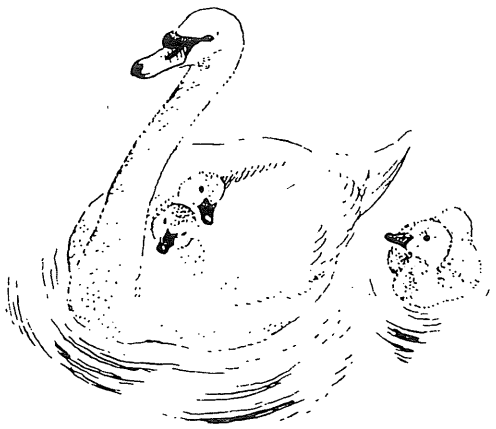
Feeding activity and body condition of Mute Swans *Cygnus olor* in rural and urban areas of a lowland river system.



JANE SEARS

The winter feeding activity of five flocks of predominantly immature, non-breeding Mute Swans was monitored during 1983–84. Four different habitats within the lowland river system of the Thames valley were compared. Total body weight and muscle and fat reserves of swans from rural and urban areas were measured in order to assess whether contrasting diets and feeding rates result in variation in body condition.

Swans feeding on fields of winter wheat and ley grass spent on average 67% of the time actively grazing. Those on the lake fed for 46% of the time on a diet comprised mainly of mixed filamentous green algae. In areas where members of the public fed bread to the swans, the average percentage time spent feeding was considerably reduced. The flock on the gravel pit was observed feeding for only 20% of the time and on the urban river, for 22% of the time. Bread appeared to be the preferred food. There was active competition between the swans whenever it was supplied, and relatively little natural food was eaten, even when there was no bread available. It is suggested that swans may be selecting bread due to its high digestibility.

The difference in feeding activity rates between flocks in rural and urban areas was consistent throughout the year. From January to August 1984 on average 36% of the rural flock were feeding during scan observations, compared with only 14% of the urban flock. The feeding rates of the urban swans are extremely low, especially when compared with other studies.

Despite the contrast between both the diet and the feeding rates of swans in urban and rural flocks, there was no significant difference in their average fat scores. Swans in the urban flock had significantly smaller breast muscle reserves but this difference may not be due to diet alone. Swans' dependence on humans for food can indirectly cause them harm; for example, their habit of begging from people draws them into areas with the highest densities of discarded lead weights, and thus increases their chances of becoming poisoned.

At the last national census of Mute Swans *Cygnus olor* in Britain, 94% were found to inhabit inland waters such as rivers, lakes, canals and gravel pits, and 6% inhabited coastal areas (Ogilvie 1986). Relatively little has been published on the feeding behaviour of Mute Swans, especially on inland waters. The most detailed studies have observed swans feeding in tidal, brackish, and saltmarsh areas (Gillham 1956, Sparck 1957, Berglund *et al.* 1963, Mathiasson 1973), or on the seasonal floodlands of the Ouse Washes (Owen & Cadbury 1975). These studies all indicate the importance of submerged aquatic vegetation in the diet of swans. Scott & Birkhead (1983) and Scott (1984) recorded the food availability for swans living on territories on the Thames and its tributaries in Oxfordshire. Families living on small streams feed mainly on the leaves and stems of submerged aquatic plants, such as water crowfoot, *Ranunculus repens*, and *Potamogeton* spp. (Birkhead & Perrins 1986). Non-breeding swans tend to congregate in flocks on larger areas of water, such as rivers, lakes and gravel pits. Within the river systems of lowland Britain many of these flocks live in urban areas, where the swans are partially dependent on humans for food (Birkhead & Perrins 1986).

This study compares the feeding behaviour of flocks of swans in rural and urban areas of the Thames valley, England. The winter feeding activity of flocks in four different habitats was recorded and the feeding behaviour of one rural flock and one urban flock was monitored throughout

one year to compare seasonal feeding activity.

Secondly, total body weight and measures of the size and fat reserves in swans from rural and urban areas were compared to assess whether their contrasting diets resulted in variation in body condition.

Study area

Five flocks of predominantly immature, non-breeding swans living in the Thames valley, England, were studied during the winter of 1983–84. Three of the flocks were in rural areas of Oxfordshire and Berkshire, and two were on the River Thames, in urban town centres (Fig. 1).

