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A comparison of the establishment, expansion and potential impacts of two introduced parakeets in the United Kingdom

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The United Kingdom population of Rose-ringed Parakeets *Psittacula krameri* became established primarily as a result of persistent releases or escapes. The behavioural flexibility of the species, its generalist feeding ecology and its ability to withstand temperate climatic conditions have contributed to significant population growth over the past 40 years. Evidence suggests that the species is becoming an agricultural pest and that it might be capable of successfully competing with native species for nest cavities. The Monk Parakeet *Myiopsitta monachus* is also present in the UK, although the current population is relatively small. Monk Parakeets are already well established in several European countries as well as in North America, where they are able to withstand cold winters and compete with native species for food. The UK Monk Parakeet population could significantly expand as Rose-ringed Parakeets have done, and the species could cause problems in future, both economically and ecologically. There is a paucity of published research on the feral populations of these introduced species in the UK and further work is needed to produce an evidence base to inform management decisions.

Introduction

Origin and taxonomy

Of the four recognized sub-species of Rose-ringed Parakeet *Psittacula krameri*, two are native to Africa and two native to India (Forshaw 2006). Morgan (1993) suggested that as those found in the United Kingdom were larger and more robust than the African subspecies, they were likely to be of Indian origin, and Pithon and Dytham (2001) confirmed this by reference to body and bill length measurements. *Psittacula krameri manillensis* is found in Sri Lanka and south of 20°N in India, whereas *Psittacula krameri borealis* is found north of 20°N in India, eastern Pakistan, Nepal and Myanmar (Ali & Ripley 1969). Rose-ringed Parakeets are popular pets (Feare 1996, Pithon & Dytham 2002) and between the early 1970s – when importation became legal – and 2007 – when the European Union (EU) introduced a permanent ban on importation of wild birds (Commission Regulation (EC) No. 318/2007) – the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) trade database records (<http://www.cites.org/eng/resources/trade.shtml>) show that 25 860 individuals were imported into the UK. Theile *et al.* (2004) reported that 137 621 birds were imported by EU and Acceding States between 1996 and 2002. It has been suggested, however, that the number of Rose-ringed Parakeets bred in the UK is several times the number imported (Morgan 1993). Using data provided by The Parrot Society UK on captive breeding success, Fletcher and Askew (2007) estimated that at least 20 105 birds were bred in captivity in the UK between 1990 and 2004. Fletcher and Askew (2007) were further able to show a positive relationship between numbers of Rose-ringed Parakeets

imported and the number of small flocks sighted in the wild the following year. This regression analysis indicates that releases and escapes of imported birds lead to augmentation of the current feral population. Although importation is no longer legal, it is likely that the same mechanism would apply with captive reared birds.

Monk Parakeets *Myiopsitta monachus* are native to South America and are formally split into four subspecies, recognized by geographical variation in morphology, coloration and nesting behaviour (Juniper & Parr 1998). The identity of birds at large in the UK is not known. Genetic work in the USA suggests that established populations there are predominantly *Myiopsitta monachus monachus* (Russello *et al.* 2008), native to Argentina and Uruguay. CITES trade database records show that of 287 137 Monk Parakeets imported to the USA between 1975 and 2007, 31.4% were from Argentina and 68.4% from Uruguay. Similarly, imports to the UK were largely from Argentina (53.2%) and Uruguay (33.1%), suggesting that Monk Parakeets found in the UK may also be predominantly *Myiopsitta monachus monachus*. The number of Monk Parakeets imported into the UK in this period was 5215, representing one-fifth of the number of Rose-ringed Parakeets imported over the same period.

Population levels

The Rose-ringed Parakeet is the most widely introduced parrot in the world with breeding populations in at least 35 countries, spanning five continents (Butler 2003). Although reports of temporarily established populations in the UK date back to 1855, the present breeding population has been extant for at least 35 years (Lever 1987). It is only in the last decade that growth has accelerated and whereas the last census of Rose-ringed Parakeets concluded that there was a minimum of 5886 in the UK (Butler 2002), it has been suggested that the population could number 20 000 (Owen 2004). In their native range, Rose-ringed Parakeets inhabit a variety of woodland types (Juniper & Parr 1998), managed farmland, urban gardens and parks (Khan 2002), and they are noted to be extraordinarily abundant in and around many cities (Ali & Ripley 1969). Roosting is often communal throughout the year and this facet of their behaviour provides a reliable mechanism for monitoring populations (Butler 2003).

