Behaviour of captive Canvasbacks *Aythya valisineria* fed different diets during winter

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Time activity budget studies were conducted on captive Canvasbacks maintained on ad libitum diets with varying levels of protein and energy during the winters of 1978–79 and 1979–80. No differences could be detected in the behaviour of the ducks as a result of the diets they received. Differences due to season and sex were observed for some behaviours. Activity decreased (P<0.05) during the winter apparently as a mechanism to conserve energy. This decrease occurred in mid-winter irrespective of diet quality and appeared to be an endogenous component of the Canvasbacks' annual cycle. This behaviour pattern has been observed in the wild and seems to persist in captive Canvasbacks.

The behaviour of wild Canvasbacks *Aythya valisineria* in North American breeding areas has been studied by Hochbaum (1944) and Anderson (1984), and on wintering grounds by Alexander & Hair (1979) and Alexander (1980a, 1980b). Although McKinney (1981) presented numerous advantages to conducting behavioural studies with captive ducks, relatively few studies have been conducted in an experimental situation with captive ducks. Bluhm & Phillips (1981) conducted an extensive study with captive Canvasbacks to examine mate selection and techniques to increase egg production. Their study was conducted with all ducks fed the same diet *ad lib.* We know of no investigations to assess behavioural differences among captive ducks on diets that vary in nutrient composition. Thus the objective of this study was to determine whether particular diets, varying in levels of protein and energy, could influence the behaviour of captive Canvasbacks during winter. Although McKinney (1981) emphasized dabbling duck behaviour, the same advantages of using captive ducks should apply to behavioural studies of Canvasbacks and other diving ducks.

Methods

Canvasback eggs were taken from the nests of wild ducks in two breeding areas (Manitoba and North Dakota) in 1978 and were hatched in an incubator at the Patuxent Wildlife Research Centre, Laurel, Maryland USA. Ducklings were fed *ad lib.* 21% protein Beacon Hi-pro Duck Starter

Table 1. Calculated composition of four experimental duck diets, Patuxent Wildlife Research Centre, Maryland, 1978–79 and 1979–80.

	Diet 1 78–79	(HE-LP)[a] 79–80	Diet 2 78–79	(LE-HP) 79–80	Diet 3 78–79	(LE-LP) 79–80	Diet 4 78–79	(LE-LP) 79–80
Protein (%)	14	14	20	20	10	10	10	10
Metab. Energy (Kcal/kg)	3638	3638	2205	2205	2205	2205	1764	1543
ME/P	260	260	110	110	220	220	176	154
Fiber (%)	2.10	2.10	8.30	8.30	7.98	7.85	8.46	7.68
Fat (%)	11.97	11.97	3.69	3.59	3.26	3.26	3.08	2.16
Calcium (%)	0.86	0.86	0.74	0.87	0.95	0.95	0.96	1.05
Phosphorus (%)	0.50	0.50	0.66	0.70	0.51	0.51	0.52	0.52

[a] H = high, L = low, E = energy, P = protein

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(Beacon Feeds, Cayuga, N.Y.) for one month and then 14% protein Beacon Duck Developer until the start of the study. (Use of trade names does not imply government endorsement of commercial products). Male and female Canvasbacks were randomly assigned to 15 outdoor pens in early October 1978 and 1979 so that each pen had an equal sex ratio with six ducks per pen. Each pen measured 1.0 × 6.0 m and had a 1.0 m^2 (0.5 m deep) water trough centred in each pen.

Three replicates of four experimental diets and one control diet were assigned randomly to the 15 pens. These experimental diets were formulated based on known nutrient assays of wild Canvasback food. Analyses of 11 different animal and ten different plant foods used by Canvasbacks showed that animal food was high (24%) in protein and low (5%) in nitrogen free extract (NFE), whereas plant food was low (14%) in protein and high (40%) in NFE (Perry 1985).

These findings were used to formulate experimental feeds having energy and protein levels similar to a vegetation diet (Diet 1) and an invertebrate diet (Diet 2). Diet 1 was high in energy and low in protein (HE-LP), and Diet 2 was low in energy and high in protein (LE-HP). Diets 3 and 4 were designed to induce stress as a result of low energy and protein levels (LE-LP). Calculated composition of the four experimental diets are shown in Table 1.