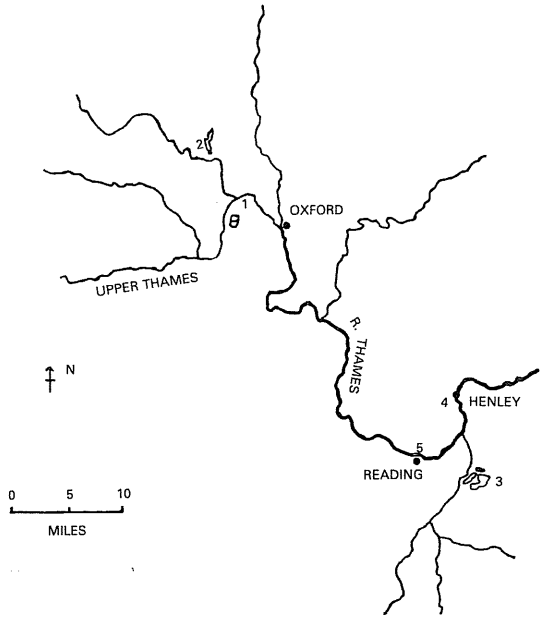


Figure 1. The study area showing sites of five winter flocks of Mute Swans: 1. Upper Thames, rural – arable fields; 2. Bladon Lake, rural – lake; 3. Dinton Pastures, rural – gravel pit; 4. Henley, urban – River Thames; 5. Reading, urban – River Thames.

Sampling methods

The flocks were observed using two sampling methods (Altmann 1974). For consistency, all observations were made between 10.00 and 13.00 h. Although the observation period was very limited there is evidence to suggest that Mute Swan feeding rates do not vary considerably during daylight hours (Owen & Cadbury 1975, Sears 1986).

1) Scan sampling: Instantaneous (or 'point') observations were made on the whole flock once every five minutes. The total number of birds and the number engaged in each activity were recorded. Twenty observations were made in each session, unless otherwise stated. In order to facilitate comparison between flocks the proportion of the flock engaged in each activity was calculated for each observation and the percentages averaged. Activity bouts generally last less than five minutes and therefore each observation should be relatively independent of the preceding one. The time taken to make a complete scan varied between habitats; on average 15 to 20 seconds for a flock of 20 swans on wheatfields and up to 60 seconds for urban flocks of varying numbers.

2) Focal-bird sampling: Individual swans were observed continuously during sample periods of 10 and 20 minutes. The type and duration of each activity was recorded throughout the sample period and the percentage of observation time spent in each activity was calculated.

Focal individuals were identified by unique numbers on large plastic rings (Ogilvie 1972), or by characteristic colouring and marks. Within these constraints the focal birds were a random sample of mixed ages and sex.

Activity types

Six types of activity were distinguished:

1) Feeding: divided by food type into a) vegetation (aquatic vegetation, wheat, grass), b) 'bread': swans were recorded as feeding on bread whenever they congregated around someone feeding them. Detailed observations suggest that only around 12% of the swans in a group actually had bread in their bills at any one time. The counts are therefore overestimates of the true consumption of bread.
2) Preening: including the 'comfort movements' described by McKinney (1965).
3) Swimming/walking.
4) 'Up': inactive, with head and neck held up, but not necessarily alert.

5) Begging: actively demanding food. Outstretched neck, often pecking at peoples' hands and feet.
6) Sleeping: in resting position. Neck bent, eyes shut, head sometimes under wing.

Seasonal observations

One urban flock and one rural flock were observed at monthly intervals throughout most of 1984. The rural 'Upper Thames' flock was observed in four different habitats. It wintered on the arable fields adjacent to the Thames; spent one month on the River Thames; then moved onto a neighbouring reservoir, at Farmoor, during May. It remained on the reservoir until August, after which it dispersed. The urban flock remained on the Thames at Caversham, Reading, throughout the year, although numbers present varied between 12 and 37. No known movement of ringed individuals occurred between the rural and urban flock.

Feeding behaviour

The feeding posture was recorded for individual swans observed on the river, lake and gravel pit. Four breeding postures were distinguished, as described by Owen & Kear (1972): 1) Surface feeding: bill horizontal along surface of water; 2) Head submerged; 3) Neck submerged; 4) Upended: whole body submerged except tail and feet.

Body condition

Measurements of total body weight, breast muscle thickness and subcutaneous fat score were made on two group of swans: a) swans found dead during 1984 from the rural areas of the Upper Thames, upstream of Oxford, the tributaries of the Windrush, Cherwell, and Thame and neighbouring gravel pits; b) live swans caught in the urban flock at Reading throughout 1984 and 1985. Measurements would have been made on live swans in the rural flocks, but it was not possible to catch these. Swans diagnosed as lead poisoned on autopsy, or with blood lead levels over 40 μg/100 ml. (Sears 1988a) have been excluded from the analysis since lead poisoned swans tend to have depleted muscle and fat reserves (Sears 1988b).

Total body weight was measured to the nearest 0.1 kg using a 20 kg pesola balance. Breast muscle thickness was measured to the nearest 0.5 mm using ultrasound, and the thickness of the subcutaneous fat layer was colour scored, following the methods described in Sears (1988b). Sex was determined by cloacal examination.

Results

Winter feeding activity

Scan and focal methods of observation showed similar variation in activity patterns of swan flocks between habitats (Table 1,

Table 1. Activity patterns for flocks of Mute Swans observed by scan sampling, November 1983 to April 1984.