Monk Parakeets have also become established in several European countries as well as in North America (Sol *et al.* 1997). The species is a more recent introduction to the UK, the first recorded population existing in Devon between 1987 and 1998 (Butler 2002). Holling & the Rare Breeding Birds Panel (RBBP) (2007) suggested that there was a minimum population of 40 birds in 2005, while, currently, an estimated 100–150 birds are thought to be living in the wild in England (<http://www.defra.gov.uk/wildlife-pets/wildlife/management/non-native/documents/faq-monkparakeet.pdf>). Monk Parakeets roost communally throughout the year and in their native range show a preference for wooded areas, whether the trees are native or introduced (Mott 1973). Where Monk Parakeets have been introduced, however, populations have initially established in predominantly urban landscapes (Kibbe & Cutright 1973, Hyman & Pruett-Jones 1995, Munoz & Real 2006).

The aim of this paper is to describe the establishment of both Rose-ringed Parakeets and Monk Parakeets, explore their breeding and feeding ecology, and investigate the economic and ecological damage that they could cause in the UK.

Methods

Web of Science and Google Scholar were initially searched in September 2007 using the terms ‘Ring necked Parakeet’, ‘Rose ringed Parakeet’ and ‘Monk Parakeet’. This resulted in an initial suite of papers from which further literature was identified. Google was then searched using the same terms in order to find relevant supplementary grey literature. The information gathered was used to complete a peer-reviewed risk assessment for the Non-native Species Secretariat on each of the Rose-ringed Parakeet and Monk Parakeet (see

<https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=51>) and these assessments form the basis for this paper. Personal communications with experts identified further relevant literature and additional searches of Web of Science, Google Scholar and Google using the same terms were undertaken in February 2009 and November 2010 to identify more recent publications.

Results

Establishment in the UK

Lever (1987) reports two historical populations of Rose-ringed Parakeets in the UK, one in Norfolk in 1855 and the other in Epping Forest during the 1930s. Neither of these populations persisted. In 1969, however, one family group was reported in Kent (Hudson 1974) and the 'Breeding Atlas of Birds in Britain and Ireland' recorded Rose-ringed Parakeets in four 10-km squares, with confirmed breeding in two (Sharrock 1976). The British Ornithologists' Union (BOU) accepted the Rose-ringed Parakeet as a Category C1 established exotic species with an estimated population of 500 birds in 1983 (BOU 1983). This estimate was supported by the 'Atlas of Wintering Birds in Britain and Ireland', in which Rose-ringed Parakeets were recorded in 68 10-km squares and numbers were estimated at 500–1000 (Lack 1986). The most recent atlas of breeding birds indicated that the southeast population of Rose-ringed Parakeets had spread south and east, and that breeding was confirmed in 15 10-km squares (Gibbon *et al.* 1993). Although Lack (1986) reported the presence of a northern population, it had disappeared by the time Gibbons *et al.* (1993) was published. Pithon and Dytham (1999a, 2002) organized simultaneous roost counts in 1996, 1997 and 1998, and reported yearly total counts of 1508, 1880 and 2060, respectively. In 1999, Butler (2002) counted in the order of 2500 Rose-ringed Parakeets at just one roost and further roost counts at the four most populated sites in the winter of 2001/02 revealed a total of 5886 individuals (Butler 2002). Fletcher and Askew (2007) note that in the period from 1995 to 2001/02, numbers at these sites increased by 716%. Rose-ringed Parakeets are still fairly localized in the UK, and local populations tend to use a limited number of habitual sites (Pithon & Dytham 2002). Butler (2003) reported that they are increasingly being seen in rural as well as the previously typical urban and semi-urban areas. Figure 1 shows the recent distribution of Rose-ringed Parakeets as derived from 2003 to 2008 data from three British Trust for Ornithology monitoring schemes, namely BirdTrack, the Breeding Bird Survey (BBS) and the Wetland Bird Survey (WeBS).

