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Conservation of the Saker Falcon *Falco cherrug* and the use of hybrids for falconry

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ABSTRACT—This paper discusses two mutually incompatible activities for the conservation of wild Saker Falcons. One action already being undertaken is to promote the use of captive-bred falcons instead of wild-sourced Saker Falcons in Arabic falconry. The promotion of captive-bred falcons depends largely on the production of hybrid falcons in order to overcome the negative aspects of captive-bred birds, which require longer more intensive training and expensive, time-consuming production effort. A second activity is the lobbying to ban the production of hybrid falcons in the European Union and beyond, in order to minimise a perceived risk of extinction of the Saker Falcon through genetic introgression caused by escaped falconry birds. In this paper I appraise the potential costs and benefits for global Saker Falcon conservation of these two mutually incompatible activities.

Keywords: Falcon, *Falco*, hybrid introgression, captive-breeding, falconry, wildlife trade

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Introduction

The Saker Falcon *Falco cherrug* is a large falcon within the subgenus *Hierofalco*, which also includes the Gyrfalcon *F. rusticolus*, Lanner Falcon *F. biarmicus* and Lagger Falcon *F. jugger (Kleinschmidt, 1901; Nittinger et al., 2005).* The breeding distributions of these four closely-related taxa are largely allopatric, with Saker and Lanner being sympatric in Turkey and parapatric in the Balkan Peninsula, whilst there are possibly sympatric or parapatric breeding populations of Saker and Lagger in Northwest Pakistan and Afghanistan *(Ferguson-Lees and Christie, 2001; Nittinger et al., 2005).* All four taxa have sympatric breeding populations with either peregrine *F. peregrinus* or Barbary Falcons *F. pelegrinoides* and instances of natural hybrid pairs have been reported between Saker × Barbary Falcon (Angelov *et al*., 2006), Saker × Lanner *(Boev & Dimitrov, 1995),* Saker × Peregrine, Lanner × Peregrine, Peregrine × Gyrfalcon and Peregrine × Barbary Falcon *(McCarthy, 2006).* Morphologically the Saker Falcon cannot be clearly defined and shares overlapping phenotypic characteristics with Gyrfalcon especially *(Eastham et al., 2001),* though preliminary data suggest genetic distinctiveness of these two taxa *(Dawnay et al., 2008).* Taxonomic authorities differ in their opinion as to whether or not the Barbary Falcon is best regarded as a distinct species (with two subspecies: *Falco pelegrinoides pelegrinoides* and *F. pelegrinoides babylonicus*) or as a subspecies of the Peregrine Falcon (*Falco peregrinus pelegrinoides* and *F. peregrinus babylonicus*; see *Rodríguez et al., 2011* for a recent review).

Saker Falcons are currently classified as Endangered on the IUCN Red List of Threatened Species on the basis of a rapid population decline, particularly in Central Asia, primar-

ily as a result of excessive trapping for the falconry trade, as well as habitat degradation and poisoning *(IUCN, 2008).* Electrocution on power lines, persecution and prey loss are further factors impacting on Saker Falcon conservation *(Gombobaatar et al., 2004; Levin, 2008; Chien and Smith, 2003).* Intensive conservation effort in central Europe has seen a gradual increase in the Saker population of the Panonnian Basin mainly in Hungary, Slovakia and Serbia *(Bagyura et al., 2004).* In eastern Europe and across Asia there are few accurate population estimates available to determine population trends in the early years of the 21st Century but there has been a marked decline in European Russia and evidence of a decline in the main population centre of central Siberia *(Karyakin, 2008).* Significant breeding populations, each holding over 2,000 breeding pairs, also occur in Kazakhstan, China and Mongolia *(Dixon, 2009).*

Additionally, there is a perceived conservation threat from hybridisation with escaped, captive-bred falconry hybrids, which could influence the genetic integrity of wild populations (BirdLife International, 2008a). In response, BirdLife International is calling for a ban on the production and keeping of hybrid falcons in the European Union and beyond *(BirdLife International, 2008b).*

Active measures to promote Saker Falcon conservation include the use of captive-bred falcons as a means of substituting for wild-taken birds in falconry *(BirdLife International, 2008a). The* importation of wild-caught Saker Falcons is prohibited across the European Union and the unlicensed taking of the species is prohibited by national laws in all of the Saker breeding range countries. The Saker is included within Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). Among the Arabic falconry nations, the United Arab Emirates has banned the import and use of wild-taken falcons that do not have accompanying CITES documentation *(Perry, 2005)* and have instead met the demand for falconry birds primarily through captive-breeding. Captive-bred falcons are used, though to a much lesser extent, in the other major Arabic falconry nations of Kuwait, Qatar, Saudi Arabia and Bahrain.

