Age-related changes in the habitat use and behaviour of Mallard *Anas platyrhynchos* broods at artificially created lakes in southern Britain

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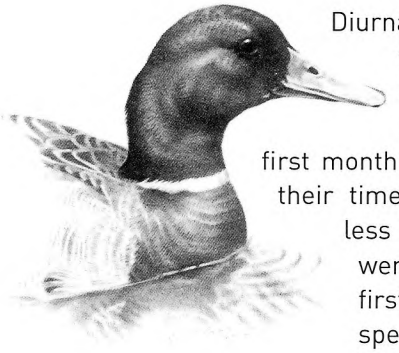

Diurnal time-activity budgets of Mallard broods were measured at the Cotswold Water Park and The New Grounds, Slimbridge in spring and summer 2000. During the first month after hatching, ducklings spent 50% of their time feeding. Ducklings spent increasingly less time feeding, more time preening, and were more mobile, as they got older. In the first two weeks after hatching, ducklings spent over 80% of their foraging time chasing or picking insects from either the surface of the water or lake-side vegetation. Older ducklings spent more time dabbling for vegetative matter. In the first two weeks after hatching, ducklings used shorelines with varying amounts of terrestrial cover, but avoided those with large amounts of aquatic vegetation. In contrast, older ducklings tended to favour shorelines with a large proportion of aquatic vegetation. The potential link between habitat use and time-activity budgets is discussed.

Key Words: Mallard, *Anas platyrhynchos*, time-activity budgets, habitat, foraging behaviour

Habitat selection has been identified as an important component in the life histories of organisms, affecting survival, productivity and recruitment, and ultimately population size (Partridge 1978; Orians 1991). Time and energy budgets change through the life cycle of an organism as a consequence of behavioural, physiological, or environmental constraints. To accommodate these changes, organisms must use a range of habitats in order to maximise survival (Begon *et al.* 1996). An understanding of the relationships between temporal changes in time and energy budgets of an organism and habitat use is therefore important when understanding life history strategies and planning habitat creation/management objectives for the benefit of target species.

The Mallard *Anas platyrhynchos* is an abundant breeding species in the UK (c. 100,000 pairs), utilising a range of wetland habitats (Hill 1993). Freshwater lakes, ponds, reservoirs and flooded gravel quarries provide suitable foraging opportunities for Mallard broods, especially in shallows around the shoreline (Pehrsson 1979). Although many studies have focused on the selection of lakes by Mallards during the breeding season (eg Pehrsson 1984; Nummi & Pöysä 1992; Pietz & Buhl 1999), there are comparatively few published data on the use of habitats in relation to the age and behaviour of broods.

In this study, time-activity budgets and habitats used by broods of Mallard were investigated through the pre-fledging period at a selection of constructed lakes in southern Britain. Artificially created lakes are important in supplementing the 'natural' wetland resource in the UK and can be designed and maintained to benefit wetland biodiversity (Andrews & Kinsman 1990; Giles 1992).

Study Area

The study was conducted at The New Grounds, Slimbridge (51° 44'N, 2° 24' W) and the Cotswold Water Park (CWP) (51° 39' N, 1° 56' W), in southern Britain.

The Wildfowl & Wetlands Trust (WWT) reserve at The New Grounds, Slimbridge, is a 754 ha wetland complex. The site comprises, in part, c.20 lakes created specifically for wetland birds, which vary in size between 0.4 and 10 ha. The margins of these lakes are managed to maintain a range of vegetation. This includes: *Typha latifolia, Carex riparia, Iris pseudocorus, Phragmites australis* and *Juncus anflexus*. The lakes are 'screened' and human disturbance is therefore minimal.

The Cotswold Water Park comprises over 130 lakes generated as part of an on-going programme of mineral extraction. Together, these lakes constitute a surface area of approximately 1,000 hectares of water. Native and non-native trees and shrubs grow around the perimeter of most lakes, predominantly *Salix* spp. in terrestrial areas. *Phragmites australis* has also

been planted extensively along many water margins and *Typha latifolia* grows in some areas. In addition, some privately owned lakes support a more diverse selection of emergent plants such as *Mentha aquatica* and *Nymphaea alba*. Some lakes are open to the public for a variety of water-sport activities, such as swimming and water-skiing, but most have been set aside as nature reserves or private fisheries with limited public access.

