Experiments on substrate choice and feeding efficiency of downy Tufted ducklings *Aythya fuligula*

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Two series of trials were carried out on broods of laboratory-reared downy Tufted ducklings. In the first trial the birds fed on snails and bivalves significantly more often over open gravel substrates than amongst lily or hornwort beds. Mean dive durations gradually increased from c.2 to c.5 seconds with age. In the second series of trials a brood of ducklings located and exploited a small food patch in an otherwise featureless tank. The brood learnt rapidly to concentrate dives over the food patch and achieved a feeding success rate of one chironomid larva per dive at a prey density of 2000/m^2. When the food density was doubled, the feeding success rate (chironomid larvae eaten per dive) also doubled whilst the dive duration (c.2 seconds) and the proportion of dives directed at the food patch (c.25%) remained constant. The value to diving ducklings of increased food availability within the brood-rearing habitat is discussed.

The food of Tufted Ducks *Aythya fuligula* and ducklings varies greatly both with habitat and season (Cramp & Simmons 1977) and includes plant and animal components from marine, estuarine and freshwater habitats. The present paper describes laboratory experiments that investigated the foraging abilities of naive downy ducklings using microhabitat and food resources typically available in gravel pit lakes. Tufted Ducks have greatly increased their breeding range in Europe in recent decades (Owen *et al.* 1986) and much of this range extension in Britain appears to be linked to the increased availability of flooded mineral-extraction sites in the south. Gravel pits often provide islands suitable for safe nesting (Hill 1984) but may also be lacking in the large numbers of larval and emerging chironomid midges essential for good growth and successful fledging of both diving and dabbling ducklings (Street 1977, Hill & Ellis 1984). The present study aims to quantify the feeding success of downy Tufted ducklings at known food densities which are within the range of those found in the lakes of the ARC wildfowl sanctuary at Great Linford, Buckinghamshire.

Methods

Clutches of Tufted Duck eggs were collected (under licence) from the wild at an interval of 14 days in July 1988 and hatched in the laboratory. A brood of six ducklings was reared from the first clutch and a brood of nine resulted from the hatching of the second clutch. All birds were initially hand-fed on turkey starter crumbs and maggots; the ducklings were reluctant to feed until offered moving live food in shallow trays of water. Once the birds had eaten live food, they subsequently readily took a wide range of freshwater invertebrates in addition to the starter crumbs and maggots. Birds in the first brood were used for trials from an age of 6–14 days and those from the second brood from 14–18 days old. Broods one and two were fed *ad lib.* and reared separately in outside runs which had covered sleeping areas with infra-red heat sources. All 15 ducklings were reared to fledging after the experiments had finished and were then released into the sanctuary.

Trial 1

The first brood of six birds was used to test the null hypothesis that open gravel substrates, a small lily bed *Nymphaea alba* and a submerged macrophyte bed of hornwort *Ceratophyllum demersum* were equally preferable micro-habitats. The brood was allowed to dive and feed in a large (1.5 m x 1.0 m x 1.0 m) glass aquarium in the laboratory and observed for nine 15-minute

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periods. The experimental tank had approximately one third of its base area covered by each of three substrate types (gravel, lily, weed). The tank was evenly provisioned with a mixed food source of small bivalves (*Sphaerium* spp.) and gastropod molluscs (*Planorbis, Physa, Bythynia*, and *Lymnaea* spp.) at a combined density of about 400/m^2, this being similar to the density of molluscs in the River Ouse, adjacent to the wildfowl reserve at Great Linford, where broods of Tufted ducklings are regularly seen feeding in the wild (Giles *et al.* 1988a). The duration of a random sample of dives was timed during each observation period and the substrate type of all dives where the birds attempted to feed was recorded.