Beacon Duck Developer was used as a control ration (Diet 5) during each experiment since it was known that Canvasbacks in captivity could be maintained adequately on this ration during winter (Perry 1985). This ration contained 2293 kcal/kg metabolizable energy (ME) and 14% protein and was fortified with vitamins and trace minerals. The exact ingredients of this ration, however, were unknown. All diets were offered *ad lib.* in 5 mm diameter pellets and were fed from 1 November until 30 April; during the remainder of the year all ducks were maintained on the control ration.

The location and behaviour of experimental ducks were recorded by observers outside the pens from November to April using scan sampling techniques (Altmann 1974). The location (land, water, air, or nest box) and behaviour (Table 2) of each duck were recorded each minute during a 5-minute period/pen. Ducks were individually marked with coloured nasal saddles for ease of identification (Bartonek & Dane 1964). The actual scan of the six ducks took 2–3 seconds. Recording of location and activity in 2-letter codes required approximately 10–30 seconds.

Table 2. Canvasback behaviour recorded during observation periods, winters 1978–79 and 1979–80[a].

Aggression	Drinking
Aggression	
Displacement	Feeding
Alert	Inactive
	Inactive
Bank feeding	Sleeping
Bank feeding	
Hardware	Locomotion
	Swimming
Courtship	Walking
Pairing	Flying
Head throw	
Kinked-neck call	Maintenance
Neck stretch	Bathing
Pre-copulation	Stretching
Mount attempt	Wing flap
Copulation	Preening
Sneak	Shaking
Nest preparation	
	Surface feeding
Diving	
Diving	Vocalization
Tipping	

[a] Location (land, water, air, or nest box) was recorded for each activity.

Observation periods and pens to be observed were randomly selected during a 9-day period in the middle of each month. All pens were observed three times during every 2-hour period of the day during the 9-day period. Observations extended from a half hour before sunrise to a half hour after sunset.

Behaviour data were analysed using a repeated-measures ANOVA (Winer 1962) for each behaviour category to determine influence of diet, sex, and month on behaviour. Only data from November–March, 1979–80 were used in these analyses. Repeated measures ANOVA was used to account for correlation resulting from observing a group of ducks at several times. All behaviour data were adjusted using arc sine transformations to correct for problems with heterogeneity of variances

(Snedecor & Cochran 1980). A probability level of 0.05 was chosen for determining statistical significance in all tests. All statistical analyses were conducted using Biomedical Computer Programs P-Series (BMDP) procedures.

Thirty separate behaviours, identified during preliminary observations, were arranged in 12 groups (Table 2), and recorded:

Aggression. Aggression was any overt attack by one duck on another duck and included pecking, chasing, pushing, bumping, and fighting. Displacement was also recorded as an aggressive behaviour and was observed at the feed tray when one duck, usually just by touching another, would displace a duck and take its place at the feed tray.

Alert. This behaviour was recorded when ducks stopped their previous behaviour and became motionless usually while standing with neck stretched upward.

Bank feeding. Bank feeding consisted of digging into the gravelly soil in the pen with the bill. It was unknown at the start of the study if this behaviour was related to feeding or bill maintenance and therefore was classified by itself. Another behaviour grouped with bank feeding, called hardware, was characterized by repeated touching, stroking, or pecking with the bill at unnatural objects in the pen including concrete, wire, or wood. Hardware behaviour is probably related to bill maintenance. In another study, ducks maintained in elevated wire pens with no access to gravel or concrete had excessive growth of the nails and lamellae of their bills (Perry *et al.* 1978).

Courtship. This behaviour group consisted of nine separate behaviours related to reproduction.

Diving. Diving was recorded when Canvasbacks completely submerged themselves head first and swam underwater. Tipping was recorded when Canvasbacks would submerge just their head, neck, and chest. Both behaviours were like those of wild ducks and appeared to be related to food searching.

Drinking. Drinking occurred while ducks stood on land or floated on the water. This behaviour was only recorded when a duck took water in its bill and raised its head to swallow.