HABITAT	Vegetation	Bread	Preen	ACTIVITY Swimming /Walking	'Up'	Beg	Sleep
Wheat field n = 180 observations, mean flock size = 20							
Mean % of flock	57.4	0	11.5	8.9	17.4	0	4.8
± S.E.	1.5	0	0.8	1.1	1.2	0	0.5
Lake/Gravel pit n = 200 observations, mean flock size = 16							
Mean % of flock	28.5	1.4	15	19.2	28.5	3.6	3.8
± S.E.	1.7	0.5	1	1.2	1.7	0.9	0.6
Urban river n = 240 observations, mean flock size = 17							
Mean % of flock	5	5.6	19.5	28.8	24.5	16.2	0.4
± S.E.	0.7	0.9	1.4	1.7	1.6	1.5	0.2

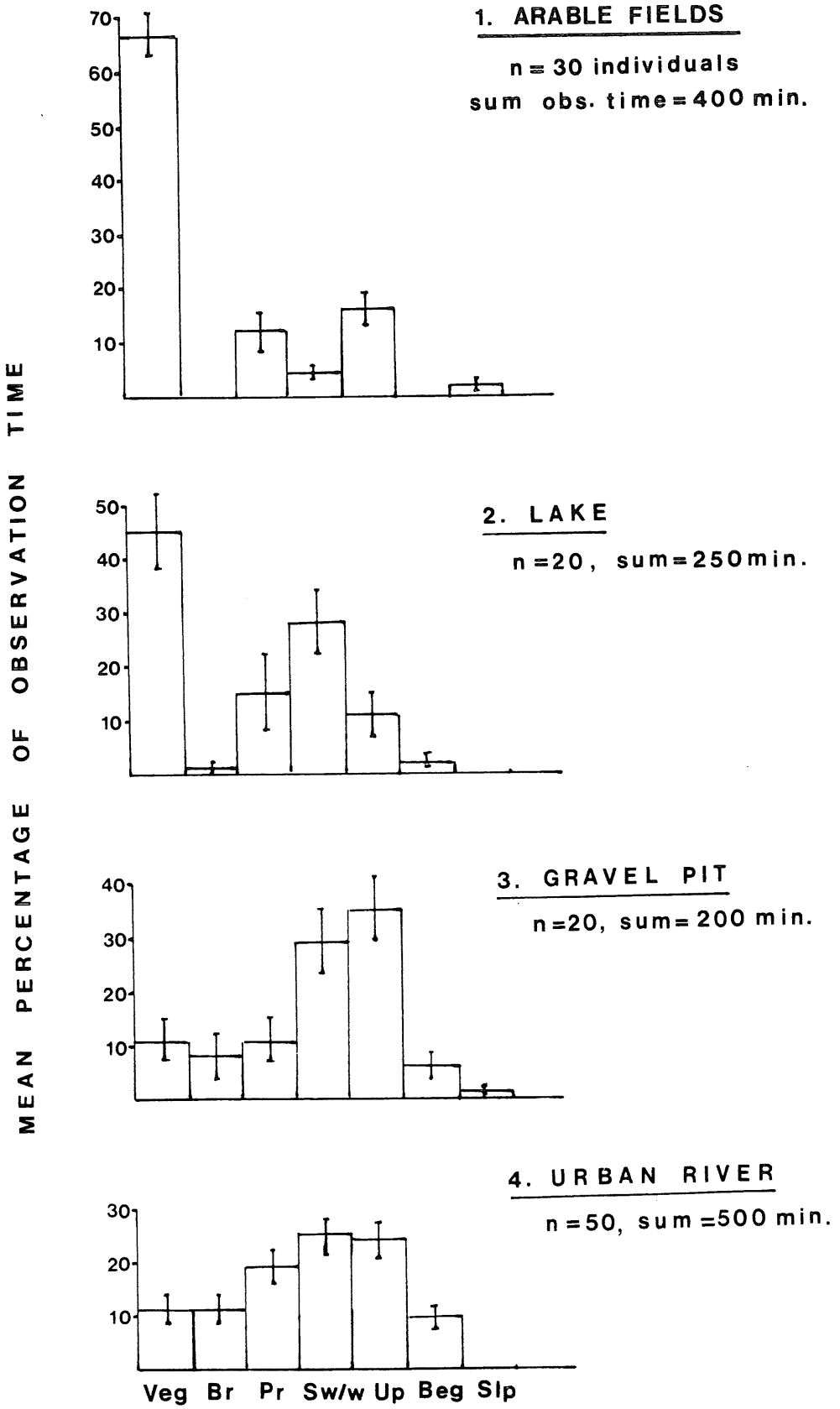


Figure 2. Activity budgets of focal individual Mute Swans comparing four habitats, December 1983 to April 1984. Key: Veg – vegetation; Br – bread; Pr – preen; Sw/w – swim/walk; 'Up' and Beg as on Table 1. Slp – sleep. One standard error bar above and below each mean.

