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DO DIFFERENT PLASTICINE EGGS IN ARTIFICIAL GROUND NESTS INFLUENCE NEST SURVIVAL?

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In order to understand the role of plasticine eggs in nest predation studies, altogether 78 ground nests were monitored in a large wheat field near to Pécs (southern Hungary) in June 2006. Two eggs were placed in each of the artificial nests, comprising, in an alternating sequence, quail + quail, quail + natural colour plasticine, and quail + white lime coloured plasticine eggs. During one week 65.4% of the artificial nests were depredated. When the damage or disappearance of any of the eggs was considered as a predation event, the daily survival rates of nest containing only two quail eggs was higher than of nests with quail and natural plasticine eggs and significantly higher than of nests with quail and white coloured plasticine eggs. When considering predation to real eggs only, the results remained similar, however, the significant difference in survival rates of the two nest types with different plasticine eggs disappeared. Simultaneously with the nest predation experiments, 78 small mammal live traps were set up in the wheat field and operated for 7 nights. The capture success of traps baited with quail egg was 9.9%, with natural plasticine egg 15.4%, and with white coloured plasticine egg 23.1%, but only a marginal significant difference was found between daily survival rates of quail vs. white coloured plasticine eggs. Natural, but especially white coloured plasticine eggs resulted in an increased predation rate, therefore we suggest that in artificial ground nest experiments nest should be considered to be predated only when the real egg is damaged or disappeared.

Key words: *Coturnix coturnix*, nest predation, small mammals, live traps, Hungary

INTRODUCTION

Predation has strong evolutionary selective power and is thus a major extrinsic factor influencing animal populations (NEWTON 1998, KRAUSE & RUXTON 2002, BEGON *et al.* 2005, CARO 2005). Nest predation affects the ecology, evolution and behaviour of bird species (MARTIN 1995). To better understand the impact of nest predation on the reproductive success of certain bird species, artificial nests are commonly used. Several authors applied dummy eggs laid by other species (e.g. quail, chicken, sparrow, zebra finch, etc.) or made of clay, plasticine or paraffin in artificial nest predation studies (MAJOR & KENDAL 1996, BAYNE & HOBSON 1999, LINDELL 2000). Clay, plasticine and paraffin eggs generally better conserve the marks of predators left on the eggs than real eggs providing useful information about the identity of predator species or guild (RANGEN *et al.* 1999, BOULTON & CASSEY 2006). The number, coloration and scent of the eggs placed in the artificial nests, as well as the size, location and material structure of these nests are different from natural eggs and nests, therefore their predation rates can be different from rates measured on real nests (BURKE *et al.* 2004). A number of comparative studies have indicated that artificial nests are exposed to significantly higher predation levels than are real nests (e.g., WILSON *et al.* 1998, KING *et al.* 1999, DAVISON & BOLLINGER 2000, BERRY & LILL 2003, BOULTON & CLARKE 2003, BATÁRY & BÁLDI 2004, 2005, LINDELL *et al.* 2004). However, there are studies that have reported just the opposite (e.g. ORTEGA *et al*. 1998, ROBEL *et al*. 2003, COLOMBELLI-NÉGREL & KLEINDORFER 2009), or did not find any difference between predation rates of the two types of nest (e.g., GOTTFRIED & THOMPSON 1978, MØLLER 1988, CRESSWELL 1997, GUYN & CLARK 1997, BUTLER & ROTELLA 1998, GRÉGOIRE *et al.* 2003). The aim of applied methods should be to measure the same predation pressure on artificial nests as on the mimicked real nests and so to minimise the bias in order to make the best decision for protecting a given bird species.