Feeding. This behaviour was recorded when ducks actively took pellets from the feed tray but not when ducks were merely standing in front of the feed tray. No attempt was made to estimate the amount of feed taken or the amount of time spent at the feed tray. Feed intake was determined in a concurrent study by measuring feed given to the ducks (Perry *et al.* 1986a).

Inactive. Ducks were classed as inactive when there was no detectable movement while in a resting position. Ducks were inactive on land in a standing or lying position, and on water sometimes with one or both legs tucked into their belly feathers. Sleeping was an inactive behaviour in which bills were tucked under feathers on the back in what Cornwell & Bartonek (1963) called pseudo sleeping attitude (PSA). Ducks are not actually asleep during PSA and can be easily aroused.

Locomotion. Locomotor behaviour was divided into swimming, walking, and flying. Since ducks were often on the water, swimming was only recorded when ducks were moving fast enough to cause a ripple in the water. Walking involved any movement on land from one place to another. Flying was restricted to when ducks actually were in the air and did not include "exercise flights" when ducks rapidly flapped their wings while standing and sometimes briefly left the ground.

Maintenance. This behaviour included all activities that were known to maintain feathers, feet, bill, and body musculature in good condition.

Surface feeding. This behaviour was similar to that of wild puddle ducks that are feeding on small organisms on the surface of the water. Captive Canvasbacks moved their bill along the surface and appeared to be straining food organisms from the surface. No food material could be found with repeated sampling with a plankton net.

Vocalization. Vocalizations exclusive of the kinked-neck call were included in this behaviour group. They were done by both sexes usually while ducks were inactive or sleeping (PSA).

Results

The repeated measures analyses of variance conducted for each of the three locations and 12 behaviour groups failed to show any effect of diet on these variables (Table 3), when averaged over time and sexes. Three of the activities (aggression, alert, and vocalization) showed an effect ($P<0.05$) due to the interaction of diet/time or diet/time/sex which will be discussed later in the paper.

Although the location of Canvasbacks was not affected by the five diets during the winter (November–March), there was clearly an effect ($P<0.01$) due to months. Canvasbacks spent more time on land than on water during January and February, the coldest months. This use of land during mid-winter may be an energy conservation tactic. During the coldest months, ducks apparently conserve more energy on land than on water, which apparently acted as a heat sink. When ducks were on land (or snow) they often had both legs completely covered by their feathers. Captive and wild Canvasbacks commonly cover their bill with their feathers (Fig. 1), further indication that they were attempting to conserve energy during the coldest months.

Siegfried (1973) suggested that Ruddy Ducks *Oxyura jamaicensis* escaped the effects of cold water on the breeding areas of Manitoba by spending more time on platforms they had built. This was considered a means of enhancing the efficiency of their thermoregulation. Although no separate data were collected concerning the location of Canvasbacks when snow was present, casual observation suggested that the ducks were taking advantage of the insulative properties of snow.

Of the 12 behaviour groups, the inactive category was the one that accounted for most of the daylight time of captive Canvasbacks. During the 5-month period, ducks spent 58% of their time in inactivity. The level of inactivity was similar for males and females ($P>0.05$), and the level increased ($P<0.01$) during mid-winter. Inactivity decreased, however, in the late winter months of February and March. The high level of inactivity in mid-winter appeared to be related to energy conservation. By decreasing activity ducks apparently were able to make efficient use of their energy reserves. Similar trends in inactive behaviour have been observed with wild Canvasbacks on Chesapeake Bay (Fig. 1) (Perry 1985).

Maintenance behaviour, did not differ by sex but did differ by time ($P<0.05$), with December being the month of least maintenance behaviour. If maintenance affects heat loss, then ducks are best able to reduce maintenance in December when body weights are highest. December was also the month when ducks were most active with feeding and feeding-related (bank feeding, surface feeding) activities, resulting in less time available for maintenance.

Locomotion constituted 6% of the Canvasbacks' time from November to March. Locomotion decreased ($P<0.01$) as the winter progressed, and probably represented another mechanism to conserve energy. Males conducted more locomotion ($P<0.05$) than females overall during the whole year, with differences being greatest in the spring ($P<0.01$). This seasonal difference in locomotion between the sexes may be related to differences in courtship behaviour.