The first population of Monk Parakeet in the UK was noted in 1987 in Tiverton, Devon (Grant 1996). Up to 30 Monk Parakeets were present, but the population disappeared in 1998, which is thought to be as a result of a change in land management (Grant 1996). Another group existed from 1988 to 1993 in Barnton, Cheshire, numbering up to nine Monk Parakeets (Barber 1994), although no reason is given for its disappearance. The population in Borehamwood, Hertfordshire, was first noted by residents in 1993 (Butler 2002) and Holling and RBBP (2007) reported a minimum roost count of 40 Monk Parakeets in 2005. Breeding was first reported in 2001, when at least three nests were active (Butler 2002). In 2005, no change in the number of active communal nests was reported (Holling & RBBP 2007), although it is not clear how many pairs were nesting in each of those active nests. More recent information suggests that there are now around 100–150 birds living in the wild in England (<http://www.defra.gov.uk/wildlife-pets/wildlife/management/non-native/documents/faq-monkparakeet.pdf>). Fig. 2 shows the recent distribution of Monk Parakeets as derived from 2003 to 2008 BirdTrack, BBS and WeBS data.

Breeding ecology

As with almost all other parrots, Rose-ringed Parakeets nest in tree holes and other cavities, including recesses in buildings (Ali & Ripley 1969). Butler (2003) found that Rose-ringed Parakeets in the UK prefer to nest in trees with larger trunk diameter at breast height (dbh) than randomly sampled trees, and more surrounding shrub and tree cover. He further reported that at the sites he monitored, nests were found in 12 genera of trees and that 33% of the

nests were in ash *Fraxinus* spp. and 22% in oak *Quercus* spp. The median date of first egg-laying in the UK is 23 March ($n = 108$), although the earliest recorded date is 27 February and egg-laying continues through to mid-May (Butler 2003). The median clutch size is four eggs and although Pithon and Dytham (1999b) estimated fledging success in the UK to be 0.8 chicks per nest ($n = 12$), more recent research based on a larger sample shows fledging success is 1.9 chicks per nest ($n = 108$) (Butler 2003). Largely consistent with this figure, Lambert *et al.* (2009) reported that in a second year of breeding attempts in captivity, 19 pairs of Rose-ringed Parakeets produced 2.5 and 1.8 fertile eggs for the first and second clutches, respectively. Rose-ringed Parakeets are largely sedentary (Juniper & Parr 1998) and wave-front models showed that Rose-ringed Parakeets in the UK were expanding their range at just 0.4 km/yr (Butler 2003). In contrast to this relatively slow geographical expansion, the expansion in numbers is very marked, with the Isle of Thanet population growing at a rate of 15% per year, and the Greater London area population at approximately 30% per year (Butler 2003).