Trial 2

Following a clear-cut result from Trial 1 the experimental tank was emptied and re-filled with a clean gravel substrate. A gravel-filled wire mesh feeding tray (666 cm^2) was used to provide a food-rich patch within the tank, in this instance chironomid larvae were used as the food source. The second brood of Tufted ducklings were used for the duration of Trial 2; a total of 15 20-minute replicate periods was recorded using a set protocol. Birds were deprived of food for 30 minutes prior to an observation period in an attempt to standardise their level of hunger. A 30-minute period was chosen since all birds fed actively during all replicates after this period of food deprivation. The food tray was removed from the tank and stocked with a known number of large, red chironomid larvae *Chironomus plumosus*. A food density of 2000/m^2 was used for Trials 1–12 and 4000/m^2 for Trials 13–15. The larvae were then allowed to burrow into the gravel until none was visible on the surface of the food tray. The tray was then

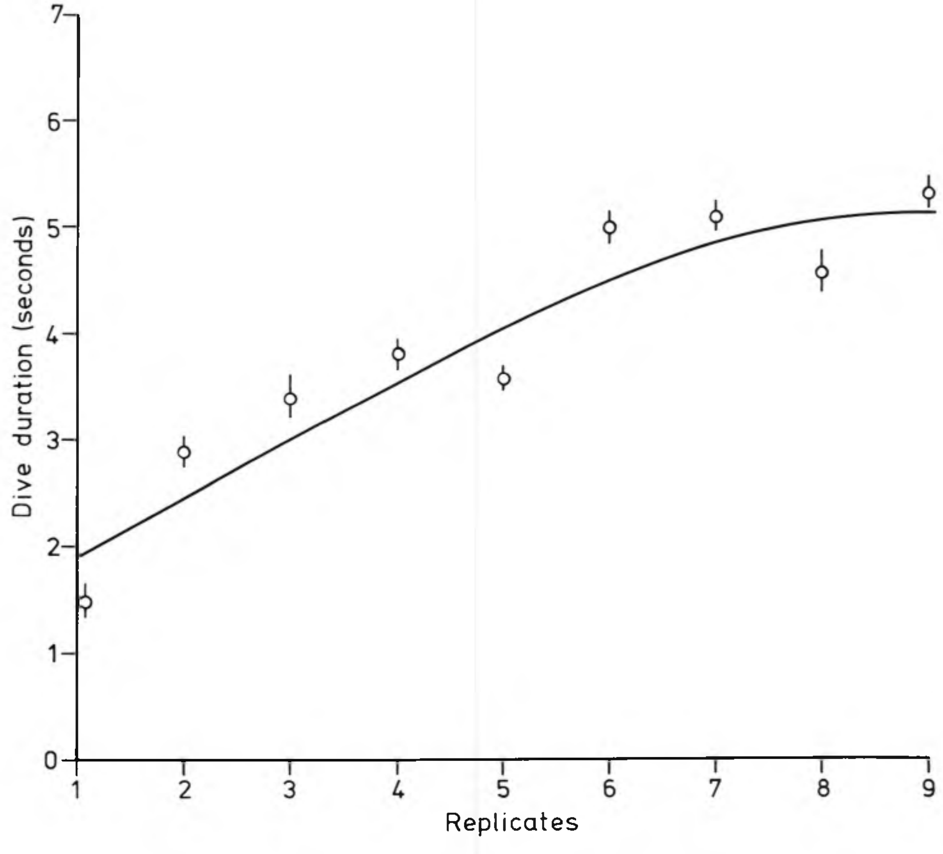

Figure 1. Trial 1 mean dive duration (±2 S.E.) of Tufted ducklings feeding on mixed molluscs. Curve fitted by eye.

lowered onto the tank bed and the brood of ducklings introduced to the tank. During each 20-minute replicate, the following were recorded: total number of dives outside food tray, total number of dives over food tray and the duration of each dive over the food tray. Birds need to preen and rest after 20 minutes of repeated diving. At the end of each test the ducklings were removed from the tank and returned to their quarters, the food tray was retrieved, the gravel sieved and the total number of surviving chironomid larvae counted. This allowed the calculation of the number (and %) of chironomids eaten during the test, the average number of chironomids eaten per dive over the food tray and the proportion of the total dives which was made onto the food tray.