Courtship increased ($P<0.01$) during the winter from 0.4% in November to 1.3% in March for both sexes, but there was no difference between the sexes. Some males travelled from female to female, which was recorded as locomotion. The actual courtship activity, although usually initiated by the males, was usually conducted also by a responding female, thereby resulting in equal time in courtship for both sexes.

Diving and tipping accounted for 3.5% of the Canvasbacks' behaviour over the winter. The frequency of these behaviours changed during the winter ($P<0.01$) with more diving in November and March and less diving in the three mid-winter months. Diving and tipping were not related to obtaining food, since sampling of the water and bottom debris throughout the winter failed to produce food organisms. It appears that diving activity is controlled by some endogenous mechanism and is related to months when ducks are usually increasing their food consumption (Perry *et al* 1986a). Decreased diving and tipping in the

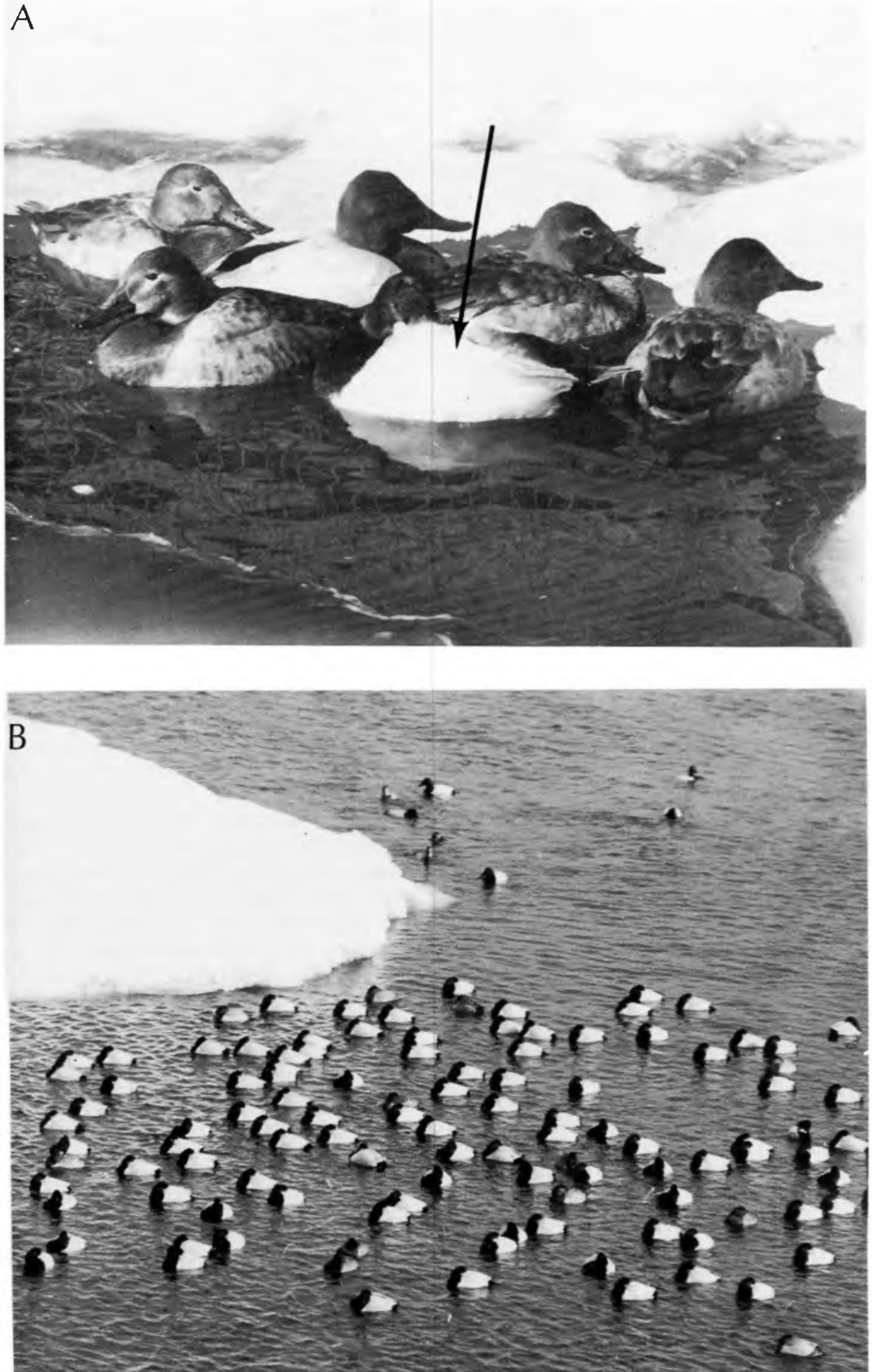

Figure 1. Canvasbacks in pseudo-sleeping attitude to conserve energy, in captivity (A) and in the wild (B).

Table 3. Location and behaviour of captive Canvasbacks during the 1979–80 winter showing % time expended for each category during daylight hours from November to March for males and females.

	November		December		January		February		March		Average	
	M	F	M	F	M	F	M	F	M	F	M	F
Location												
Land	66.3	67.4	52.0	54.4	72.1	74.3	67.9	69.4	61.0	69.4	63.8	67.0
Water	33.7	32.5	48.0	45.5	27.9	25.7	32.1	30.5	39.0	30.6	36.1	33.0
Air	tr	tr	0	tr	tr	0	0	tr	0	0	tr	tr
Totals	100.0	99.9	100.0	99.9	100.0	100.0	100.0	99.9	100.0	100.0	99.9	100.0
Behaviour												
Inactive	52.5	52.1	56.0	54.5	62.4	63.3	62.4	61.0	56.9	57.3	58.0	57.6