Methods

Time-activity budgets of Mallard ducklings were recorded between 6 May and 14 July 2000. Observations were made at 21 and six lakes at the CWP and The New Grounds, respectively, each of which supported at least one Mallard brood during the peak brood-rearing period. With high breeding density and low rates of predation across the two study sites, coupled with moderate weather conditions, it was felt that data collected in 2000 were representative of an 'average' breeding season for Mallards at these sites (Robinson *et al.* in press). Although each lake was visited at least twice a week during the study period to monitor breeding success (see Robinson *et al.* in press), observations of broods were made opportunistically. Individual broods were located and observed continually, at distance, for up to two hours. The behaviour of brood members was recorded at five minute intervals, using an instantaneous sampling technique (Altman 1974). Observations were spread evenly across the daylight period (04.30h-22.30h BST). Categories of brood activity were modified from those defined by Klima (1966) and Hohman & Rave (1990):

1. *Chasing insects over water* (skimming, darting at and catching insects from the air and from the water surface)

2. *Dabbling* (feeding on vegetation by immersing bill, face or head and neck or by up-ending)

3. *Foraging in water* (picking insects, invertebrates and unknown particles off water surface or subsurface)

4. *Foraging in marginal vegetation* (picking insects, invertebrates or unknown particles off vegetation around the lake edge)

5. *Preening*

6. *Sleeping and resting* (ducklings inactive with head position low on chest, bill sitting on breast or sleeping with bill tucked under scapular feathers. Included being brooded by the female)

7. *Movement between areas* (ducklings swimming, walking or running)

8. *Other* (included aggressive and vigilant behaviour)

The proportion of time allocated to each of these activities was calculated for each brood observed, with data from all brood sizes combined for the purposes of this study. Data collected for the first four categories were pooled to obtain an estimate of the proportion

of time spent feeding.

At each five-minute sampling interval, the habitat used by ducklings was classified in relation to vegetation characteristics of the shoreline habitat (see Robinson *et al.* (in press) for methodological details). Seven habitat classes were identified (**Table 1**), and the proportion of time ducklings were present in each of these habitats calculated for observed broods. To ensure ducklings were able to choose between shoreline habitats within lakes, only those lakes that included at least five of the habitat classes identified were surveyed.

Plumage characteristics were used to determine the ages of broods observed, using a technique established by Gollop & Marshall (1954). Broods were assigned to one of seven age classes: class IA: 1-7 days old, class IB: 8-13 days old; class IC: 14-18 days old; class IIA: 19-27 days old; class IIB: 28-36 days old; class IIC: 37-42 days old and class III: 43-60 days old.

Table 1. Categories used to describe habitats used by Mallard ducklings at the CWP and The New Grounds, Slimbridge, 2000.

Habitat category	Description
Sparse vegetation	>50% of aquatic sediment bare or exposed <50% of adjacent terrestrial land covered with herbaceous plants <25% of the shore shaded by trees
Terrestrial herbs dominant	>50% of aquatic sediment bare or exposed >50% of adjacent terrestrial land covered with herbaceous plants <25% of the shore shaded by trees.
Terrestrial woodland dominant	>25% of shoreline shaded by trees <50% of aquatic sediment has plant coverage Algae not present; only true plants
Terrestrial *Carex* spp. dominant	<50% of aquatic sediment has plant coverage >50% of adjacent terrestrial land covered with *Carex* spp.
Aquatic and terrestrial herbs dominant	>50% of aquatic sediment covered by small aquatic plants (<50cm in height) >50% of adjacent terrestrial land covered with herbaceous plants *Typha* spp. and *Phragmites* spp. not present *Equisetum* spp. present
Aquatic *Typha* spp. dominant	>50% aquatic *Typha* spp. coverage
Aquatic *Phragmites* spp. dominant	>50% aquatic *Phragmites* spp. coverage

Results

Age-related changes in activity budgets

Diurnal time-activity budgets of Mallard broods were based on 64 hours of observations of 37 individual broods. The activities of broods changed markedly through the pre-fledging period (χ^2_{36}=495.5, P<0.001). Overall, foraging was the most commonly occurring activity of ducklings in the first four weeks after hatching (**Figure 1**). These ducklings spent most of the remainder of their time resting. As ducklings got older, the proportion of time spent feeding declined, and other activities occupied a greater proportion of the activity budget. Movements between areas and preening were more frequently recorded for ducklings in class III, ie at and around the time of fledging.