Fig. 2). There was no significant difference between the average activity patterns recorded by scan observation for the lake and gravel pit flocks (Chi-squared arcsin $\sqrt{p} = 2.3$, df = 6, $P>0.05$) or for the two urban flocks (Chi-squared arcsin $\sqrt{p} = 5.3$, df = 6, $P>0.05$), and therefore the data were combined into two groups. Likewise, there was no significant difference in the average time budgets for focal birds in the two urban flocks (Chi-squared = 1.82, df = 5, $P>0.05$) and these have also been combined.

Swans in the rural flocks on the fields and lake were most commonly observed feeding. Focal birds on the fields spent an average of 67% of the observation time feeding, in contrast to those in the urban flocks which only fed for 22% of the time. Urban flock birds were seen begging for food more often than swans in any of the other flocks. They competed actively for bread whenever it was supplied and appeared to be always hungry. However, when no-one was feeding them, the urban swans and the ones on the gravel pit spent more time swimming around or remaining inactive than feeding on the available vegetation.

The type of food eaten also varied between habitats. The flock on the fields grazed winter wheat from November to February and ley grass in March. On water, Mute Swans often ingested vegetation whilst their heads were submerged, which made detailed observations of the type of food eaten impossible. On the lake the main food was mixed filamentous green algae (*Cladophora, Spirogyra* and others) which grows around the bases of old rushes. Focal swans on the lake were observed feeding on bread in less than 1% of the feeding observations. Swans on the gravel pit fed on vegetation in 58% of the feeding observations. The vegetation consisted of fragments of Canadian pondweed *Elodea canadensis*, rushes *Juncus* spp., young willow leaves *Salix* spp. and filamentous green algae. Bread formed a relatively large part of the diet of swans in urban flocks and was eaten in 50% of feeding observations. Other food consisted of filamentous algae or 'blanket weed' coating the stones and banks, and grass *Poa* spp. growing on the banks.

Seasonal feeding activity

a) Rural flock

The Upper Thames flock was observed feeding in four different habitats from January to August 1984, when it dispersed (Fig. 3). The greatest feeding activity was observed on the wheatfields in the winter months and on the reservoir in May and August. Feeding activity was reduced when the flock moved on to the River Thames in April and also whilst on the reservoir during June and July. The latter months correspond to the moult period when preening became the main activity.

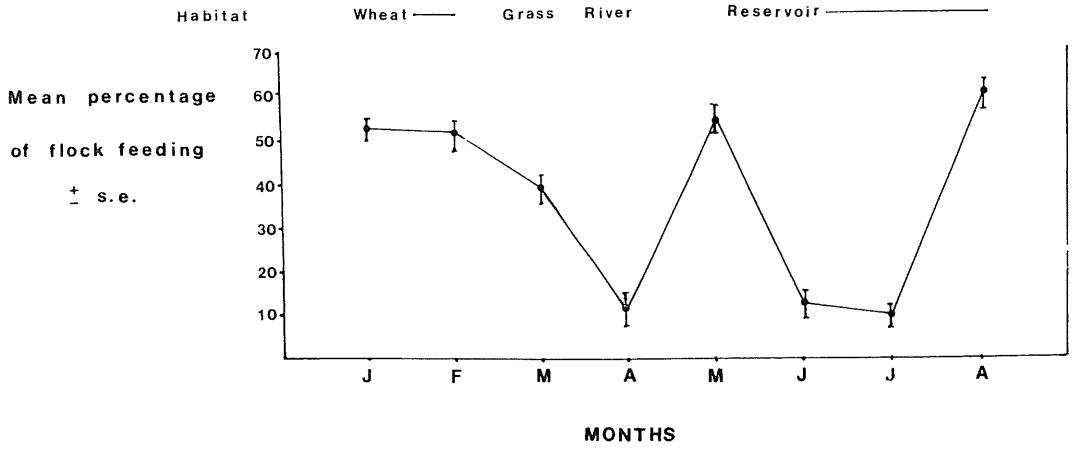
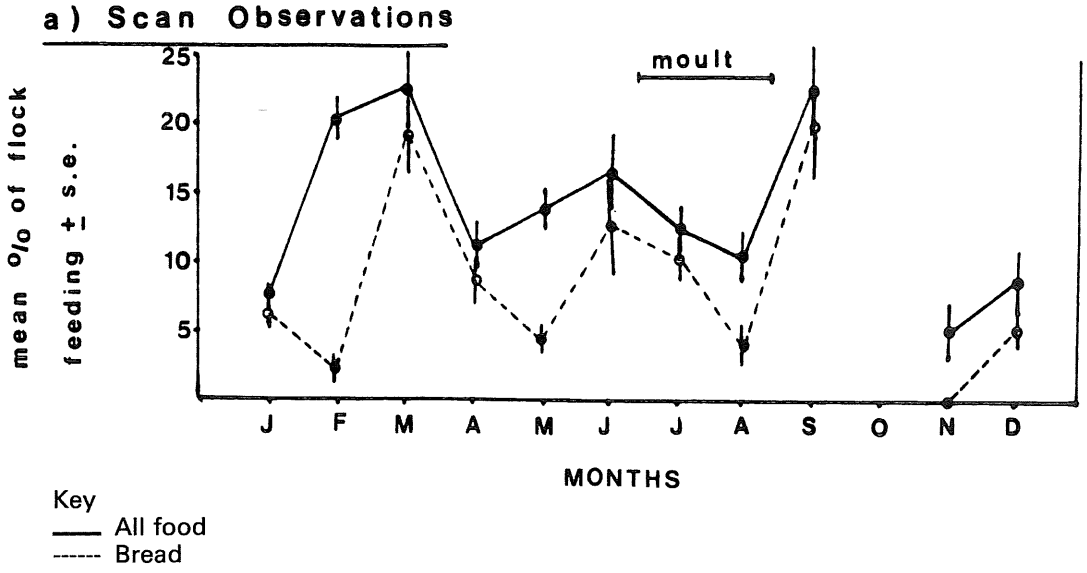


