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Standing out from the crowd: are patagial wing tags a potential predator attraction for harriers (*Circus spp.*)?

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Concise title: Wing tags: predator attraction

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Abstract
Wing tags have been used on many bird species to facilitate individual recognition, although tags are not only conspicuous for humans but may also attract the attention of potential predators. During a Peregrine Falcon monitoring program (1997-2011) we collected prey remains from the nests of 37 peregrine territories in the Basque Country, Northern Spain. We identified 3127 prey items representing 132 bird species. In the 2009 breeding season we found, for first time, four Hen Harrier remains and the two wings with orange wing tags of a Montagu`s Harrier in one nest, one year later we found in the same nest eight Montagu`s Harrier remains, one of them with wing tags, and in 2011 we found eight Montagu's Harriers more, one of them marked. Simultaneously, in the breeding season of 2010 the remains of another Montagu's Harrier were found in other peregrine nest and two wings with orange and blue wing tags in the perch of a third pair. Our data thus shows an increase of predation rate of harriers by peregrines; we discuss whether this could be related to the increasing use of wing tags in this species, and thus whether wing tags may have potential negative effects on the birds. We argue that further studies about the impact of identification techniques, and wing-tags in particular, on the survival of target species should be carried out.
Keywords
Wing tags, Montagu´s Harrier, Circus pygargus, Peregrine falcon, Falco peregrinus, predator attraction.

Introduction

Wing tags have been used on many bird species to facilitate individual recognition and to document for example dispersal, survival and migration (Anderson 1963; Hester 1963; Knowlton *et al*. 1964; Kochert *et al*. 1983; Etheridge and Summers 2006). Tags are designed to be conspicuous in order to facilitate the research and may not only attract human attention, but also the attention of potential predators. It is accepted that raptors are quick to single out a bird that shows any physical weakness (Treleaven 1998; Kenward 2006). We document a shift in diet in peregrine falcons to preying on harriers, including wing-tagged ones, in Northern Spain, and discuss whether the increased predation rate on that group may be related to the use of wing tags.

Material and methods

During a long-term Peregrine Falcon (*Falco peregrinus*) monitoring programme (1997-2011) in the Basque Country, Northern Spain, we systematically collected prey remains from the nests of 37 peregrine territories whilst ringing the chicks between 20th April and the end of May each year. The prey remains found in the nests usually belonged to the seven- to ten-day period prior to the visit, depending on the age of the chicks. Feathers, bills, skulls and legs were identified using a private reference collection (skins of more than 200 potential prey species). We identified and counted each prey item using the most frequently found body part or feather, in order to give the minimum number of individuals (MNI) present in the sample (see Martínez and Zuberogoitia 2001).

In order to compare the proportion of wing-tagged harriers in the peregrine nests in relation to those potentially present in the population, we estimated the number of wing-tagged birds alive in each of the study years from the numbers tagged and estimated annual survival. In total, 1545 juveniles were wing-tagged in France in 2007, 1947 in 2008 and 1254 in 2009 (www.busards.com). Survival has been estimated at 31% for the first winter, and 68% subsequently, using wing-tagged birds (Millon and Bretagnolle 2008). However, overwinter survival in the first year from birds with satellite transmitters has been estimated at 50% (Arroyo 2009). We thus calculated a minimum and a maximum value of birds potentially alive using both survival estimates. We related estimated number of wing-tagged birds each year to the total estimated number of French harriers, assuming that the French Montagu´s harrier population is estimated to be ca. 4500 pairs (Millon *et al*. 2004), with an average productivity of 2 (Millon and Bretagnolle 2008).

Results

In total, during the 15 monitoring years we identified 3127 prey items representing 132 bird species. In the 2009 breeding season, we found remains of harriers for the first time, namely four Hen Harriers (*Circus cyaneus*) and one Montagu's Harrier (*Circus pygargus*) in the one nest. The Montagu´s Harrier remains consisted of two wings with orange wing tags. One year later, we found in the same nest remains of eight different Montagu`s Harriers, one of them with orange wing tags, and eight more in 2011, one of them marked with blue wing tags. Both peregrine adults in that territory had been monitored and individually identified (with rings and individual plumage characteristics) from 2005 to 2011 (and they successfully bred each year), thus the change in diet was not associated to an incorporation of a new bird to the pair/territory. Instead, results suggest that this could be the first step for an individual specialization. Moreover, in the 2010 breeding season we also found some harrier primaries in the nest of another peregrine pair (11 km from the previous one) and the wings of a Montagu´s Harrier with orange and blue wing tags in the perch of a third pair (19 km from the previous one). In total, from the 19 Montagu´s Harriers found, 4 (21%) were wing-

tagged. Table 1 presents the estimated proportions of wing-tagged birds in the French population each study year, which range between 7 and 15%. We positively identified six adults (one female and five males) and seven second calendar year birds (four females and three males) among the Montagu´s harriers found.

