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Nesting success of the Mallard *(Anas platyrynchos)* in wetlands in Kashmir, India

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Mallards, *Anas platyrynchos* are widely distributed throughout the northern hemisphere and have also been introduced to the Antipodes, where they pose a threat to native duck diversity through hybridization and introgression. Studies of their breeding ecology in their natural range provide useful information relevant to their conservation there and their control in introduction sites. Nesting success of Mallards was studied at Anchar Lake and Shallabugh wetlands, Kashmir over two breeding seasons. One hundred and one nests were found, of which 37% totally failed. Seventy-one percent of nests were in tall, dense macrophytic vegetation, 23% in willow bushes and 6% in cavities in willows. Overall nesting success calculated by the Mayfield method was 54%; it was similar in tall, dense, macrophytic vegetation (53%) and willow bushes (47%), but the apparently higher observed success rate in willow cavities (78%) was hard to evaluate because of the small sample size for that site type. Predation (49%) and nest desertion (43%) were the most common causes of clutch losses. Clutch failure was greater during the first half of the breeding season, mainly because all observed nest predation occurred at that time; nest desertion occurred equally commonly in the first and second halves of the nesting season. An effective management strategy for increasing Mallard breeding success in Kashmir would appear to be conserving nesting cover, particularly tall, dense, macrophytic vegetation; equally, controlling introduced Mallard populations elsewhere, particularly in wetlands, might incorporate reducing the amount of dense nesting cover available, providing it does not negatively affect the breeding of other native, cohabiting bird species.

Keywords: Mallard; nest site; nesting success; macrophytic vegetation; willows; clutch mortality agents

INTRODUCTION

The Mallard, *Anas platyrhynchos* is a widely-distributed and much studied dabbling duck, whose natural range extends across North America, Greenland and Eurasia (Baldassare 2014). It was introduced to Hawaii, South Africa, Australia, New Zealand and many Pacific islands during the 19th and 20th centuries (Marchant and Higgins 1990; McDowall 1994; Rhymer *et al*. 1994; Engilis *et al*. 2004; Dyer and Williams 2010; Stephens *et al*. 2020). Several studies have shown that introduced Mallards hybridize with native, related duck species, thus effectively diminishing the genetically 'pure' populations of the resident species. For example, in New Zealand hybridisation and displacement by Mallards are partly responsible for the demise of the Grey Duck *Anas superciliosa superciliosa* (Williams and Basse 2006). Tracey *et al*. (2008) reported that on Lord Howe Island in Australia the Mallard also hybridizes with native Grey Ducks. Phenotypic characteristics suggest that Mallards are now dominant on the island and have supplanted the Grey Duck, with 81% of birds classified as Mallard or Mallard-like hybrids, 17% as intermediate hybrids and only 2% as Grey Duck-like hybrids; no pure Grey Ducks were observed. The threat to the native Pacific Black Duck, *Anas superciliosa rogersi* on mainland Australia appears to be less, but is probably significant (Guay *et al*. 2014; Taysom 2015). Thus, hybridization with introduced Mallards poses a considerable threat to the viability of native duck populations and avian diversity in several countries, including Australia. Strategies are required in such countries to control invading Mallards and protect native ducks. The breeding ecology of Mallards has been documented in New Zealand (Sheppard *et al*. 2019), but less so in Australia. Documenting the nesting ecology of Mallards in their natural range has relevance for both the conservation of the species in its natural range and its control in areas to which it has been introduced and become problematic.