Maintenance	24.2	25.5	18.9	18.8	23.6	20.5	20.4	20.6	21.0	22.0	21.6	21.5
Locomotion	8.6	7.1	8.5	8.4	3.8	4.7	6.1	4.8	6.7	3.8	6.7	5.8
Diving/tipping	5.3	5.9	2.5	2.2	2.3	2.8	2.3	3.1	4.1	4.6	3.3	3.7
Surface feeding	2.0	2.2	5.0	4.7	1.7	1.5	3.0	2.9	4.3	3.7	3.2	3.0
Bank feeding	1.6	2.4	3.8	5.0	1.4	1.7	1.4	2.4	1.3	3.1	1.9	2.9
Drinking	1.8	1.4	2.3	2.6	1.9	2.2	1.5	1.5	1.6	1.3	1.8	1.8
Feeding	1.1	1.1	0.9	1.6	1.0	1.3	0.9	1.0	1.4	1.4	1.1	1.3
Alert	1.9	1.2	1.2	1.3	0.5	0.8	0.4	0.7	0.9	0.9	1.0	1.0
Courtship	0.4	0.4	0.5	0.4	0.9	0.7	1.1	1.3	1.2	1.4	0.8	0.9
Aggression	0.4	0.4	0.3	0.4	0.4	0.3	0.4	0.3	0.2	0.2	0.3	0.3
Vocalization	0.2	0.2	tr	0	0.1	tr	0.1	0.3	0.3	0.3	0.2	0.2
Totals	100.0	99.9	99.9	99.9	100.0	99.8	100.0	99.9	99.9	100.0	99.9	100.0

colder winter months is probably another energy conservation mechanism. No differences were observed between sexes for diving behaviour.

Surface feeding constituted 3.1% of the Canvasbacks' behaviour between November and March and no differences (P>0.05) between sexes were observed. There was an effect (P<0.05) due to season, with most surface feeding occurring during December and March. This behaviour pattern may be related to an endogenous mechanism similar to diving and tipping which causes an increase in feeding behaviours at a time when Canvasbacks are normally increasing their feeding activity.

Bank feeding formed 2.4% of the Canvasback winter behaviour and was most prevalent during December and March. Females did more bank feeding than males (P<0.01). Bank feeding, like surface feeding, diving, and tipping, may also represent an endogenous mechanism related to feeding. Females may conduct more bank feeding to obtain invertebrates and grit and thus more calcium needed for egg production.