Figure 3. Seasonal pattern of feeding activity in the rural flock of Mute Swans studied by scan observation. January to August 1984.

b) Urban flock

A different seasonal pattern of activity was recorded for the flock at Reading (Fig. 4a). Feeding activity was surprisingly low during the winter months, but peaked in March. There was a drop in activity during April and again in August, a month later than the drop recorded for the rural flock. The seasonal pattern of feeding activity is closely related to the seasonal supply of bread, measured by the total length of time bread was fed to the swans by the public during each monthly observation session of 100 minutes (Fig. 4b). There was an exception during February when bread was supplied for a total of 40 minutes but only 2% of the flock fed on bread and 18% grazed grass on average during the observation period.

Throughout the year a significantly higher rate of feeding activity was observed in the rural flock than the urban flock. Overall from January to August on average 36% of the rural flock were observed feeding compared with only 14% of the urban flock.



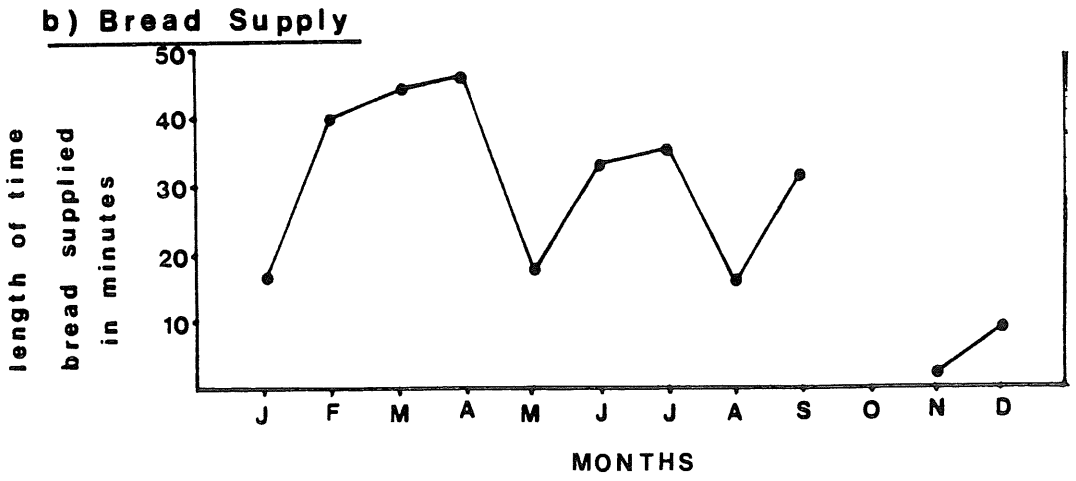


Figure 4. Seasonal pattern of feeding activity in the urban flock of Mute Swans studied by scan observation in relation to the seasonal supply of bread. January to December 1984.

No observations were made during October.

Feeding Behaviour

Swans on open water most commonly fed with their necks submerged (Table 2). Head submergence and surface feeding were recorded in 30–50% of observations of swans in urban flocks. Surface feeding was the most common posture for swans observed on the Upper Thames. Upending occurred where the water was deep, on the Upper Thames and on the reservoir.

Body condition

The total body weights of rural and urban swans are compared for two age groups; fledged swans of under three years old and adults of three years and over (Table 3). There was no significant difference between the weights of rural and urban swans except for males of under three years old, which were on average 1 kg heavier in the urban swans. There was no significant variation in muscle thickness or subcutaneous fat score with age (comparing fledged swans of under three years old with adults of three years and over) and therefore the data for all ages have been combined. Swans from the rural areas had significantly larger average breast muscle reserves than those in the urban flock, but there was no significant difference in their average fat scores (Table 4).

Table 2. Feeding postures of Mute Swans in five habitats.

FLOCK	FEEDING POSTURE Surface	Head down	Neck down	Up-ended
Rural river: Upper Thames				
Observations n = 57				
n	29	0	16	12
%	51%	0	28%	21%
Reservoir: Farmoor				
Observations n = 181				
n	0	11	143	27
%	0	6%	79%	15%
Gravel Pit: Dinton Pastures				
Observations n = 179				
n	17	10	146	6
%	9%	6%	82%	3%
Urban river: Henley				
Observations n = 52				
n	6	10	33	3
%	12%	19%	63%	6%
Urban river: Reading				
Observations n = 150				
n	54	27	65	4
%	36%	18%	43%	3%

Observations are not independent, since several individuals were observed more than once.