Mallards are winter visitors to the wetlands and lakes of Kashmir where the present study was conducted. Together with other species of waterfowl, they occur in huge numbers there during winter (Pandit and Fotedar 1982; Shah and Qadri 1988; Holmes and Parr 1988; Qadri 1989; Pandit 1991; Zargar and Naqash 1993). In spring (March and April) most of them leave for their breeding grounds in the Palearctic region extending from Northern Europe to Central Asia (Ali 1979). However, a small population remains to breed in the lakes and wetlands of the Kashmir valley (Shah *et al*. 2009; Ahanger *et al*. 2010; Habib and Davidar 2017). Almost a century ago Mallards bred in the lakes and wetlands of Kashmir in large numbers; there are accounts of boat loads of eggs of this species being sold in the bazaars of Srinagar (Bates and Lowther 1952). These depredations, together with destruction of nesting sites and hunting, must have had disastrous repercussions, as in the early 1950s Bates and Lowther (1952) could find only a few Mallard nests in Kashmir. It seems likely that the species subsequently ceased breeding in Kashmir, as no breeding birds were recorded by various researchers during the late 20th century (Pandit and Fotedar 1982; Shah and Qadri 1988; Holmes and Parr 1988; Qadri 1989; Pandit 1991; Zargar and Naqash 1993). However, in

recent years, breeding Mallards have been observed once again in the water bodies of Kashmir and the number of these birds is increasing gradually, as is the number of nests observed (Shah *et al*. 2008, 2009; Ahanger *et al*. 2013; Habib and Davidar 2017).

Nesting success and the variables that influence it are important aspects of the breeding biology and demography of bird species. It is the most influential variable affecting population growth rates of Mallards in North America (Cowardin *et al*. 1985). In this study, the nesting success of Mallards that use various types of nesting site in Kashmir wetlands is examined.

STUDY AREA AND METHODS

The present study was conducted at two Kashmir wetlands, Shallabugh and Anchar Lake. Shallabugh wetland is ~16 km north of Srinagar and extends over an area of 7.5 km^2. The periphery of the wetland is surrounded by willows, *Salix* sp. and poplars, *Populus* sp. Towards the Shallabugh side of the wetland, a dense growth of willows in the form of the Shallabugh plantation exists. Most of the wetland comprises marshy areas, but for the winter-visiting waterfowl several compartments have been made that retain a considerable amount of water in that season. Shallabugh wetland has been included in the Indian network of Important Bird Areas (IBA) (Rahmani and Islam 2004). Anchar Lake, although neither a Ramsar site nor an IBA, is nevertheless extremely important bird habitat, as several species of waterbirds breed in the lake in summer and it forms a staging point for many avian winter visitors. The lake has dense, tall beds of macrophytic vegetation, open water and areas with floating vegetation and peripheral willows.

The investigation was conducted during 2014 and 2015. In the study area, Mallards nest in tall, dense macrophytic vegetation (TDMV), willow bushes (root mats) and hollows of old willows. Nests were detected by flushing ducks by gently disturbing the patches of TDMV and willow bushes (Klett *et al*. 1988) and thoroughly searching the hollows of old willows (Gec 1970). A nest was defined as any depression in which a bird laid one or more eggs (Miller and Johnson 1978). Care was taken to avoid excessive disturbance, which might have attracted predators, and to avoid stepping upon the well-concealed nests. Slender willow stakes flagged with strips of cloth were used to mark nest locations so that the nests could be found again (Klett *et al*.1988). Predation was determined by searching for egg remains. For the determination of nesting success, the nests were monitored until the fate of all eggs was determined. A nest in which at least one duckling hatched was considered successful. However, as some nests were found after incubation had commenced, breeding failure in the population was also calculated as the number of breeding attempts that failed divided by the total number of nest-days of exposure (Mayfield 1961), a method commonly employed in duck breeding ecology research (e.g. Landress *et al*. 1996).

Chi squared (with Yates' correction) and Binomial tests were used to examine apparent disparities in nest site use between wetlands, nesting success among nest site types and the timing of clutch failures and their causes. To examine temporal trends in clutch failure and its causes we divided the nesting season (admittedly somewhat arbitrarily) into two halves (March-April and May-June).