Feeding constituted only 1.2% of the behaviour of Canvasbacks during the winter. No effects due to diet, time, and sex were detected. Although non-significant, the pattern of feeding behaviour through the winter was similar to the pattern in the intake of feed (Perry *et al.* 1986a), since both decreased in mid-winter. The failure to show significant temporal variation in feeding behaviour may reflect the fact that ducks during mid-winter months consume less during each trip to the feed container, but do not make fewer trips.

Drinking constituted 1.8% of the total winter behaviour, and no effects were observed due to diet, time, or sex. Drinking was often observed following feeding and seemed necessary to aid in deglutition. Paired ducks often drank together while facing each other, suggesting that some drinking may be related to courtship. These results are consistent with Purol (1975), who found no differences between the volume of water consumed by males and non-laying females.

Aggression constituted 0.3% of the total winter behaviour, but there was no overall effect due to time, diet, or sex. However, the change in aggressive behaviour through time was influenced by diet (P<0.05) and differed with various combinations of diet and sex (P<0.01). Although interactions were difficult to partition, it seemed that Canvasbacks fed the low energy diets (Diets 2, 3, and 4) were less aggressive in mid-winter than those fed the high energy diets (Diets 1 and 5), and that males fed the high energy diets were more aggressive than females on this diet during mid-winter.

Alert formed 1.0% of the total behaviours and decreased ($P<0.05$) as the winter progressed. Females were more alert ($P<0.05$) during mid-winter than males, and ducks on the low energy diet (Diet 4) were the least alert ($P<0.05$).

Vocalizations, separate from the kinked-neck call, formed 0.2% of the behaviour and increased ($P<0.01$) in the spring indicating that vocalization was probably related to courtship. Males often vocalized while in a pseudo-sleeping attitude on land and on water.

Discussion

Research conducted during the 1970s clearly showed changes in the distribution and abundance of Canvasbacks in Chesapeake Bay which were related to changing food preferences and habitat use (Perry *et al.* 1981). An extensive nutrition study conducted in the late 1970s by Perry (1985) was done to determine if a change in nutrients consumed by Canvasbacks could influence the physiology and behaviour of these ducks. Food intake measurements revealed that captive Canvasbacks varied their food intake when given *ad lib.* diets that varied in nutrient content (Perry *et al.* 1986a). Although no differences could be detected in the weights among Canvasbacks on the different diets, there were some indications that body composition might have been influenced. Analyses of the blood of the captive Canvasbacks showed no significant differences among the diets (Perry *et al.* 1986b).

The behaviour of Canvasbacks was monitored to determine if differences in behaviour could be detected as a result of varying levels of protein and energy in the diets. Such an effect on behaviour of Canvasbacks would suggest that survival could be altered indirectly by changing vulnerability of the ducks to hunters or predators or by altering reproduction of the ducks in the spring. The fact that behaviour did not significantly differ among the groups of Canvasbacks fed different diets, indicates that, by varying feed intake, ducks were able to get comparable nutrients when feed was presented *ad lib.* Subsequent studies with captive Canvasbacks showed increased aggressive behaviour when diets were restricted (Perry *et al.* 1987).

The seasonal differences detected for Canvasbacks when data were grouped across diets clearly indicated that they were altering their behaviour to conserve energy. The decline in activity during the coldest months occurred in spite of the fact that food was easily available throughout the winter. It appears that this behaviour reflects an endogenous mechanism correlated with decreased feed intake during the coldest months (Perry *et al.* 1986a). Canvasbacks apparently evolved with a mechanism to conserve energy during the coldest months when food sources in the wild would be less available due to ice cover.

Based on this hypothesis, one would not expect Canvasbacks to migrate further south to unfamiliar territory when their normal food sources are unavailable because of ice cover. By conserving energy through modification of behaviour, Canvasbacks probably increase their chances of survival. During the late 1970s when long extreme cold periods froze Chesapeake Bay, only small numbers of Canvasbacks were reported to have died. The behavioural adaptions of Canvasbacks appear best suited for mid-Atlantic coast latitudes, where adequate food supplies are coupled with relatively mild winters. In more northern latitudes, these mechanisms may be impossible due to insufficient energy reserves for the longer extreme cold periods.

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