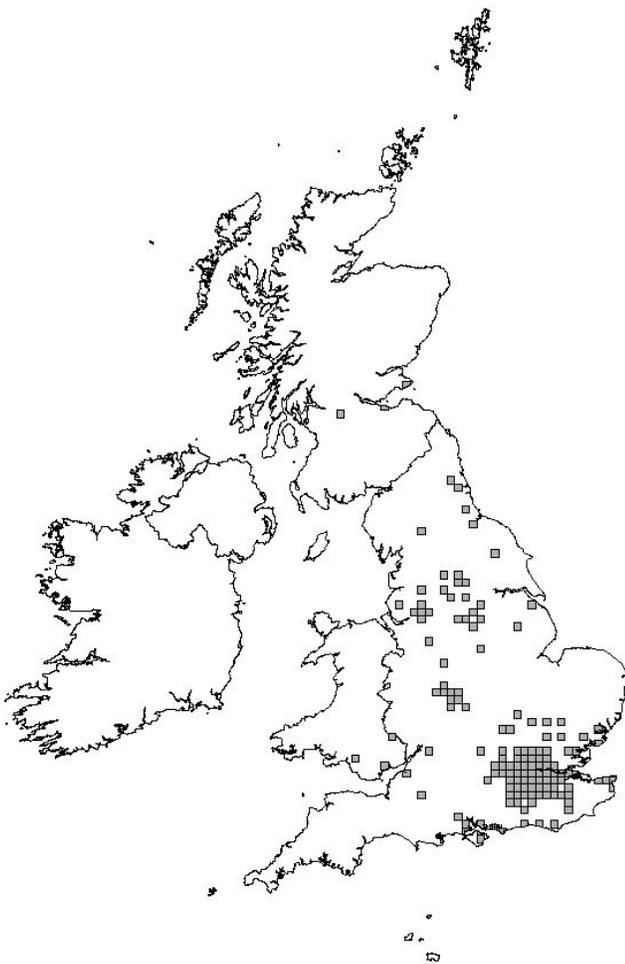


Figure 1. Recorded presence (note: absence could equal not detected or not present) of Ring-necked Parakeets *Psittacula krameri* at a 10-km square resolution in one or more of the past six survey years (2003-2008).



Figure 2. Recorded presence (note: absence could equal not detected or not present) of Monk Parakeet *Myiopsitta monachus* at a 10-km square resolution in one or more of the past six survey years (2003-2008).

Monk Parakeets are the only species of parrot to build a nest from sticks (Forshaw 1989, Juniper & Parr 1998) and they may at times breed cooperatively (Eberhard 1998). The nests are large, domed and enclosed, often comprising several isolated chambers (Eberhard 1996). They are most often built in trees, with a preference for taller trees with thicker trunks (Burger & Gochfeld 2005). A variety of artificial structures such as pylons and radio towers are also readily used (Davis 1974). Indeed, in South Florida 80% of nests are built on artificial structures (Avery *et al.* 2006). Nests are often clustered in close proximity and at high density, forming colonies (Eberhard 1998). At just one nesting site in the State of Colonia, Uruguay, Mott (1973) reported that 5000 nests have been recorded. Nests are maintained and occupied throughout the year (Eberhard 1998) and there is evidence that some may be built purely for occupation rather than breeding (Martin & Bucher 1993). Caccamise and Weathers (1977) found that the mean internal temperature of Monk Parakeet nest cavities was 1.8 °C higher than the external temperature, although a difference as high as 4.6 °C was noted. As nests are used year round, this temperature variation is likely to aid survival during cold winters (Butler 2005) as well as breeding success (Schwartz *et al.* 2009). When groups were displaced as a result of catastrophic storm damage, Martin and Bucher (1993) found that none moved further than 300 m to start rebuilding nests. They also reported that 50% of adults changed nests annually, moving a median distance of 503 ± 118 m. Navarro *et al.* (1992) reported that mean clutch sizes were 6.0 ± 0.2 and 5.4 ± 0.1 in two Argentinean sites. Fledging success was 2.2 ± 0.3 and 1.4 ± 0.2 chicks per pair at those same sites. Martin and Bucher (1993) found that the median dispersal distance of young from their natal site was 1230 m.

Feeding ecology

Rose-ringed Parakeets are generalist feeders but are predominantly vegetarian in their native range, consuming fruits, flowers, nectar, cereals, grain and seeds according to availability during the year (Ali & Ripley 1969). In Europe, they also show a great deal of plasticity in their feeding behaviour, consuming fruit such as apples *Malus* spp., pears *Pyrus* spp., cherries and plums *Prunus* spp. and grapes *Vitaceae* spp., the berries of holly *Ilex* spp. and elder *Sambucus* spp., cereals such as barley *Hordeum* spp. and Maize *Zea mays*, the seeds of European Hornbeam *Carpinus betulus* and European Ash *Fraxinus excelsior*, and even bread, bacon rind and meat (Cramp 1985). Rose-ringed Parakeets also make extensive use of garden bird feeders, consuming large quantities of peanuts and sunflower seeds (Lack 1986).

