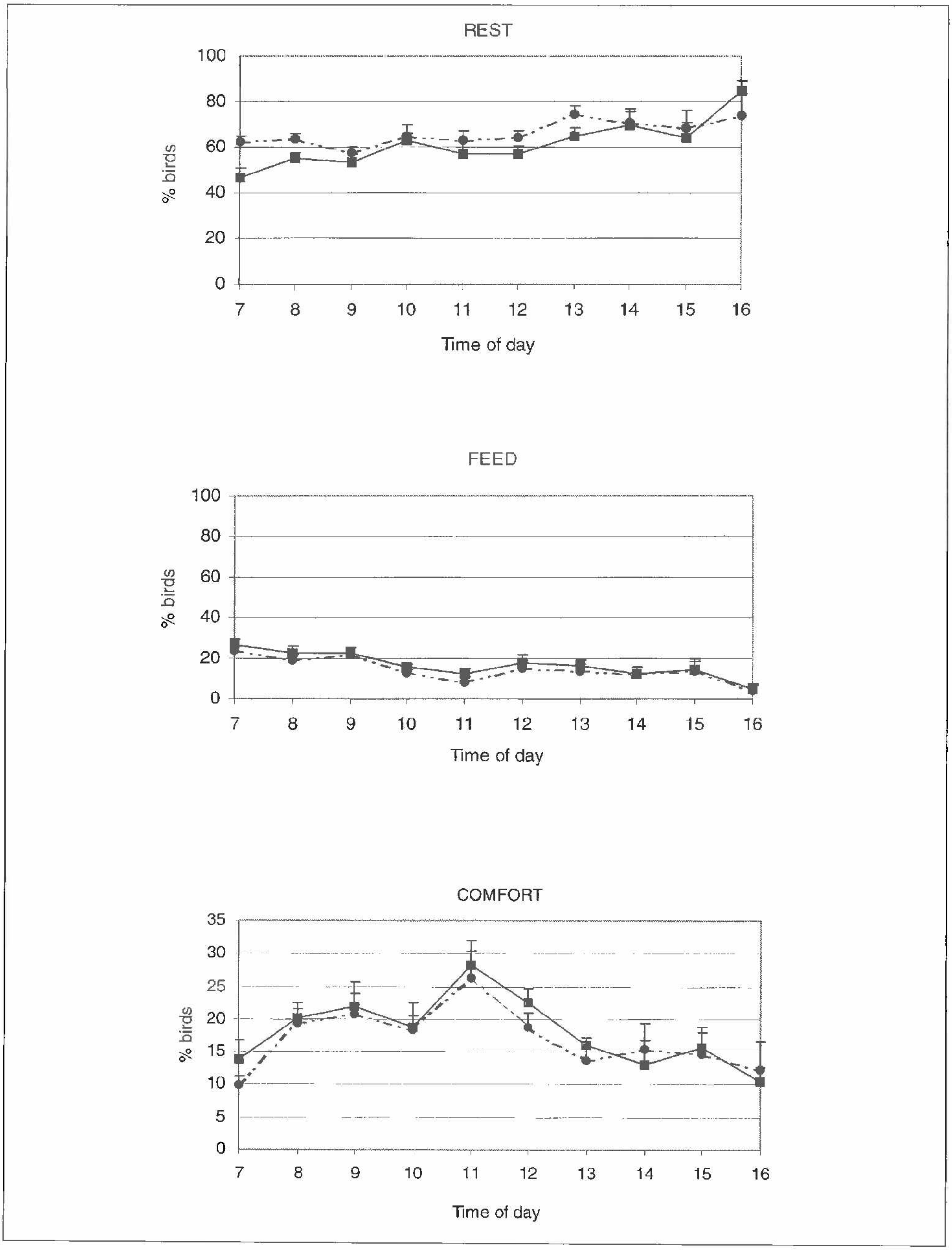

Figure 3. Percentage of male and female Goosander (± 1 S.E.) engaged in the three dominant behaviours in relation to time of day at Chew Valley Lake, North Somerset, England, November 1995 - February 1996 (n=195 scans on a mean of 152.5 individuals). Males=circles, females=squares

Table 4. Calculated Daily Food Intake (DFI) of Goosanders at Chew Valley Lake, North Somerset, England, November 1995 – February 1996.

	DEE (kj/day)	DFI (g/fish/day)	G/fish/hr feeding	% body mass/day
Male roost land	718.7	224.6	175.5	10.5
Male roost water	886.9	277.2	216.6	13.0
Female roost land	566.5	177.0	117.2	9.7
Female roost water	698.7	218.3	144.6	12.0

success in species such as Cormorants (Bowler *et al.* 1998). Furthermore, Goosander at CVL were observed on several occasions to either fly or swim directly to Cormorants engaged in group fishing, and immediately begin foraging themselves amongst the Cormorants. This suggests that Goosander may be using the Cormorants as indicators of fish shoals, therefore saving energy required to locate shoals themselves.

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