In particular, the applicability of plasticine eggs is often questioned and heavily criticized, due to its unnatural smell, which can influence and modify the behaviour of predators relying on olfactory cues (MAJOR & KENDAL 1996, BAYNE & HOBSON 1999). Despite all the criticism, this method remains widely used because of its simplicity and advantage in conserving predator marks (MOORE & ROBINSON 2004). Real eggs placed in artificial nests are used for the evaluation of predation rates, whereas plasticine eggs put beside them serve for the identification of predators, as they preserve the traces and marks of pecking and biting left on them (MAJOR 1991, BAYNE *et al.* 1997, CRESSWELL 1997, SÖDERSTRÖM *et al.* 1998, BÁLDI & KISBENEDEK 1999, NIEHAUS *et al.* 2003, TRNKA *et al.* 2008). Therefore these sorts of eggs are often used in combination with real eggs. However, in the majority of nest predation studies a nest is considered as predated, if any of the eggs (regardless if it is a real or e.g. a plasticine egg) has disappeared or has been damaged by predators (BAYNE *et al.* 1997, CRESSWELL 1997, WILSON *et al.* 1998, BÁLDI & KISBENEDEK 1999, PURGER *et al.* 2004*a, b*, TRNKA *et al.* 2008, PEHLAK & LÕHMUS 2008). This basically does not seem to cause a problem for artificial nests, such as for those used in bushes because predation on real eggs and plasticine eggs is similar (PURGER *et al.* 2004*a*). However, in previous experiments with artificial ground nests, we found that nests containing plasticine eggs are in general earlier discovered and depredated by mammals leading to a decreased Mayfield nest survival rate on them (PURGER *et al.* 2004*b*, 2008). Small mammal traps baited with plasticine eggs captured significantly more individuals than those with normal quail eggs (PURGER *et al.* 2008). The smell of plasticine is assumed to cause this preference (RANGEN *et al.* 2000). Here we aimed to answer the question whether this effect could be reduced or eliminated by covering the plasticine egg with a coat of white lime. Painted and varnished clay eggs were used by BOULTON and CASSEY (2006), while clay eggs coated with plastic were applied by HASKELL (1999), but attractiveness of those eggs was not compared with real eggs. We conducted a nest predation experiment and trapped small mammals with live traps baited with different eggs: (1) to compare the survival rates of artificial nests containing different combinations of eggs (two real eggs only, real egg with plasticine egg and real egg with white coloured plasticine egg); (2) to investigate, through the use of live capture traps, how do the three egg combinations attract small mammals; (3) and finally to compare the results of nest predation experiments and the small mammal trapping.

METHODS

A 30 hectare conventionally managed wheat field was selected as study site (45°59'39.12"N, 18°10'9.74"E), west of the village Gyód (about 6 km south-west from the city of Pécs, southern Hungary). Quails *Coturnix coturnix*, typical ground nesting birds of the area were present in the study area. Potential large-sized predators whose presence was noted in the area were Western Marsh Harrier *Circus aeruginosus,* Red Fox *Vulpes vulpes*, Wild Boar *Sus scrofa*, Pine Marten *Martes martes* and Weasel *Mustela nivalis*. Among potential small mammal predators, we noted Common Vole *Microtus arvalis*, Yellow-necked Mouse *Apodemus flavicollis* and Steppe Mouse *Mus spicilegus* (PURGER *et al.* 2008).

Altogether 78 artificial ground nests were exposed in the wheat filed along three transect lines on the 11th of June, 2006. Artificial ground nests were formed by creating a depression in the soil using our heel (MARINI *et al.* 1995, FENSKE-CRAWFORD & NIEMI 1997), we did not use any material for the nest itself. The four transects were 400 m long and were situated 50 m from each other running parallel to the track lines in the field. Nests within each transect were separated for 20 m one from each other (BAYNE *et al.* 1997). A pair of eggs were placed in each nests comprising in an alternating sequence, of quail + quail, quail + natural colour plasticine (produced by KOH-I-NOOR, Czech Republic), and quail + white coloured plasticine eggs, respectively (hereafter Q+Q, Q+NP and Q+WP). White plasticine eggs were coloured natural plasticine eggs using the following procedure: eggs were pinned on toothpick, dipped into white lime (diluted with water) and left to dry. After one week the process was repeated. Quail eggs and plasticine eggs were similar in size. For marking the location of the nests, yellow signal tape was used, positioned at a standard distance and direction from the nests (BUTLER & ROTELLA 1998). After setting up the artificial nest experiment, the nests were controlled daily between 4–6 p.m. for a period of seven days. For the first series of analysis we considered those nests to be predated in which the first event of predation was recorded (one of the eggs had been damaged or had disappeared). In the second analysis, however, we considered the nest to be predated only if the quail egg was affected (disregarding the appearance of several small mammal marks on plasticine eggs during days prior to predation to the real eggs).