RESULTS

One hundred and one active nests were found during the study, 71% in TDMV, 23% in willow bushes and 6% in willow hollows (Table 1). A greater percentage of active nests occurred in TDMV at Anchar Lake (83%) than at Shallabugh (58%) ($\chi^2_{(1)}$ = 7.011, P = 0.008). The proportion of breeding attempts in which at least one duckling hatched was 63% and did not differ between TDMV (61%) and combined willow (69%) sites ($\chi^2_{(1)}$ = 0.263, P = 0.608). An estimate of nesting success using Mayfield's (1961) method indicated that daily clutch survival rate was 0.983 overall, but varied among nest site types from 0.979 (willow bushes) to 0.993 (willow hollows) (Table 1). These daily rates translate into an overall survival rate for the entire incubation period of 54% of clutches, varying from 47% (willow bushes) to 78% (willow hollows). However, the high percentage for willow hollows is an unreliable estimate, as it is based on only six nests. Clutch failures (from all causes) were more common in the first than the second half of the breeding season (78% versus 22% of failures; Binomial test, P<0.001) (Table 2). Predation accounted for 49% of nest failures, clutch abandonment for 43% and flooding for 8% (Table 2). All clutch predation occurred in the first half of the breeding season, but clutch abandonments occurred equally in the first and second halves of the season (Binomial test, P = 0.067) (Table 2).

DISCUSSION

Documenting the breeding ecology of a species is an important component of devising: (a) conservation strategies aimed at increasing its abundance in its natural range and (b)

Table 1

Nesting success of Mallards in different types of nesting site at Anchar Lake and Shallabugh wetlands, Kashmir. Total exposure days is the number of days on which clutches were known to be present for all nests combined. Daily nest survival rate is derived from the number of nests in which at least one duckling hatched and the total number of exposure days. Nest success is extrapolated from the daily nest survival rate and the duration of the incubation period.

Nesting site	No. of nests found at Anchar Lake	No. of nests found at Shallabugh	Total nests	Number failed	Exposure days	Daily nest survival rate	Nest success (%)
Tall, dense macrophytic vegetation	45	27	72	28	1592	0.982	52.8
Willow brush	7	16	23	8	391	0.979	46.6
Hollows in old willows	2	4	6	1	150	0.993	77.7
All sites	54	47	101	37	2133	0.983	53.9

Table 2

Numbers of clutch failures of Mallards at both study sites combined that were attributable to three mortality agents.

Nesting site	Cause	March	April	May	June	Total
Tall, dense macrophytic vegetation	Predation	9	5	–	–	14
	Abandonment	5	3	2	2	12
	Flooding	–	–	2	–	2
Willow bushes	Predation	2	2	–	–	4
	Abandonment	2	1	–	–	3
	Flooding	–	–	1	–	1
Hollows in old willows	Predation	–	–	–	–	–
	Abandonment	–	–	1	–	1
	Flooding	–	–	–	–	–
All sites combined	Predation					18 (48.7%)
	Abandonment					16 (43.2%)
	Flooding					3 (8.1%)

methods of population control in areas to which it has been introduced and in which it is proving a threat to native bird diversity. This study has provided information that could help in promoting Mallard conservation in Kashmir and other parts of the species' natural range, but that also has some relevance for population control of the species in Australia and other countries to which it has been introduced and where it poses a threat to native duck' species diversity through hybridization (Williams and Basse 2006; Guay *et al*. 2014; Stephens *et al*. 2020). We found that Mallards in two localities in Kashmir wetlands nested predominantly in TDMV and willow bushes, had a mean nesting success rate of 54% (Mayfield method) and that the main causes of clutch failure were predation and nest abandonment.