Results

Trial 1

The data for the total numbers of feeding dives over each substrate from each of the nine substrate choice replicates were used to calculate Chi squared tests, using for each replicate the null hypothesis of equal preference between substrates. For replicate 1 significantly more feeding dives were made over lilies than the other substrates ($\chi^2 = 14.7$, $P<0.001$), in replicate 2 there was no significant preference for substrate type whilst in replicates 3–9 the gravel substrate was clearly preferred (χ^2 varied from 16.3–49, $P<0.001$ in all seven cases). Figure 1 shows the mean dive duration (± 2 standard errors) made by the six ducklings over all substrate types (sample sizes vary from 20–35 dives per replicate). Dive duration increased from an initial average of 1.5 seconds to an average of around 5 seconds by replicate 6. As in previous work (Giles *et al.* 1988a) a combination of visual hunting and substrate probing with the tip of the bill was used to capture the molluscs.

Trial 2

The second brood of ducklings initially showed no preference for feeding over the

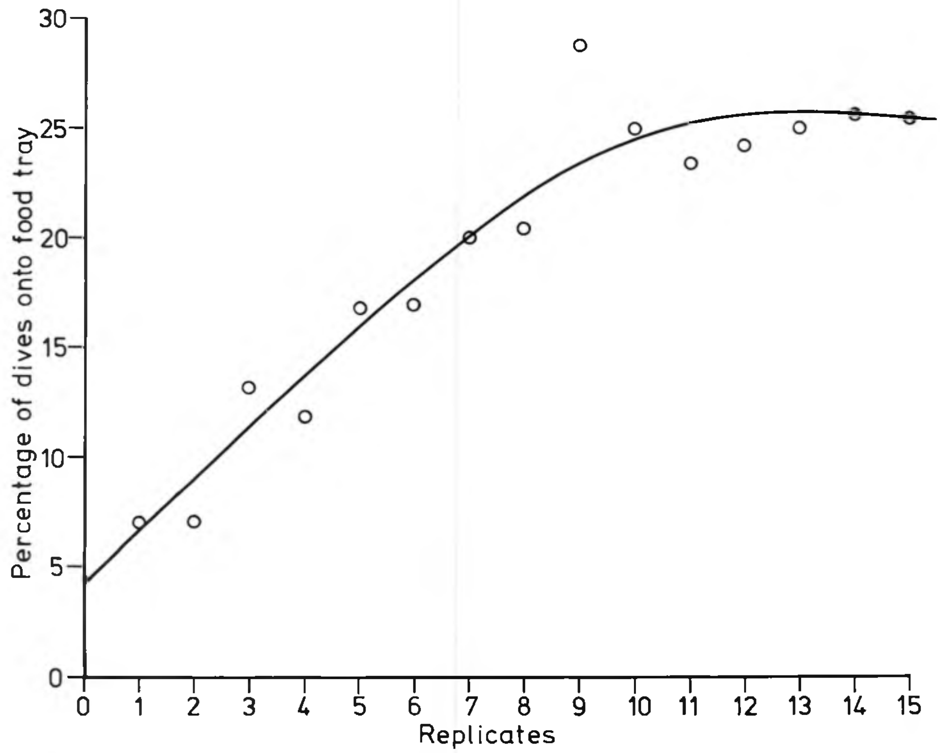

Figure 2. Proportion of dives made over food tray by brood of Tufted ducklings. Curve fitted by eye.

food tray when presented with a bare gravel substrate and food area. Figure 2 gives the proportion of total dives made over the food tray from replicate 1 through to replicate 15. The area of the food tray represented 4% of the tank base area and in the first two replicates about 6% of all dives were made on to the tray. This proportion then rose rapidly as the birds learnt that the food tray contained chironomid larvae, such that by replicate 10 about 25% of all dives were made on to the tray. Figure 3 gives the mean number of chironomid larvae eaten per dive onto the food tray throughout the 15 replicates. While the food density remained at 2000/m^2, ducklings achieved a feeding success rate of around one chironomid larva per dive; this increased to >2 chironomids per dive when the density of chironomid larvae was doubled for replicates 13, 14 and 15. Over the whole 15 replicates, the average duration of dives made over the food tray rose gradually from c.0.5 seconds (replicate 1) to approaching 2 seconds per dive by replicate 15 (Fig. 4). The doubling of the food availability, however, had no obvious effect upon either dive duration (Fig. 4) or the proportion of dives made on to the food tray (Fig. 2).