Captive-bred falcons are generally more manageable than wild birds for falconry but require more effort and time in fitness training for hunting, and are expensive and time-consuming to produce. Among those falconers using captive-bred falcons, hybrids are commonly used in Europe, particularly for bird pest control, and by Arabic falconers, who frequently hunt with these birds outside the Middle East in North Africa and Central Asia. Typically, but not exclusively, these hybrids consist of hierofalcon taxa (especially Saker and Gyrfalcon) crossed with Peregrines or Barbary Falcons; these can be first generation crosses or later generation back-crosses that involve two, or sometimes more, different taxa. Hybrid falcons exhibit a combination of the phenotypic and behavioural attributes of their constituent taxa. Falconers use hybrids because these combined attributes are preferred (for reasons of suitability for purpose, husbandry and aesthetics) to the pure taxa. The attributes of hybrid falcons have been particularly important for promoting the use of captive-bred falcons in Arabic falconry.

This paper examines the issues surrounding the conflicting measures for Saker Falcon conservation of (i) promoting the use of captive-bred falcons through the use of hybrid falcons in Arabic falconry, in order to reduce the market demand for wild-taken Sakers and

(ii) attempting to ban the production and use of hybrid falcons, in order to remove the risk of genetic extinction of wild Sakers through introgression.

Escaped falconry hybrids and genetic introgression risk

Observations of hybridisation events involving wild-breeding Saker Falcons

Data on reported cases of hybrid breeding events involving Saker Falcons in the wild has been collated by *BirdLife International (2008b)*, the International Association of Falconry (*C. de Coune* in litt., 2008), International Wildlife Consultants (UK) Ltd and through the European *Falco cherrug* Conservation Taskforce's (EFcCT) mailing list (Table 1).

In Slovakia there are dated records for eight instances of hybrid matings or suspected hybrid falcons breeding with Sakers in the period 1999–2003. With a Slovakian breeding population of 20-25 pairs in the period 1999–2003 *(Nagy & Demeter, 2006)* these 8 hybrid breeding events amount to 6.4–8.0% of the potential nesting opportunities over this five-year period.

BirdLife International (2008b) reported that the 2003 case in Slovakia related to a Peregrine × Saker hybrid, whereas *Michel Adamec* (EFcCT mailing list, 15 November 2007) reported that this case involved a Peregrine and a Saker or hybrid (from observation). Given that the DNA analysis apparently proved the offspring to be a 50:50 Saker × Peregrine hybrid, neither of the parents could have been a hybrid. *BirdLife International (2008b)* reported that the 1999 case in Slovakia involved a Peregrine × Saker hybrid, but this case related to a bigamous trio between a male Peregrine and a female Peregrine and female Saker (*J. Mihok*, EFcCT mailing list 25 November 2008). Four eggs were laid, it was not known whether one or both females laid these eggs, but both females shared incubation and chick feeding duties. Hybridisation was inferred in the 2002 case from Slovakia because two chicks were observed to have yellow legs. However, it is difficult to see how this could be the result of a hybrid pairing as back-crossed F2 generation chicks of hierofalcon hybrids have blue-grey legs, which are typical of hierofalcon species (*M. Patterson* pers. comm., 2008).

In Hungary there is a single reported case of a hybrid falcon breeding with a Saker in the wild, whilst the remaining reported cases all refer to natural hybridisation events. Two museum specimens, on the basis of plumage characteristics, were considered by *Boev & Dimitrov (1995)* to be the result of a natural hybrid pairings between Saker and Lanner Falcon, though genetic analysis of the 1884 male bird did not support the idea that this was a hybrid *(Nittinger et al., 2007).* A case in China involved a female Barbary Falcon, occupying a territory outside the known breeding range of this species, which was apparently paired with a male Saker Falcon; the pair occupied a nest with four eggs but incubation was never observed and the eggs were deserted and subsequently predated *(Angelov et al., 2006).*

Case No.	Hybrid Mate	Country	Year	Evidence/Observations	Outcome
1a	Peregrine ♂	Slovakia	1999	♀ Saker in bigamous trio with ♂ and ♀ Peregrines. 4 chicks, two had hybrid appearance	fledged
1b	Peregrine ♂	Slovakia	2000–2002	sterile eggs	failed
1c	Peregrine ♂	Slovakia	2003	one young proved by DNA analysis to be 50:50 Saker × Peregrine hybrid	chick removed
2	Hybrid ♂	Slovakia	2000–2001	observation of hybrid male	?
3	Peregrine or Hybrid	Slovakia	2002	observation of two chicks with yellow legs	fledged?
4	Hybrid ♂	Hungary	2000	hybrid observed and video-recorded; single chick ringed	fledged
5	Barbary Falcon ♀	China	2006	observation of pair at nest with eggs	failed
6	Lanner Falcon	Bulgaria	1987	hybridisation inferred from ♀ museum specimen	fledged
7	Lanner Falcon	Bulgaria	1884	hybridisation inferred from ♂ museum specimen	fledged