Table 3. Comparison of total body weight of Mute Swans from rural and urban areas.

Total body weight (kg)	RURAL Mean	± s.d.	n	URBAN Mean	± s.d.	n	t-test t	P
Under three years old								
Males	8.72	0.77	6	9.98	0.74	6	2.91	0.02
Females	6.97	0.93	3	7.77	0.66	16	1.42	0.29
Both	8.13	1.16	9	8.37	1.21	22	0.51	0.61
Three years and over								
Males	10.78	1.18	6	10.61	0.93	18	−0.3	0.75
Females	8.83	1.12	6	8.5	0.31	8	−0.7	0.51
Both	9.81	1.5	12	9.96	1.26	26	0.3	0.77

Table 4. Measures of the size of muscle and fat reserves of Mute Swans from rural and urban areas.

		RURAL			URBAN			t-test	
		Mean	± s.d.	*n*	Mean	± s.d.	*n*	t	P
Muscle Thickness (mm)	Males	62.7	9.7	12	48.9	6	24	4.52	0.001
	Females	64.2	7.9	9	44.7	7.2	24	6.52	0.001
	Both	63.3	8.8	21	46.8	6.9	48	7.68	0.001
Fat score									
	Males	17.2	4.5	11	15.4	4.4	24	1.09	0.29
	Females	16.2	7.2	9	15.4	5.3	24	0.3	0.77
	Both	16.8	5.7	20	15.4	4.8	48	0.91	0.37

Discussion

Highly variable feeding rates were recorded for Mute Swan flocks in different habitats within the Thames valley. The highest feeding rate recorded in this study was for swans grazing on winter wheat, where on average 57% of the flock were feeding during observations. Even this rate is lower than that recorded by Owen & Cadbury (1975) for Mute Swans on the Ouse Washes, where activity reached a plateau when 70–80% of the flock were feeding.

Flocks of swans in the Thames valley tend to move onto arable fields during the winter months when they are precluded from the rivers due to the fast flow. Mute Swans are relatively inefficient at grazing on land and need to sustain a high feeding rate. When feeding on luscious growth they tend to drop a large proportion of the material they have cropped, apparently because they are unable to swallow it all at once. This behaviour has also been observed in grazing Bewick's Swans (E. Rees, pers. comm.). It is possible that the swans are selectively discarding less nutritious parts of the vegetation but this seems unlikely in the light of field observations. Mute Swans need to ingest large quantities of vegetation in order to meet their nutritional requirements. It is possible that swans, like geese, are unable to digest cellulose (Mattocks 1971). Wheat plants have a relatively high fibre content (average 37% dry matter, M. East, pers. comm.) especially compared to a Mute Swan's more usual diet of submerged aquatic vegetation. For example, the North American *Potamageton richardsonii* has a fibre content of 14% dry matter (Coleman & Boag 1987) and this is likely to be fairly representative of other species of submerged aquatic plants. Therefore, to compensate for the low digestibility, swans need a large intake of cereals and coarse grasses. Precise quantities are unknown but, in view of their relative fibre contents, the average daily consumption is likely to be considerably higher than the 4 kg (wet weight) of aquatic vegetation estimated by Mathiasson (1973).

An extremely low feeding rate was recorded for swans living in urban areas of the River Thames. Urban swans spent an average of 22% of their time feeding, yet even this is an overestimate given that in observations of feeding on bread, only 12% of the swans were actually eating at any one time. No other known studies of swan or goose feeding behaviour have reported such a low rate of activity. It is possible that since all the observations were made between 10.00 and 13.00 h., the swans increased their feeding activity at other times of the day, but this seems unlikely. Owen & Cadbury (1975) found that feeding activity on the Ouse Washes reached a plateau three hours after sunrise. Swans in the Upper Thames flock, observed grazing wheat, maintained a relatively constant feeding rate throughout the day (Sears 1986).

Bread forms a significant part of the diet of the swans in urban flocks. There is a sparsity of aquatic vegetation in urban areas of the Thames (Scott & Birkhead 1983). Since Mute Swans are known to be opportunistic feeders (Owen & Kear 1972) they may have changed their diet due to the lack of natural food. Bread was also extremely popular amongst swans living in areas where natural food was readily available, such as on the gravel pit and lake. On the gravel pit it appeared that swans were

selecting bread preferentially. When no bread was supplied the swans would eagerly wait for more rather than go and feed on the abundant water weed. Many studies have shown that geese are selective feeders and there is some evidence that swans are also selective in their diet (Mathiasson 1973). Geese have been found to select food that is highly digestible (Boudewijn 1984, Coleman & Boag 1987). It is possible that Mute Swans select bread because it is easily digested and assimilated.