Monk Parakeets are also generalist feeders and although the main part of their diet consists of wild and cultivated seeds, fruit, vegetable matter and root vegetables, they are also known to consume adult insects and larvae (Juniper & Parr 1998). South and Pruett-Jones (2000) found that in Chicago one-quarter of their diet was bird seed taken from garden feeding stations, but other significant items included crab-apple *Malus* spp. fruit, hawthorn *Crataegus* spp. berries, seeds of ash *Fraxinus* spp., dandelion *Taraxacum* spp. flowers and buds of elm trees *Ulmus* spp. South and Pruett-Jones (2000) further reported that their diet changed seasonally. Fruit consumption was highest in July but continued through to mid-October, seeds were the sole recorded food source taken in January and February, and flowers and buds formed the principal part of their diet in April and May. In Spain, Monk Parakeets have been observed feeding on cypress *Cupressus* spp., poplar *Populus* spp., Yew *Taxus baccata*, London Plane *Planatus hybrida* and Common Fig *Ficus carica* (Sol *et al.* 1997).

Known damage

Throughout their native ranges both the Rose-ringed Parakeet and Monk Parakeet are considered to be agricultural pests (Ali & Ripley 1969, Mott 1973, Long 1981). Rose-ringed Parakeets are reported to cause significant damage to a variety of crops including Maize (Long 1981) and Sorghum *Sorghum bicolor* (Reddy 1998). Long (1981) reports an average loss of 21% of maize crops in India. There are no published studies of agricultural damage by Rose-ringed

Parakeets in the UK or across Europe. There are, however, increasing numbers of reports in the grey literature (Butler 2003). Fletcher and Askew (2007) reported that the cost of damage done at one vineyard in Surrey was estimated to be £5000 annually. By 2009, Natural England had issued one licence to kill, by shooting, 30 parakeets for the purpose of preventing serious damage to crops. In January 2010, Natural England implemented changes to the licensing situation and General Licences WML/GEN L05, WML/GEN L06 and WML/GEN L08 now allow for Monk and Rose-ringed Parakeets to be killed to prevent serious damage or disease, to preserve air safety, to preserve public health or public safety, and to conserve flora and fauna. In Argentina, the amount of damage caused by Monk Parakeets is locally severe, but regionally negligible (Bucher 1992). Very little empirical evidence exists that Monk Parakeets are highly destructive agricultural pests and predictions of severe damage to crops in the USA (Davis 1974) appear not to have been borne out (Spreyer & Bucher 1998). Tillman *et al.* (2001), however, questioned Longan *Euphoria longana* and Lychee *Litchi chinensis* farmers and estimated bird damage to their respective crops to be between 1% and 28% and between 4% and 64%. There are no reports of agricultural damage by Monk Parakeets in the UK.

Additional economic damage is caused by parakeet involvement in aircraft strikes (Fletcher & Askew 2007), although no reports yet exist for Monk Parakeets. Fletcher and Askew (2007) found that of 54 bird strikes at Heathrow Airport in 2005, one involved Rose-ringed Parakeets, whereas in 2006, two of 44 bird strikes involved Rose-ringed Parakeets. The cost per bird strike was reported to be £20 000.

In the USA, Monk Parakeets are increasingly causing damage to artificial structures because of their large and heavy nesting structures (Avery *et al.* 2002). The principal damage is to electrical utility structures which short circuit when nesting material gets wet. In the first five months of 2001 Florida Power and Light logged 498 outages, affecting 21 000 customers and the annual cost was estimated at \$585 000 (Avery *et al.* 2002).