Discussion

There are no published records of peregrines preying on harriers (Klem *et al*. 1985; Ratcliffe 1993; Rockenbauch 2002; Drewitt and Dixon 2008; Sergio and Hiraldo 2008), although harassment of harriers by peregrines is infrequently noted (B. O'Donoghue, pers obs.). Additionally, there are a few non-published observations of peregrines occasionally preying on harriers. For example, in England, during the 2003 breeding season, three recently fledged wing tagged juveniles of Hen Harrier were located by radio-tracking in a peregrine eyrie where the leg (with ring) of an adult male Hen Harrier was also found; in 2006, old remains of another tagged Hen Harrier were found by radio-tracking to a peregrine plucking post (Murphy, unpublished data). Finally, a ringed French Montagu´s harrier was found in the nest of a peregrine pair in Asturias (Northern Spain) in autumn 2008 (http://aves.eldelweb.com/Cantabria/ficha/666-0-Aguilucho-Cenizo.html).

Rudebeck (1951) suggests that in the migration season some peregrines may specialize on raptors such as Sparrowhawks (*Accipiter nisus*) and Short-eared Owls (*Asio flammeus*). However, the percentage of raptors in the diet of peregrines is low and Peregrine Falcon is not usually quoted as an important raptor predator (Zuberogoitia & Prommer 2011).

Mesopredators are normally included in low percentages in the diet of apex predator species (see Sergio and Hiraldo 2008). The main reasons proposed to explain the evolution of Intra Guild Predation in vertebrate top predators are: (1) active removal of competitors; (2) obtaining energy in situations of scarce availability of trophic resources; and (3) direct elimination of a potential killer threatening the top predator or its offspring (Lourenco et al., 2011b). In our case, Montagu´s harriers are neither competitors nor predators of peregrine offspring, so peregrines may be killing harriers merely for foraging. In this sense, Lourenco *et al*. (2011a) correlate the increase of mesopredators in the diet of superpredators under food stress situations caused by the decline of their main prey species. They suggest that this may be associated to low breeding success. However, this is not our case, since the peregrines involved in this study successfully bred (i.e. 4, 3 and 3 fledglings in 2009, 2010 and 2011 in the case of the specialized pair).

There are no breeding pairs of Montagu's Harrier within 40 km of the monitored Spanish peregrine nest sites, thus most of the captured harriers there should be migrant birds. Montagu´s Harriers breeding in France and central Europe migrate through Spain to Africa and *vice versa* and at least some of this population passes through our study area, mainly in the middle of April. However, we had never detected harriers in the diet of our peregrines until 2009 (Zuberogoitia and Prommer 2011). The sudden occurrence of harrier predation by peregrines in our study area at this time was not associated to an increase in the Montagu´s harrier population in either Spain, where it has been stable in recent years (Arroyo & García 2007) or France, where it has apparently declined (Millon et al. 2004), or to an increase in peregrine populations (REF). It coincided temporally with the implementation of a large-scale wing-tagging programme in France from 2007 to 2009 (www.busards.com).

The predation rate of wing tagged harriers observed in our study area and in England could result from a higher attack rate by predators or a higher success rate per attack (Bolen 1980). Alternatively, it could reflect availability, as the large-scale wing-tagging

programme carried out in France means that wing-tagged harriers were indeed relatively common in the population during the study period. However, and although our sample size each year was too low to make statistical analyses, the estimated proportion of wing-tagged birds in the French population (Table 1) was lower than that observed in our nests in each of the years. This suggests that peregrine predation on harriers may be enhanced by the presence of wing-tags. Detrimental effects (including higher mortality rates) related to wing-tags have previously been documented in other species (e.g. Bolen 1980; Howe 1980; Southern and Southern 1985; Kindel 1989).