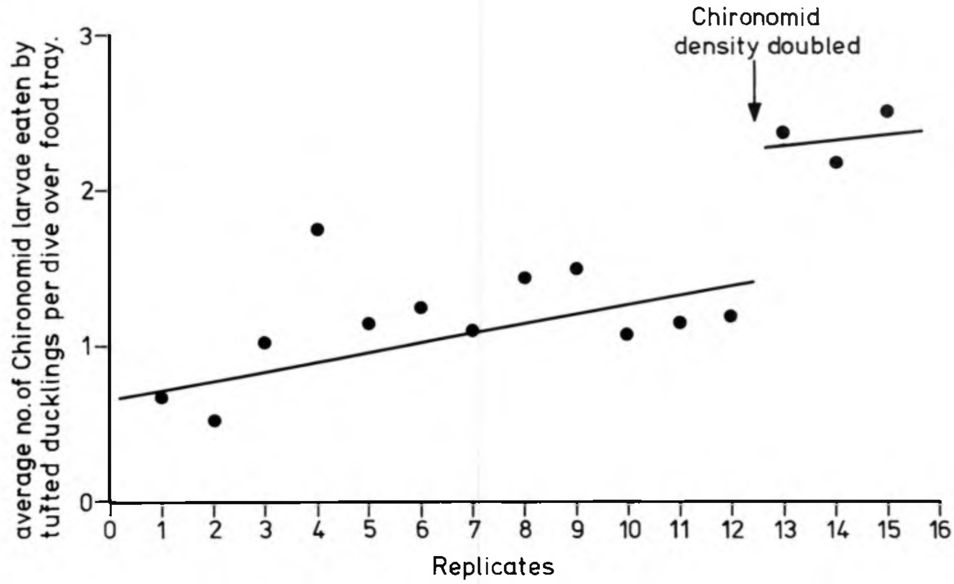

Figure 3. Average number of chironomid larvae eaten by Tufted ducklings per dive over food tray. Lines fitted by eye.

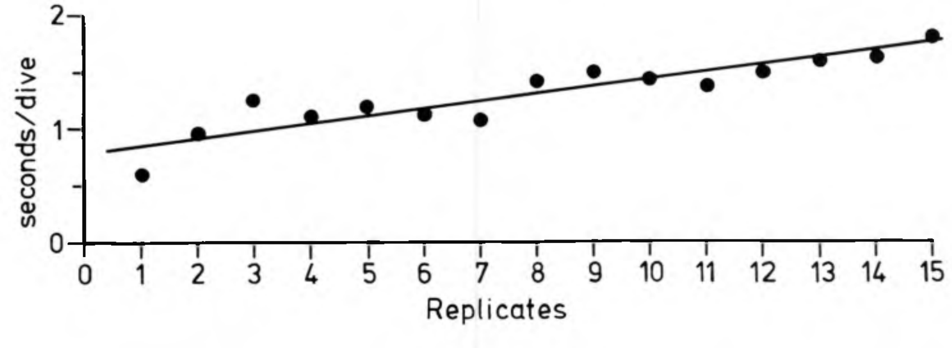

Figure 4. Mean dive durations of Tufted ducklings feeding on chironomid larvae in gravel. Line fitted by eye.