Nest sites

Some bird species utilize a variety of types of nest site and the relative use of these types is likely to depend on both their availability and particular, advantageous properties that each possesses. Many waterfowl need a thick cover of vegetation for successful nesting (Miller 1971; Dwernychuk and Boag 1972; Bilogan 1992). Hill (1984) reported that Mallards in Buckinghamshire, England mostly nested in TDMV, probably because it provided good cover that reduced nest predation, and Cowardin *et al*. (1985) attributed the lack of nesting by Mallards during drought in grassland in North Dakota, USA to the sparse residual cover present at the appropriate time for nest initiation. However, Gec (1970) observed that 98% of Mallard nests in his study area in Croatia were not in macrophytic vegetation but in willow bushes, probably because the area contained huge willow plantations; only a few Mallards nested in hollows in willows, presumably because the trees were mostly harvested before they were old enough to be hollow-bearing.

In the present investigation, Mallards nested in both TDMV and willows; the former was clearly the favoured nesting site in both study areas, but willows were exploited more at Shallabugh than at Ankar Lake, probably because of their much greater relative abundance there. The predominant use of TDMV and willow bushes as nesting sites in the present investigation confirms the earlier finding of Ahanger *et al*. (2013) for these two study areas and three other Kashmir wetlands. However, Habib and Davidar (2017) found that in three Kashmir wetlands (including Shallabugh and two others studied by Ahanger *et al*. 2013) in the two years preceding the present investigation only 35% of Mallard nests were in reed beds, with 33% occurring in willow root mats and 32% in tree cavities, although 67% of nests at Shallabugh were in reed beds. Although there seem to be only three main types of Mallard nest site in the Kashmir valley wetlands, there appears to be variation among wetlands and years in the distribution of nests among these site types.

Breeding success

Overall nesting success for the entire incubation period (typically ~26 days plus the egg-laying phase, Sheppard *et al*. 2019) calculated by the Mayfield method was 54% of clutches, a very similar proportion to that reported by Habib and Davidar (2017) in another study in the Kashmir wetlands. Nesting success was similar in TDMV and willow bushes; it appeared to be much greater in willow hollows, but this estimate must be treated with caution as the sample size was very small. It would be interesting to determine nesting success in a larger sample of willow hollow nests in our study sites because potentially such nests are particularly well concealed from predators and safe from flooding because of their height above ground level. Habib and Davidar (2017) reported that the greatest nesting success in their investigation occurred in such hollows. Nests in TDMV and willow bushes are likely to be more susceptible to flooding, disturbance and possibly predation than those in willow hollows (Habib and Davidar 2017).

Mallard nesting success has been investigated most intensively in North America and estimates there vary greatly. Oetting and Dixon (1975), Ohlendorf *et al*. (1989) and Lokemoen and Woodward (1992) reported similar values (57% -59%) to that observed in the present study, and a few of the published estimates are much higher (e.g. 85%, Miller and Collins 1954; 69%, Steel *et al*. 1956). However, most of the estimates are much lower than our Kashmir value (e.g. Gates 1965; Klett *et al*. 1988; Greenwood *et al*. 1995; Losito *et al*. 1995; Landress *et al*. 1996; Maxson *et al*. 1996; Maisonneuve *et al*. 2000; Ackerman 2002; McPherson *et al.* 2003; Davis 2008;

Yetter *et al*. 2009). This probably reflects the fact that many of the North American studies have been conducted in highly modified habitats in which human disturbance and predator densities are high. It is consistent with this proposition that some of the American and Canadian investigations indicate that success may be greater for nests in wetlands than those in upland (e.g. Arnold *et al*. 1993), (although there are exceptions e.g. Kaminski *et al*. 2013), and in nests in dense rather than sparse cover (e.g. McKinnon *et al*. 1999). Nest success among naturalized Mallards in New Zealand (58%) resembled that in the Kashmir Valley (Sheppard *et al*. 2019).