It has long been suggested that as a result of early nesting in the UK, Rose-ringed Parakeets may have a competitive advantage over native breeding birds (England 1974, Tozer 1974). They are robust and able to excavate existing cavities (Butler 2003), which might further aid their ability to compete. Common Kestrel *Falco tinnunculus*, Stock Dove *Columba oenas*, Western Jackdaw *Corvus monedula*, Eurasian Nuthatches *Sitta europaea* and Common Starlings *Sturnus vulgaris* are considered the most likely species to be vulnerable to nest-site displacement (Butler 2003, Fletcher & Askew 2007, Strubbe & Matthysen 2007). Although Butler (2003) reported that Rose-ringed Parakeets in the UK primarily nest in old woodpecker nests, woodpeckers are primary cavity nesters, which is likely to reduce the competition pressure they experience. Strubbe and Matthysen (2007) found that Rose-ringed Parakeet abundance was a significant predictor of Eurasian Nuthatch abundance and that greater numbers of Parakeets resulted in fewer Eurasian Nuthatches. Strubbe and Matthysen (2009b) also demonstrated nest-site competition experimentally by blocking Rose-ringed Parakeet nest cavities, with numbers of native Eurasian Nuthatches declining significantly, largely due to nest take-overs by Rose-ringed Parakeets. Strubbe *et al.* (2010) modelled the potential impact of Rose-ringed Parakeets on Eurasian Nuthatches in Belgium and given predicted abundance, geographical spread and moderate competition strength, concluded that at most one-third of the population of Eurasian Nuthatches would be at risk. Monk Parakeets build nests and do not require a cavity to breed. No studies were identified that examined whether Monk Parakeets compete with native breeding birds for nest-sites. One report exists, however, of Monk Parakeets acting aggressively to the extent that they killed Blue Jays *Cyanocitta cristata* and an American Robin *Turdus migratorius* (Davis 1974). There is a suggestion that Rose-ringed Parakeets may be predators of nestlings (Tozer 1974), although no supporting evidence was found for this.

Rose-ringed Parakeets may also be able to take some fruit earlier than native species, and Fletcher and Askew (2007) report unpublished evidence suggesting that they may be able to take mistletoe *Viscum* spp. berries, before thrushes are able to consume them. Both Rose-ringed Parakeets and Monk Parakeets are known to consume food items that are also consumed by native birds (Cramp 1985, Lack 1986, Juniper & Parr 1998, South & Pruett-Jones 2000).

Rose-ringed Parakeets are possible vectors for diseases such as Newcastle disease (Butler 2003), cryptosporidium (Morgan *et al.* 2000) and psittacosis (Fletcher & Askew 2007), which could affect both poultry and humans. Monk Parakeets can also carry several diseases that could be passed on to wild birds and poultry (Newcastle disease) and humans (psittacosis) (Stafford 2003).

In Australia, Rose-ringed Parakeets are known to cause severe damage to plantations by stripping the bark from young stems, killing those trees and locally changing the arboreal composition (Fletcher & Askew 2007). Fletcher and Askew (2007) suggested it is possible that accumulated droppings beneath large roosts might kill vegetation under the roost thereby altering the local habitat. Butler (2003), however, considered it unlikely that any significant alteration of semi-natural habitats would take place.

Discussion

Despite Rose-ringed Parakeets successfully establishing more widely than any other avian species worldwide (Butler 2003) it was nearly 130 years after they were first recorded as a feral species in the UK (Lever 1987) that a self-sustaining population became established (BOU 1983). The population is now increasing exponentially (Butler 2003) and the same model of growth is also reported in several European countries (Strubbe & Matthysen 2006). Rose-ringed Parakeets are reported to establish less well in colder areas (Strubbe & Matthysen 2009b) and breeding performance has similarly been found to be lower in colder conditions (Schwartz *et al.* 2009). Specifically, Schwartz *et al.* (2009) found a negative correlation between number of frost days and reproductive success. They found that nest predation in India, however, was significantly higher than in the UK. It is also possible that adult Rose-ringed Parakeets are released from some predation pressure in the UK, as the only predator likely to pose a significant threat to adults is the Eurasian Sparrowhawk *Accipiter nisus*, although no successful kills have yet been formally reported (Pithon & Dytham 1999a). In addition to successful and sustained breeding in the UK, the population could be regularly augmented by released and escaped captive birds (Pithon & Dytham 2002), although these birds are liable to have a lower survival or breeding success and thus the full complement of escaped and released Rose-ringed Parakeets is unlikely to represent useful recruitment to the existing feral population.