The value of bread as a food source for swans is debatable since the precise dietary requirements of swans are unknown. A diet consisting wholly of bread is unlikely to be balanced. Since wheat grain is known to be deficient in several amino-acids that are required by geese (Joyner *et al.* 1987) it is possible that bread is deficient in protein for swans. To see whether there was any evidence of this, measures of body condition in rural and urban swans were compared. Total body weight provides a useful overall index of body condition of swans (Bacon & Coleman 1986) but estimates of the size of muscle and fat reserves indicate important variation in body composition. It is necessary to measure both of these reserves since the relative quantities of fat and protein can vary independently of each other. Swans in the urban flock were found to have lower muscle reserves than those from the rural areas. This may be a result of the extremely low feeding rates recorded for urban swans, although in this case one would also expect urban swans to have lower body weights and diminished fat reserves compared with rural swans. In fact there was no significant difference between the two groups in the size of fat reserves and only the juvenile males varied in total body weight. Suprisingly the urban juvenile males were heavier than the rural ones. This may just be a sampling effect due to the small number of individuals compared. Given that the rural swans had larger muscle reserves, one would expect them to be heavier. It is possible that the swans from the rural areas, all of which were dead when measured, had lost weight as a result of water loss, and also that the live swans had more food in their guts, thus increasing their body weight but not their reserves.

The urban swans' muscle reserves may have been depleted as a result of a lack of protein in a diet comprised substantially of bread. Unfortunately this comparison is confounded by the problem of lead poisoning. Lead inhibits protein synthesis and causes muscle wasting (Buck *et al.* 1985). The incidence of lead poisoning is higher in swans from the urban areas (Sears 1988a) and although all swans with elevated blood lead levels were excluded from the analysis, it is possible that some of the birds with normal blood levels had previously been exposed to lead. Thus the differences in the size of muscle reserves may not arise from the diet alone.

Other evidence suggests that a diet consisting largely of bread is not seriously deficient in protein. Pairs of swans living on territories with high potential bread supplies but low quantities of aquatic vegetation were found to lay large clutches (Scott & Birkhead 1983). The size of protein reserves is known to be an important factor for breeding in a number of bird species (for example: Fogden & Fogden 1979, Jones & Ward 1976, Ward 1969). It has been demonstrated that the potential clutch size of individual female Lesser Snow Geese *Anser caerulescens caerulescens* is a function of their protein reserves (Ankney & MacInnes 1978). This evidence suggests, therefore, that swans feeding largely on bread are able to establish sufficiently large protein reserves to be able to lay relatively large clutches.

The habit of eating bread can be harmful for swans in other ways, since it has caused them to become very dependent on humans. Large numbers of swans are drawn into areas such as urban centres where people feed the birds. Problems can arise when the food supply is seasonal. Fewer people come to feed the birds after the end of summer, and the supply of bread diminishes at a most critical time for the birds which need to build up reserves for the winter. Supplementary winter feeding is then often required. A swan which demands food by approaching people and hissing is often branded as aggressive, and in some cases measures are taken to remove such swans. On the other hand, tame swans are easy prey for vandals. The areas where swans are fed are often very popular fishing areas. This can cause two problems: swans are often attracted towards the anglers, particularly when bread is used as bait, and they can easily become entangled in nylon line as a result. High densities of anglers'

lead weights tend to accumulate in such areas, particularly on concrete embankments (Bell *et al.* 1985, Sears 1988a). Swans drawn to the bank to search for food and grit have a chance of ingesting lead weights and becoming lead poisoned as a result.

I would like to thank all those who have helped catch swans and in particular my summer assistants during 1984 and 1985, Chris Briggs and Glen Tyler. I am indebted to the many members of the public who have notified me of dead swans. This work was carried out whilst I was funded by the Nature Conservancy Council, the Royal Society for the Protection of Birds, the Water Research Council, the International Fund for Animal Welfare, the World Wildlife Fund and the Ernest Cooke Trust.