Causes and timing of clutch failure

Thirty-seven of the 101 clutches found failed to produce a single hatchling. Nest predation and clutch abandonment caused similar proportions of failures and together were responsible for 92% of losses, with flooding accounting for the remaining failures. We were unable to determine which predators were responsible for clutch failures. Predation, mainly by mammals and birds, is the main cause of clutch failure in Mallards in a variety of nesting habitats in North America (e.g. Higgins 1977; Duebbert *et al.* 1983; Hill 1984; Cowardin *et al*. 1985; Bilogan 1992; Gazda 1994; Greenwood *et al*. 1995; Losito *et al*. 1995; Hine *et al*. 1998; Hoekman *et al*. 2006; Dyson *et al*. 2020), commonly causing 60-90+% of observed losses. In some other parts of the species' natural range predation is also the principal clutch mortality factor (e.g. Algeria 76% of losses, Fouzari *et al*. 2018; Spain 40%, Amat 1982), and it is significant in naturalized populations in New Zealand (Sheppard *et al*. 2019). Fitting anti-predator guards to artificial nest sites can greatly improve nesting success rate (e.g. by 20%, Laubergs *et al*. 2004), as can reduction of predator numbers (Duebbert and Loekemoen 1980; Pieron and Rowher 2010).

Abandonment is the other main cause of clutch failure in Mallard populations in their natural range, and in Tibet Lu (2011) found that it was a slightly more common cause of failures (52% of losses) than predation (43%). Nest abandonment by birds can occur for many reasons, including a failure of embryonic development and disturbance of the nesting birds or the nest itself by humans, agricultural machinery or other agents (Higgins 1977; Hoekman *et al*. 2002). Although desertion accounted for 43% of clutch failures in our investigation, its causes could not be ascertained. Flooding was a minor cause of clutch failure in our study, as has been reported for Mallards in North American boreal forest (Dyson *et al*. 2020).

Just over 75% of the clutch failures in our study occurred in the first half of the nesting season, mainly because all nest predation observed took place then; abandonment occurred equally in the first and second halves of the breeding season. The prevalence of nest predation in the first half of the breeding season was probably because March-April is the start of the growth season and the macrophytic vegetation much used for nesting sites was therefore not yet very dense or tall. Ahanger *et al*. (2010) reported a negative correlation between clutch predation rate and mean vegetation height at Mallard nests in Anchar Lake. Hill (1984) also reported that the proportion of Mallard and Tufted Duck, *Aythya fuligula* clutches preyed upon in Buckinghamshire, England decreased as the height of the vegetation around nests increased. More generally, Reynolds *et al*. (2001) indicated that duck nesting success in the Prairie Pothole Region of North America increased as a function of the amount of grass in the area and Ball *et al*. (1995) found high duck productivity rates in Montana, USA where large areas of grass remained intact. Dwernychuk and Boag (1972) found that the amount of overhead cover at artificial ducks' nests was an important factor in their survival, because egg-eating bird species were the main predators. Lizevy (1981) showed that successful nests of ducks in Wisconsin, USA were in taller vegetation than those destroyed by predators.

Implications for Mallard conservation and control

High quality nesting sites are important for the successful breeding of a bird species. A good management strategy for increasing Mallard breeding success in Kashmir would appear to be providing adequate nesting cover for them. The TDMV patches in wetlands need to be maintained and possibly extended. As the Mallard is an early breeder in Kashmir and early breeders begin nest building before the new growth of TDMV is optimal for nesting, the presence of residual cover from the previous year should improve the breeding success of early breeding pairs. Thus, the previous year's residual cover should not be eliminated completely by burning in winter, a common practice in Kashmir aimed at promoting the growth of fresh macrophytic vegetation in the coming spring. Willow bushes in wetlands should also be protected. Thus restoration of damaged habitat, maintenance of sufficient macrophytic vegetation cover and planting of willows at suitable locations would improve the breeding conditions of Mallards in Kashmir wetlands. Conversely, manipulating cover, so long as it does not impair the reproductive success of other native duck and other waterbird species, may offer a means of controlling Mallards where they have been introduced and pose a threat to native bird diversity, as in Australia, New Zealand and South Africa.

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