The UK Monk Parakeet population is small, whereas they are widely introduced across the globe, and have successfully colonized several European countries as well as North America (Hyman & Pruett-Jones 1995, Sol *et al.* 1997). The populations in Spain (Domènech *et al.* 2003) and the USA (Van Bael & Pruett-Jones 1996) are reported to fit a model of exponential growth. In the USA, after an unsuccessful nationwide eradication programme instigated in the 1970s, the Monk Parakeet population is currently doubling in size every 6–7 years (Pruett-Jones *et al.* 2007) and numbers have now exceeded pre-control levels (Butler 2005). Monk Parakeets are a more recent introduction to the UK so it may be that they are still in the establishment phase. Although the extent of captive breeding of Monk Parakeets in the UK is unknown, numbers imported between 1975 and 2007 were 20.2% of the number of Rose-ringed Parakeets imported in the same time period, indicating that they are a less popular pet. Considering the recruitment mechanism described by Fletcher and Askew (2007), it seems likely that fewer Monk Parakeets have entered into feral populations than Rose-ringed Parakeets and that they do so at a slower rate. This could adversely affect their successful establishment as introduction effort is one of the most consistent predictors of establishment

success (Cassey *et al.* 2005). Interestingly, Monk Parakeets were first introduced to the USA in the late 1960s (Hyman & Pruett Jones 1995), which is similar to the timing of establishment of the current Rose-ringed Parakeet population in the UK (Hudson 1974). Both Rose-ringed Parakeet in the UK and Monk Parakeet in the USA now fit a model of exponential population growth (Van Bael & Pruett-Jones 1996, Butler 2003). This suggests that the UK Monk Parakeet population could also reach a point at which growth becomes exponential.

Pithon and Dytham (2002) have suggested that food supply is not likely to be a factor that limits population growth of Rose-ringed Parakeets and this is borne out by the fact that the population is rapidly increasing (Butler 2003). Rose-ringed Parakeets and Monk Parakeets have largely similar diets, to the extent that both are largely vegetarian, but known to exhibit high dietary adaptability, and will also eat non-plant items (Juniper & Parr 1998). As such, it is likely that they will be under similar food resource constraints in the UK. There is some suggestion from the USA that Monk Parakeets require feeding stations during the winter months when natural food is scarce (South & Pruett Jones 2000). However, Rose-ringed Parakeets in the UK are increasingly recorded in more semi-urban and rural environments where such food sources are likely to be less frequently encountered (Butler 2003) and, indeed, even in the USA, Monk Parakeets are widespread in rural areas (Van Bael & Pruett-Jones 1996). Strubbe and Matthysen (2009a) found that Rose-ringed Parakeets are likely to be found in built-up areas and parks, but also old forests and uneven aged forests. This was explained by their requirement for habitat with sufficient nest-sites, and Strubbe and Matthysen (2009a) suggested that the Rose-ringed Parakeet's tolerance for environmental conditions within parks and forests might be related to their generalist feeding behaviour. There is no indication of either species having saturated the urban and semi-urban environments they currently occupy in the UK.

Parakeet damage to crops is generally light and the economic impact minor (Bucher 1992), and it is increasingly thought that some reports may have been overstated (Pruett-Jones & Tarvin 1998, Spreyer & Bucher 1998). There is, however, evidence that both Rose-ringed Parakeets (Long 1981) and Monk Parakeets (Tillman *et al.* 2001) are capable of causing some agricultural damage, although the extent of this damage in Europe is unquantified. Monk Parakeet nests are known to cause regular power outages in the USA (Avery *et al.* 2002), whereas no reports of such damage exist in Europe. Some effort has been made to quantify the impact in the USA and the cost is significant, although comparable to the cost of parakeet management (Avery *et al.* 2002). It is possible that the lack of reported damage in Europe could be explained by the fact that population levels in European countries have not yet reached those in the USA. Another possible explanation is that the affected infrastructure in the USA could by design be less resistant than in Europe. One final category of economic damage caused by parakeets is that of aircraft strikes. Rose-ringed Parakeets in the UK were responsible for 3.1% of birds strikes reported at Heathrow Airport in 2005 and 2006 (Fletcher & Askew 2007). Currently the population of Monk Parakeets is too small to be likely to cause aircraft strikes, although should it grow to the size of the current Rose-ringed Parakeet population, it is likely that they would have a similar impact.