Careful planning is imperative before applying markers, and biologists need to consider potential effects on social and breeding behaviour, breeding success or survival rate, among others (Varland *et al*. 2007). In the case of the Montagu´s Harrier, some initial studies had been carried out to evaluate the impact of wing tags on the behaviour and survival of this species (Bavoux *et al*. 2001), and none had been found. In fact, adult survival estimated through this technique is high and comparable to those in other raptors of similar size (Millon and Bretagnolle 2008). Additionally, results coming from the long-term wing tagging projects in France and Spain have been critical to understand the population dynamics of the species, change its conservation status, and have allowed the development of successful conservation programmes (Pomarol and Heredia 1994; Arroyo *et al*. 2002; Millon *et al*. 2004; Millon and Bretagnolle 2008; Arroyo 2009). Results from the current large-scale wing tag project mentioned above, which aims to identify the connectivity between areas and the impact of juvenile dispersal on population dynamics, potentially have a strong impact on the understanding of the species metapopulation dynamics and on the development of conservation programmes at the appropriate scale. Thus, in the case of Montagu´s Harriers, the potential costs of the use of wing tags *vs* the benefits that they have given to the conservation of the species, could be weighted towards the latter.

It is not possible with our data to firmly conclude that wing-tags increase the predation rate of harriers. However, it is not possible to discard this hypothesis either. Results found here are a reminder that wing tags, as other identification techniques, may have negative effects on the birds. Because of that, and overall, we think that it is critical that particular attention is urgently given to the two following aspects:

1) Specific studies evaluating the impact of identification techniques, and wing-tags in particular, on the survival of target species should be carried out. It is not possible to develop experimental studies on this issue due to many ethical and logistic restrictions (Lourenco *et al*. 2011a). However, there are a number of modern techniques available for tracking individual birds (e.g. PIT tagging, genetics, radio, satellite and GPS telemetry). It would be extremely useful to compare the survival rate of individuals using these different methods. This should be strongly considered by authorities granted marking licences, as well as those involved in research aimed towards better understanding their target species.

2) Researchers and ornithologists should also weigh the expected benefits for the species vs. the potential detrimental effects when considering whether to use a particular identification method in a study. In Kazakhstan, where harriers are a common prey of large eagles (Katzner *et al*. 2006), the use of wing tags on a Pallid Harrier (*Circus macrourus*) study was abandoned as it was considered risky for the species and unlikely to provide sufficient data to compensate for the costs (Madders and Arroyo unpublished data).

We cannot forget that the absence of negative effects of any identification method is a basic assumption of all methods involving marking of individuals, and relaxation or violations of this assumption may cause serious biases in the results that could potentially be translated into wrong or ineffective conservation and management measures (McDonald *et al*. 2003).

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Table 2. Estimated proportion of wing-tagged Montagu´s harriers among the French Montagu´s harrier population in the three study years. Number tagged alive estimated from Table 1. Percentages calculated for a population of 4500 pairs with a productivity of 2 fledglings per pair in spring (when predation took place), i.e. for a total of 6120 adults and 2790-4500 juveniles (this figures calculated from survival estimates).

Year	*N tagged (max)*	*N tagged (min)*	*% tagged (max)*	*% tagged (min)*
2009	1499	930	14.11	10.43
2010	1646	1020	15.50	11.45
2011	1119	694	10.54	7.79

Table 1. Estimated number of wing-tagged Montagu´s harriers alive each year. The Table presents the number tagged each cohort. Maximum and minimum values of second calendar-year birds alive assume juvenile survival estimates of 50% and 31% respectively. Adult survival is estimated at 68%.

year marked	2007	2008	2009	TOTAL
N marked	1545	1947	1254	4746
Second cal-year wing-tagged birds alive in spring 2008 (min-max)	479-773			479-773
Second cal-year wing-tagged birds alive in spring 2009 (min-max)		604-974		604-974
Adult birds wing-tagged alive in spring 2009 (min-max)	326-525			326-525
Total wing-tagged alive in 2009	**326-525**	**604-974**		930-1499
Second cal-year wing-tagged birds alive in spring 2010 (min-max)			389-627	389-627
Adult birds wing-tagged alive in spring 2010 (min-max)	221-357	410-662		631-1019
Total wing-tagged alive in 2010	**221-357**	**410-662**	**389-627**	1020-1646
Adult birds wing-tagged alive in spring 2011 (min-max)	151-243	279-450	264-426	694-1119
Total wing-tagged alive in 2011	**151-243**	**279-450**	**264-426**	694-1119