Discussion

Kear (1970) noted that Tufted ducklings have good cold-hardiness, a relatively high metabolic rate, a high hatching weight (as % of female weight: Tufted = 4.2%, Mallard *Anas platyrhynchos* = 3.4%) and a high liver weight compared with Mallard ducklings of similar age. Such active precocial young must need abundant resources of food in the brood rearing habitat. Observations made during the current study showed that when diving, downy Tufted ducklings are covered in a continuous envelope of air which gives the plumage a silver sheen. This air:water interface probably reduces surface drag on diving birds as well as reducing waterlogging of the down, helping to minimise energy expenditure during foraging. Tufted ducklings at two weeks old in the present study weighed, on average, 187 g. Kear (1970, Table 8, page 131) recorded that captive Tufted ducklings of this age ate, on average, 34 g dry weight of chick starter crumbs (21% protein) daily; 34 g dry weight of freshwater invertebrates (which contain 45% protein, Street 1977) equates with around 30,000 large chironomid larvae, 10,000 *Sphaerium* sp. bivalve molluscs or 5500 mixed *Planorbis*/*Lymnaea* sp. snails. Whilst the invertebrates have a higher % dry weight of protein the clear implication from the above is that foraging for molluscs where they are available is likely to be an energetically cost-effective strategy for Tufted Ducks. The zebra mussel *Dreissena polymorpha* whilst being rare in the Linford lakes, is a favourite food of Tufted Ducks in many habitats. Draulans (1982) found that captive adult Tufted Ducks selected smaller (sub-optimal) zebra mussels than predicted from prey profitability curves when allowed to dive for a range of different sized mussels. This effect became more marked at higher prey densities and he suggests that during the c.9 seconds available for searching and feeding on the bed of the Plas Leblanc (a flooded sand pit) the ducks may choose to take two smaller mussels rather than a single, larger (optimally-sized) one thus maximising their energy gain per dive.

Giles *et al.* (1988a) found during observations carried out in 1987 that naive laboratory-reared Tufted ducklings were able to feed successfully underwater both on bivalve and gastropod molluscs and appeared to be especially efficient at capturing snails from the submerged stems and leaves of water lilies. This appeared to agree with field observations made on feeding Tufted duckling broods where sightings were concentrated around the marginal lily beds of the River Ouse adjacent to the ARC wildfowl sanctuary. However, in the early laboratory experiments the lily beds represented around 50% of the area of the test tank with the rest comprised of gravel and large stones covered with filamentous algae. Trial 1 in the present study was designed to investigate whether the apparent preference for lily bed feeding by birds in 1987 was real or an artefact of the design of the feeding tank. The 1988 results show that when given equal areas of open gravel, lily and weed beds ducklings showed significant habitat preferences feeding selectively over lily beds in the first replicate but then switching to the open gravel substrate in subsequent runs. This was the case even though both the lily and hornwort beds had numerous large snails crawling over and feeding upon their surfaces. This indicates that the 1987 results were misleading because of the design of the test.

By replicate 6 (Trial 1) in 1988 dive duration had reached a plateau at around 5 seconds (Fig. 1) at a food density of c.400 molluscs/m^2. Tufted ducklings of a similar age dived for similar periods under natural conditions at Linford (Hill & Ellis 1984). In the second trial the mean dive duration over the food tray (containing burrowing chironomid larvae) increased gradually to peak at around 2 seconds per dive (Fig. 4), the food density in these runs was 2000/m^2 (rising to 4000/m^2 for the final three runs). The shorter dive duration made by birds from the second brood is likely to be related both to the increased food density and localised availability on the food tray. The rapid increase in the proportion of dives made onto the food tray during Trial 2 (Fig. 2) illustrates a rapid learning curve for a group of previously naive ducklings feeding with no parental guidance. This result is particularly interesting since it demonstrates the ability of very young birds to locate and exploit small food patches within a novel environment over the course of a relatively few experimental replicates. Chironomid larvae were chosen as the prey type for Trial 2 since they are the most numerous benthic macro-invertebrates in the Linford lakes and are known to form the natural diet of Tufted Ducks in some habitats, e.g. Loch Leven, Scotland (Laughlin 1973) where larval midge densities exceed 54,000 per square metre in July (Maitland & Hudspith 1973). The initial chironomid density of c.2000/m^2 was chosen because it is equivalent to the estimated standing crop of chironomid larvae during the late summer of 1987 in the Main Lake of the wildfowl sanctuary at Great Linford (Giles *et al.* 1988b). After a large scale fish-removal during the autumn of 1987, the 1988 late-summer peak of larval chironomid numbers increased to >4000/m^2 at the time when Tufted duckling broods were most often seen in the wild. When the chironomid density was raised to the 1988 level in the laboratory, the feeding success per dive doubled (Fig. 3) indicating that increases in the standing crop of potential food organisms for diving ducks and ducklings can lead to instant improvements in feeding efficiency. The removal of fish as food competitors with wildfowl may prove to be a worthwhile management practice on wetlands where waterfowl production is the primary conservation objective.

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