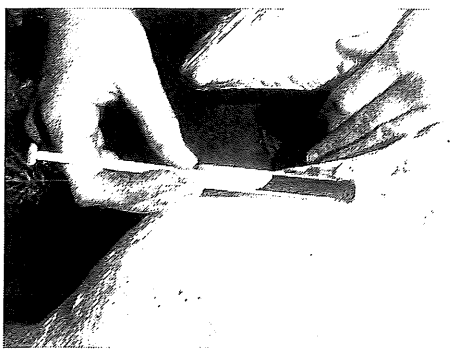
References

Altmann, J. 1974. Observational study of behaviour: sampling methods. *Behaviour* 49:227–267.
Ankney, C.D. & MacInnes, C.D. 1978. Nutrient reserves and reproductive performance of female Lesser Snow Geese. *Auk* 95:459–471.
Bacon, P.J. & Coleman, A.E. 1986. An analysis of weight changes in the Mute Swan *Cygnus olor*. *Bird Study*. 33:145–158.
Bell, D.V., Odin, N. & Torres, E. 1985. Accumulation of angling litter at game and coarse fisheries in South Wales, UK. *Biol. Cons.* 34:369–379.
Berglund, B.E., Curry-Lindahl, K., Luther, H., Olsson, V., Rodhe, W. & Sellerberg, G. 1963. Ecological studies of the Mute Swan *(Cygnus olor)* in South-eastern Sweden. *Acta vertebratica* 2:167–288.
Birkhead, M. & Perrins, C.M. 1986. *The Mute Swan*. London: Croom Helm.
Boudewijn, T. 1984. The role of digestibility in the selection of spring feeding by Brent Geese. *Wildfowl* 35:97–105.
Buck, W.B., Osweiler, G.D. & Van Gelder, G.A. 1985. Pp. 319–333 in *Clinical and diagnostic veterinary toxicology* (Van Gelder, G.A. Ed.). Iowa: Kendall/ Hunt.
Coleman, T.S. & Boag. D.A. 1987. Canada Goose foods: their significance to weight gain. *Wildfowl* 38:82–88.
Fogden, M.P.L. & Fogden, P.M. 1979. The role of fat and protein reserves in the annual cycle of the Grey-backed Camaroptera (Aves: Sylvidae) in Uganda. *J. Zool. Lond.* 189:233–258.
Gillham, M.E. 1956. Feeding habits and seasonal movements of Mute Swans on two South Devon estuaries. *Bird Study* 3:205–212.
Jones P.J. & Ward, P. 1976. The level of reserve protein as the proximate factor controlling the timing of breeding and clutch size in the Red-billed Quelea *Quelea quelea*. *Ibis* 118:547–574.
Joyner, D., Jacobson, B.N. & Arthur, R.D. 1987. Nutritional characteristics of grain fed to Canada Geese. *Wildfowl* 38:89–93.
Mathiasson, S. 1973. A moulting population of non-breeding Mute Swans with special reference to flight-feather moult, feeding ecology and habitat selection. *Wildfowl* 24:43–53.
Mattocks, J.C. 1971. Goose feeding and cellulose digestion. *Wildfowl* 22:107–113.
McKinney, F. 1965. The comfort movements of Anatidae. *Behaviour* 25:120–220.
Ogilvie, M.A. 1972. Large numbered leg bands for individual identification of swans. *J. Wildl. Manage.* 36:1261–1265.
Ogilvie, M.A. 1986. The Mute Swan, *Cygnus olor*, in Britain, 1983. *Bird Study* 33:121–137.
Owen, M. & Cadbury, C.J. 1975. The ecology and mortality of swans at the Ouse Washes, England. *Wildfowl* 26:31–42.
Owen, M. & Kear, J. 1972. Food and feeding habits of swans. Pp. 58–77 in the *The Swans* by Peter Scott and The Wildfowl Trust. London: Michael Joseph.
Scott, D.K. 1984. Winter territoriality of Mute Swans *Cygnus olor*. *Ibis* 126:168–176.
Scott, D.K. & Birkhead, M.E. 1983. Resources and reproductive performance in Mute Swans, *Cygnus olor*. *J. Zool. Lond.* 200:539–547.
Sears, J. 1986. A study of Mute Swans in relation to lead poisoning. Unpublished D. Phil. thesis University of Oxford.

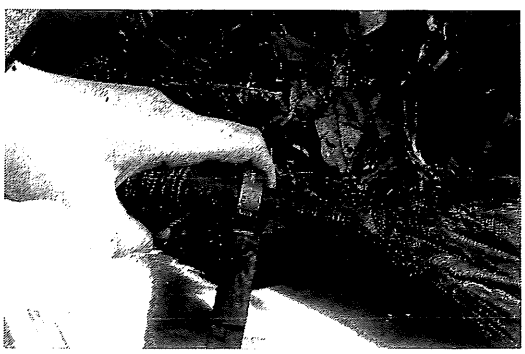
Sears, J. 1988a. Regional and seasonal variations in lead poisoning in the Mute Swan, *Cygnus olor*, in relation to the distribution of lead and lead weights, in the Thames area, England. *Biol. Cons.* 46:115–134.
Sears, J. 1988b. Assessment of body condition in live birds; measurements of protein and fat reserves in the Mute Swan, *Cygnus olor*. *J. Zool. Lond.* 216:295–308.
Sparck, R. 1958. An investigation of the food of swans and ducks in Denmark. *Trans. Cong. Int. Union Game Biol.* 3:45–47.
Ward, P. 1969. The annual cycle of the Yellow-vented Bulbul *Pycnonoyus goiavier* in a humid equatorial environment. *J. Zool. Lond.* 157:25–45.

J. Sears, Edward Grey Institute, Department of Zoology, The University, Oxford, OX1 3PS.

A Mute Swan has its body condition measured.



Blood is taken from the wing vein of a swan; its lead content will be analysed.



A British Trust for Ornithology ring is put on the leg of a swan so that it can be identified in the future.