Age-related changes in foraging behaviour

The foraging techniques of ducklings changed markedly through the pre-fledging period (χ^2_{18}=215.5, P<0.001). In the first two weeks after

Figure 1. Diurnal time-activity budgets of Mallard ducklings of different ages at the Cotswold Water Park and The New Grounds, Slimbridge, 2000.

hatching, ducklings used a wide variety of foraging techniques (**Figure 2**). However, these birds spent approximately 80% of their foraging time catching insects emerging from the water or in marginal vegetation. The proportion of time spent dabbling for vegetation increased as ducklings neared fledging age; ducklings over two weeks old fed almost exclusively using this method. Only in age-class IIC did ducklings older than two weeks spend large proportions of their foraging time catching insects.

Age-related changes in habitat use

Habitat use changed throughout the pre-fledging period (χ^2_{36}=526.8, P<0.001). During the first five weeks after hatching, ducklings spent large proportions of time in shoreline habitats with very little aquatic vegetation (**Figure 3**). Ducklings less than two weeks old spent up to around 20% of their time using shorelines fringed with trees or terrestrial herbaceous vegetation. Ducklings over two weeks old used a greater range of shoreline habitats, and shorelines fringed with *Carex*, *Typha* and *Phragmites* were used to a greater extent compared to use by younger ducklings.

Foraging behaviour in relation to habitat use

Ducklings tended to use different foraging techniques in different habitats (χ^2_{18}=123.1, P<0.001). Along

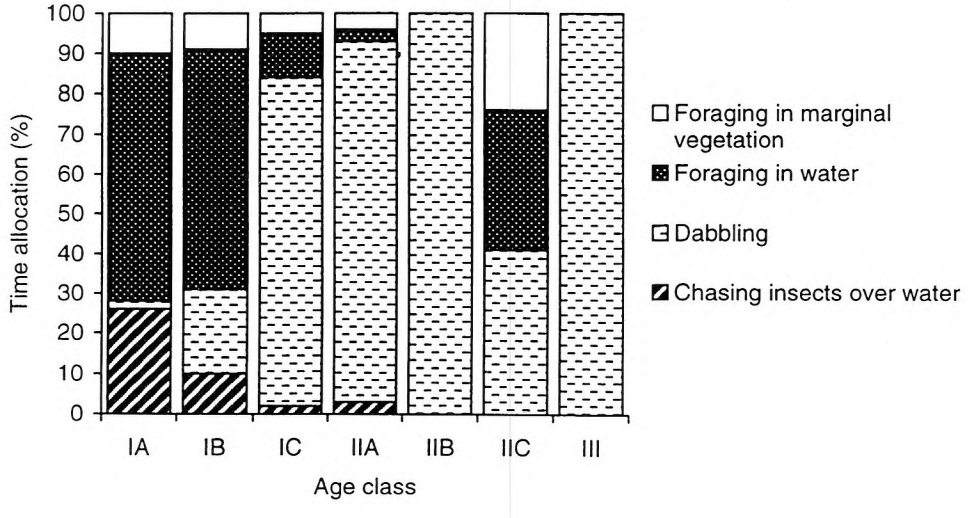

Figure 2. Foraging techniques used by Mallard ducklings of different ages at the Cotswold Water Park and the New Grounds, Slimbridge, 2000.