Simultaneously with the nest predation experiment, small mammal live traps were also set up: their numbers and spatial arrangement was as for the artificial nests, but we used a different part of the wheat field. Accordingly, 26 traps were baited with quail eggs, 26 with plasticine and another 26 with white coloured plasticine eggs. The traps were operated for seven nights (from 11th to 18th June). The traps were activated at about the same time when the nests were controlled. Trap control was done at around 6–7 a.m. each morning, after that traps were closed for the daytime period. Traps containing small mammal in the morning were then taken away from the plot for clearing and drying thoroughly, and then returned to their locations in the same afternoon and activated (see also PURGER *et al.* 2008). Captured small mammals after species identification were released without marking in the same location, this is why a few individuals were captured multiple times by the same trap. The capture success of traps only shows how many individuals were caught using the particular bait types. For further analysis, the values of the daily survival rates of eggs in the traps were used . Traps used for the experiment were newly fabricated plastic box traps measuring 180 mm × 75 mm × 95 mm.

We analysed the effect of egg combination types on daily probability of nest survival using a generalised linear mixed model (GLMM) with binomial error distribution, logit link function, and involving nest days as denominator. Nest days were rounded up to the nearest day (HAZLER 2004). Transect was random factor. This method is known as Mayfield logistic regression (HAZLER 2004, PASINELLI & SCHIEGG 2006). Calculations were made using the lme4 (version 0.999375–39, BATES *et al.* 2011) package for R 2.11.1 software (R DEVELOPMENT CORE TEAM 2010).

Daily survival rates of eggs in the traps was analysed on the same way as the nest data above: we performed a generalised linear mixed model (GLMM) with binomial error distribution, logit link function, involving nest days as denominator. A trap was considered as “depredated” when it contained the first small mammal species. Nest days were rounded up to the nearest day (HAZLER 2004). Transect was random factor.

RESULTS

Nest predation experiment

During one week 65.4% of the artificial nests were discovered and destroyed by predators. From a total of 26 nests with two quail eggs (Q+Q) nine (35%) were depredated: in seven cases eggs disappeared from the nests and in two cases eggs were broken (identification of predator was not possible). From 26 nests containing quail and plasticine eggs (Q+NP) 19 (73%) were depredated: quail eggs disappeared from the nests in ten cases (among these in four cases large mammal left tooth marks on plasticine eggs), in two cases quail eggs were broken, and in the remaining seven cases quail eggs remained intact but plasticine eggs contained tooth marks of small mammals. From 26 nests containing quail and white coloured plasticine eggs (Q+WP) 23 (88%) were predated: in five cases quail eggs were taken away from the nests by unidentified predators (among these, large mammals left tooth marks on two white coloured plasticine eggs), in two nests quail eggs were broken (in both cases large mammal tooth marks were left on white coloured plasticine eggs) and in 16 cases quail eggs remained intact but small mammal tooth marks were left on white coloured plasticine eggs.

GLMM showed that daily nest survival rates differed among nests with different egg combinations (Fig. 1), which was manifested in a significant difference between nests containing only quail eggs and those containing quail with white coloured plasticine eggs ($z = 3.59$, $P < 0.001$). We also found a marginal significant difference between nests with only quail and those with quail and plasticine eggs ($z = 2.27$, $P = 0.059$).