There are many ways in which introduced species can impact on the environment they invade (Manchester & Bullock 2000), but only four are pertinent to parakeets in the UK, namely competition for nesting sites, competition for food resources, disease and habitat alteration. Rose-ringed Parakeets and Monk Parakeets carry a similar suite of diseases that could cause harm both to the poultry industry and to humans (Stafford 2003, Fletcher & Askew 2007). With respect to habitat alteration, both Rose-ringed Parakeets and Monk Parakeets form high-density roosts, from which large quantities of droppings fall each night. This could have a very local effect on surrounding vegetation. Rose-ringed Parakeets are known to strip bark, killing trees and changing the local arboreal make-up in Australia

(Fletcher & Askew 2007). However, no reports yet exist indicating that either Rose-ringed Parakeets or Monk Parakeets have altered semi-natural habitats in the UK, or across Europe.

Since early in their establishment in the UK it has been suggested that Rose-ringed Parakeets could compete with native secondary cavity nesters for nesting cavities (England 1974, Tozer 1974). Strubbe and Matthysen (2007) found a negative relationship only between Rose-ringed Parakeet and Eurasian Nuthatch abundance – the first study to identify a negative relationship between introduced Rose-ringed Parakeets and native birds. No relationship was found between Rose-ringed Parakeet abundance and the abundance of Common Starlings or any of the other hole-nesting species examined. Species such as Common Kestrel, Stock Dove and Western Jackdaw may have avoided competition because they prefer wider openings and will also nest in rock crevices and buildings (Cramp 1985). Common Starlings and Eurasian Nuthatches are known to have similar nest cavity requirements, but Starlings are known to be able to evict other cavity nesters, including parrots (Pell & Tidemann 1997). Monk Parakeets, in contrast, have not been reported to compete with native birds for nest-sites. As they are not cavity nesters, competition with native birds for nest-sites is likely to be less severe. Should they become established permanently, their impact on native species when compared with Rose-ringed Parakeets may thus be reduced. Monk Parakeets in the USA have been reported to behave aggressively towards some native species, resulting in fatalities (Davis 1974). This is an isolated report and no supporting evidence has been found, which suggests that it is a rare occurrence and therefore unlikely to have a significant impact on native species.

There is a paucity of evidence relating to parakeet competition with native species for food resources as very few studies have been undertaken. Although both Rose-ringed Parakeets and Monk Parakeets are known to eat native plant species, which presents a mechanism for competition, no quantification of this has been undertaken. Fletcher and Askew (2007) report that unpublished data suggest Rose-ringed Parakeets may be able to take mistletoe berries earlier than native thrushes, but this is the sole report of such an effect. Further work is required to identify whether this could indeed be an issue should parakeet populations continue to expand. Whether it is the case or not, it is likely that both Rose-ringed Parakeets and Monk Parakeets would exhibit similar levels of competition as their diets are very alike (Juniper & Parr 1998).

There are currently only three small breeding populations of Monk Parakeets known in the UK, and previous populations have died out rapidly without the reasons leading to extinction being properly understood. However, Monk Parakeets have very successfully colonized the USA and other European countries, where they now number in their thousands. The small size of the UK Monk Parakeet population may be as a result of their relatively recent establishment, but also the relatively small number of birds imported. However, it seems likely that, without control, Monk Parakeets will become more widely established in the UK, especially if they continue to be captive-bred and traded as pets. Should Monk Parakeets increase their numbers and expand their range in the UK, they are likely to have similar impacts, both economically and environmentally, to those of the Rose-ringed Parakeet.

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