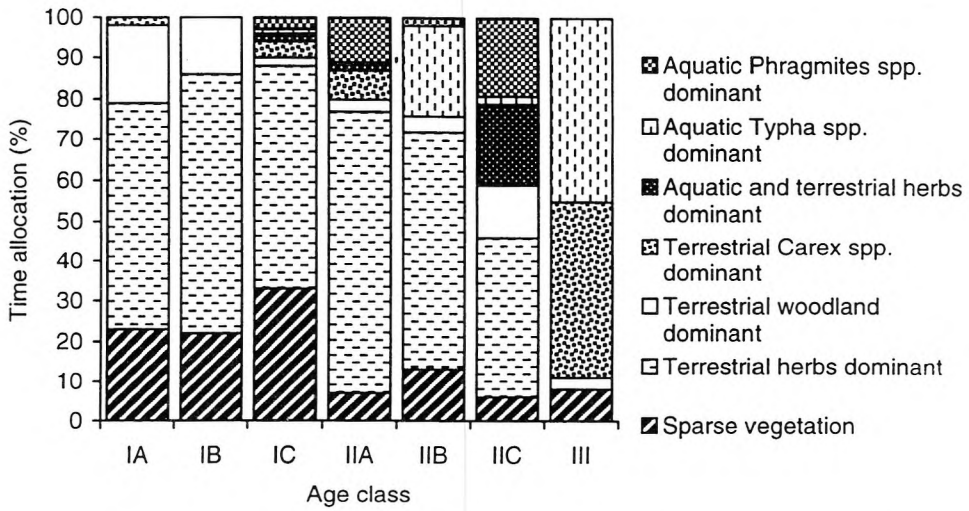

Figure 3. Habitats used by Mallard ducklings of different ages at the Cotswold Water Park and The New Grounds, Slimbridge, 2000.

shorelines fringed with woodlands, ducklings most often foraged on emerging insects and aquatic invertebrates at the water's surface (**Figure 4**). These foraging techniques were also used to a large extent at shorelines with large amounts of bare substrate, and along stands of *Phragmites*. Ducklings tended to dabble along *Typha* margins, in areas with varying amounts of aquatic and terrestrial vegetation, and along *Carex*-lined margins.

Discussion

In this study, Mallard ducklings of all ages spent the majority of their diurnal activity budget feeding or resting, with time spent feeding tending to decline as ducklings got older. Foraging techniques of ducklings also changed through the pre-fledging period, as did use of shoreline habitat.

The factors determining time allocation within duckling activity budgets are primarily related to requirements for foraging and feather maintenance (Maxson & Pace 1992). Downy ducklings possess smaller gut capacities and higher metabolic requirements per unit body weight than older ducklings, and therefore younger birds should be expected to satiate sooner but feed more frequently than older birds (Ringelman & Flake 1980). As birds get older and increase in size, the energy required for growth and thermoregulation declines (Ricklefs 1983; Drent *et al.* 1992). In addition, as feather growth

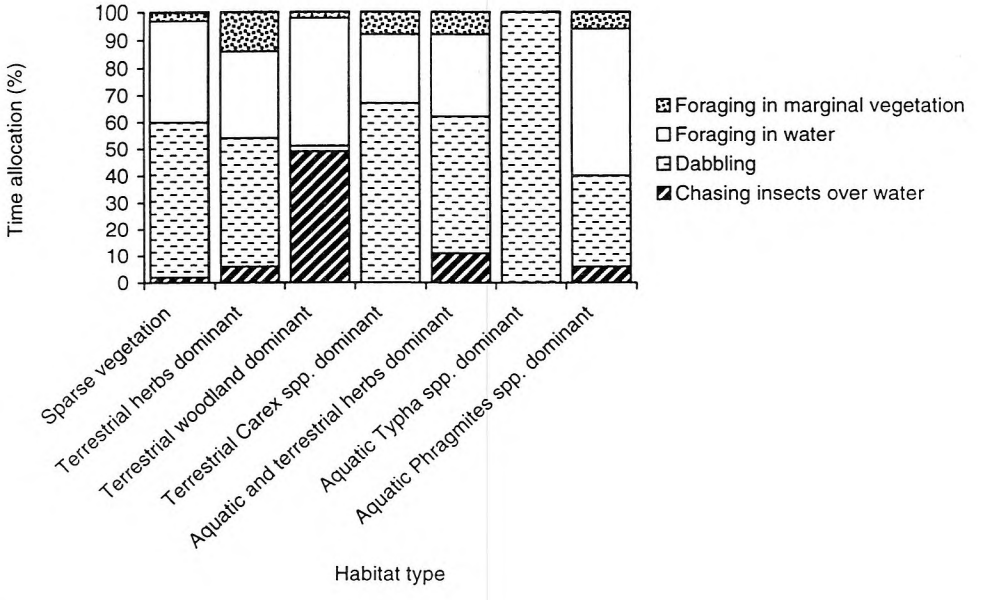

Figure 4. Foraging techniques used by Mallard duckings in different shoreline habitat types at The Cotswold Water Park and The New Grounds, Slimbridge, 2000.