When predation to real eggs only was taken as a predation event, the daily survival rates of nests with two quail eggs did not differ significantly ($z = 1.44$, $P = 0.151$; Fig. 1) from the daily survival rates of nests containing quail and plasticine eggs. At the same time, the daily survival rates of nests containing quail and white coloured plasticine eggs were significantly lower ($z = 2.01$, $P = 0.044$) than those of nests containing two quail eggs.

Small mammals capture success

In traps baited with quail egg only18 small mammals, with natural plasticine egg 28, while with white coloured plasticine egg 42 specimens was captured. The

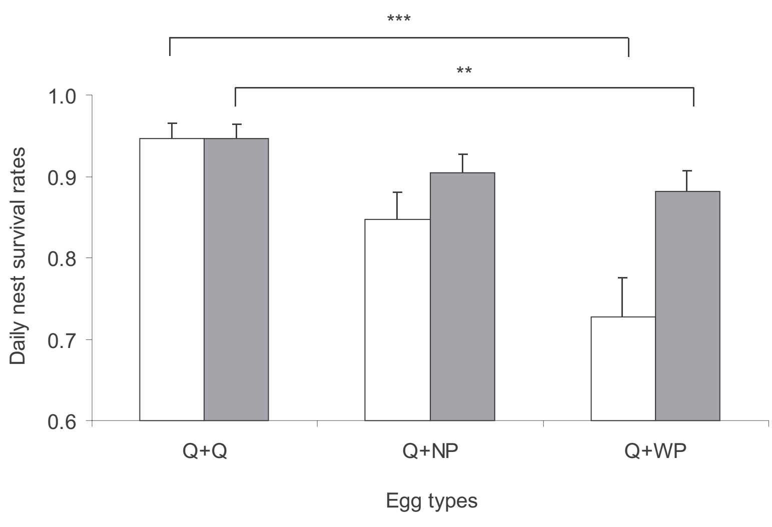

Fig. 1. Daily survival rates (+1SE) of artificial ground nests with different egg combinations (Q+Q – nest baited with two quail eggs, Q+NP – one quail and one natural plasticine eggs, Q+WP – one quail and one white coloured plasticine eggs). White bars represent the survival rates, when damage or disappearance of any types of egg in the nest was considered as a predation event; gray bars represent the survival rates, when only damage or disappearance of quail eggs was considered as a predation event. Stars indicate significant differences, **: $P < 0.05$; ***: $P < 0.01$

traps with different eggs (Q, NP, WP) captured four small mammal species (Steppe Mouse *Mus spicilegus*, Yellow-necked Mouse *Apodemus flavicollis*, Wood Mouse *Apodemus sylvaticus*, Common Vole *Microtus arvalis*). Survival rates of different egg types in traps followed similar patterns the survival rates in the nest predation experiment (Fig. 2). However, the survival rates of quail vs. white coloured plasticine eggs differed only marginally (z = 1.81, P = 0.071), while no difference in survival rates could be shown between quail and natural plasticine eggs (z = 0.54, P = 0.589).

DISCUSSION

Plasticine eggs, especially those with white colour seem to be responsible for an increased nest predation. While the smell of plasticine eggs might have had, their colour probably did not have a significant effect in our experiment, since the eggs were visible only from a very close distance in the dense growth of wheat stems. This would also suggest that apart from the smell of plasticine, the smell of white lime could further increase the attraction of small mammals (see also PURGER *et al*. 2012). All predators identified upon imprints on plasticine eggs were mammals. It is widely known that mammals tend to use olfactory cues to look for food, but birds use mainly visual cues (RANGEN *et al.* 2000). Furthermore, not painted natural plasticine eggs were also light coloured, visible for potential predators. LINDELL (2000) and SVAGELJ *et al.* (2003) suggested that real egg type used in nest predation experiments has an effect on the predation rates of particular nests.