progresses, ducklings spend more time preening. It is likely that these factors in combination, probably explain the reduction in time spent feeding with age among Mallard broods in this study (**Figure 1**).

It has been shown previously that older Mallard ducklings tend to be more mobile and able to exploit resources over a larger area than downy ducklings (Perret 1962; Pehrsson 1984; Nummi 1993). The probability of predation declines towards fledging in waterfowl (Street 1977), and therefore movements between areas are potentially less costly for older ducklings. Increased mobility in older ducklings was also evident in the results of this study, particularly just before fledging (class III) (**Figure 1**).

The results of this study reflect other results published in relation to changes in feeding techniques with age in Mallards (Chura 1961; Street 1977). High protein requirements for growth and prey-size limitation (influenced by body and bill size), probably cause ducklings to spend a high proportion of time foraging on insects and other small invertebrates which occur on or near the surface of the water or on marginal and emergent vegetation

(Street 1978). Most downy ducklings, including Mallards, are almost entirely dependent on invertebrate food during the early duckling development (Bengston 1972; Street 1977). In this study, dabbling was seen to increase in frequency with age (**Figure 2**). Observations indicate that vegetation was being taken by dabbling ducklings (L. G. Culzac pers. obs.). It has been shown elsewhere that the percentage of animal matter in the stomachs of ducklings is greatest in the young, and that a much greater proportion of vegetable matter is eaten as the duck grows older (Cottam 1939; Mendall 1949; Pehrsson 1979).

The seemingly unusual increase in foraging techniques used to catch invertebrate food during age class IIC (**Figure 2**) coincided with the emergence of small damsel flies at the time when most broods in that age class were being observed (L. G. Culzac pers. obs.). This switch in diet composition indicates that there is some flexibility in the food preferences of older ducklings in response to food availability. Similar flexibility has been recorded for Mallard ducklings elsewhere (Cox *et al.* 1988; Pietz & Buhl 1999).

Bengston (1977) showed that for the variety of duck species recorded at Lake Myvatn, Iceland, ducklings were less bound to the proximity of concealment as they got older. The results of this study indicate a similar pattern, with very young ducklings spending a large proportion of their time in areas with over-hanging woodland or terrestrial herbaceous plants (**Figure 3**). However, young ducklings also spent a large proportion of their time along shorelines with very little vegetation. These habitats were generally used as resting areas (L. G. Culzac pers. comm.), probably because they offer good visibility and easy access to the water when predators approach (Bengston 1971). In general, as ducklings got older, they tended to use habitats with large amounts of aquatic vegetation. Given that ducklings over four weeks old tended to spend more time dabbling for vegetation (**Figure 2**) and that dabbling was the most frequently used foraging technique along shorelines with a high proportion of aquatic vegetation (**Figure 4**), this could, in part, explain why ducklings favoured areas richer in aquatic vegetation when older (**Figure 3**).

The results of this study indicate that Mallard ducklings use a range of different shoreline habitat types, both within and along the shores of artificially created lakes, and that use appears to be related to brood age and behaviour. A mosaic of shoreline habitats, including areas of bare and well-vegetated aquatic substrate and plenty of terrestrial cover with some less well-vegetated loafing areas for younger ducklings, is probably necessary for brood rearing in this species. However, more data are required to determine how habitat use changes in relation to availability and whether habitat requirements differ in other areas of Britain. In addition, although

vegetation structure adjacent to brood-rearing areas is important for nesting and resting cover for adult birds (Hines & Mitchell 1983), these relationships have yet to be fully explored in artificially created habitats in the UK. A complete picture of the habitat use by Mallards in these areas will be necessary to inform creation and management of wetlands for this species and should remain a priority for future research.

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