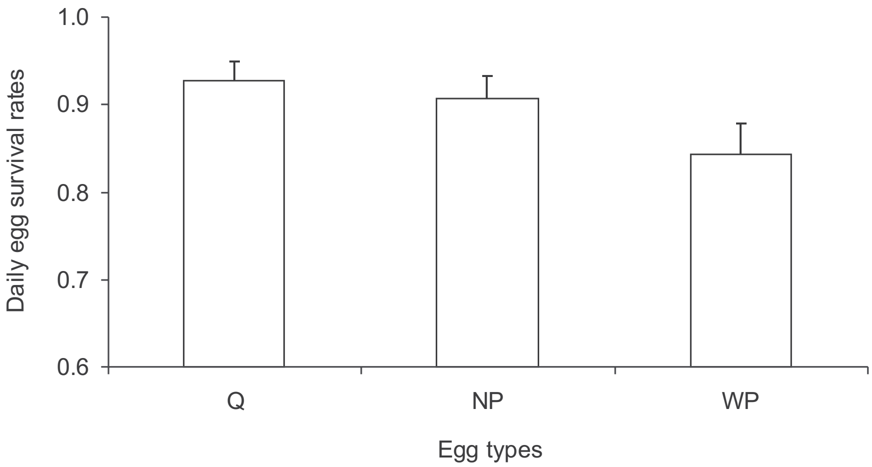

Fig. 2. Daily survival rates (+1SE) of different egg types in small mammal traps. Q: small mammal trap baited with one quail egg; NP: natural plasticine egg; WP: white coloured plasticine egg

Nests with plasticine eggs are thought to be discovered earlier by small mammals having sensible smelling than the ones with real eggs only (e.g. RANGEN *et al.* 2000, MAIER & DEGRAAF 2001). On the contrary, MAJOR (1991) and BAYNE and HOBSON (1999) claim that plasticine eggs do not attract predators better than normal eggs. From the tooth marks left on the two types of plasticine eggs in our experiment (natural and white) it can be concluded that mostly small mammals discovered the nests. Plasticine eggs may indicate the presence of certain predator species, but not necessarily their ability to predate on birds' eggs (FULTON & FORD 2003, MAIER & DEGRAAF 2001).

Despite the lack of significant difference, according to our trapping results it appears that plasticine eggs, especially the white coloured ones, may attract small mammals. This may be due to the fact that small mammals that came across quail eggs in the artificial nests did not leave visible marks there, whereas they were captured equally in the traps.

Colours have no effect since eggs used as a bite in traps were not visible; a small mammal can see them only when they were captured. One year earlier a similar study, although performed with fewer traps and for a shorter duration, yielded three times more small mammals with plasticine eggs than with quail eggs (PURGER *et al.* 2008). This suggests that small mammals may considerably influence the results of nest predation investigations, if the marks on plasticine eggs left by small mammals are considered to be predation. In fact when the survival rates of large-bodied bird nests' are investigated, like in our study, small mammals should not be considered as true predators. Whenever we found small mammal marks on plasticine and white plasticine eggs, all the real eggs in the same nests were intact.

The density of small mammals, especially with species that have seasonal gradations, can seriously influence the results of nest predation investigations if damage to any type of eggs in the nest is considered to be predation. Accordingly, although our studies have only partially confirmed it, we suggest that a nest should be considered to be predated only if the real egg is damaged or disappeared. Marks left as impressions and incisions in the plasticine surface should be used solely for the identification of the predator, we cannot recommend their use for calculation of nest predation rates. The size of the bird species (large vs. small) to be modelled should be considered as well, because it might be possible that small mammals capable of breaking small eggs are attracted to the nest by the smell of plasticine (DEGRAAF & MAIER 1996, BURES 1997).

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