Table 1. Records of reported hybrid breeding events involving Saker falcons in the wild. References: 1a: Mihok, J. (EFcCT Mailing List, 2008); 1b: Kenward & Larsson (2007); 1c: Adamec, M. (EFcCT Mailing List, 2007); 2-3: Kenward & Larsson (2007); 4: M. Prommer (BirdLife Hungary); 5: Angelov et al. (2006); 6-7: Boev & Dimitrov (1995). Cases 1a-c refer to the same breeding site in the Slovak Karst National Park over the period 1999–2003

Genetic evidence of introgression in wild Saker Falcon populations

Researchers at the Museum of Natural History Vienna have undertaken a phylogenetic analysis of the hierofalcons *(Nittinger et al., 2005)* and have examined the influence of hybridisation on the genetic structure of Saker Falcon populations *(Nittinger et al., 2007).* Earlier publications arising from this work claimed that gene flow from escaped hybrid falcons has had a great impact on the gene pool of wild Saker Falcon populations in Europe *(Nittinger, 2004; Nittinger et al., 2004; 2006).* However, these claims were not repeated in two peer-reviewed publications arising from the same study *(Nittinger et al., 2005; 2007).* The original claim was based on mitochondrial and microsatellite DNA analyses, specifically the presence of a mitochondrial haplotype in a sample of contemporary European Saker Falcons but not in a historical sample from the same geographical region, and a low degree of differentiation between Saker Falcon and Gyrfalcons at seven microsatellite loci *(Nittinger et al., 2006).* The mitochondrial haplotype was common to all four hierofalcon species and was more frequent in eastern populations (southern Kazakhstan and Mongolia) than western populations of Saker Falcons (Europe and northern Kazakhstan). The presence of shared haplotypes in all four hierofalcon species could be the result of incomplete lineage assortment from a common ancestor and/or ancient hybridisation associated with range changes and glaciation events *(Wink et al., 2005; Nittinger et al., 2005);* it certainly cannot be ascribed to escaped falconry hybrids. Difference in frequency of the haplotype between western and eastern populations of Saker Falcons could be the result of ancient hybridisation, mainly in eastern areas of the Saker distribution range *(Nittinger et al., 2005),* or contemporary gene flow between eastern and western Saker populations. The absence of this haplotype in historical samples may simply be an artefact of the small sample size (n = 15 individuals; *Nittinger et al., 2007*).

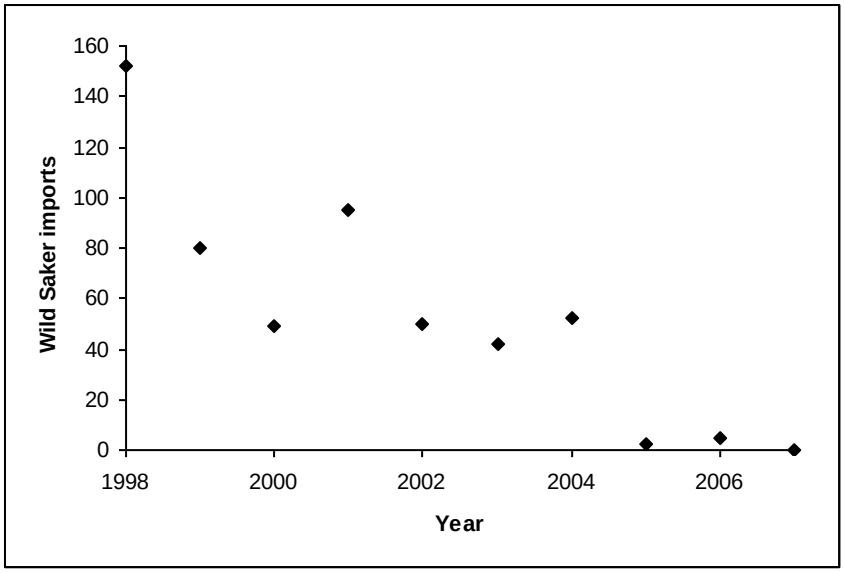

Figure 1. CITES trade data for the numbers of wild-sourced Saker Falcons imported into the UAE over the period 1998–2007

Hybrid falcons and the use of captive-bred birds in Arabic falconry

The use of captive-bred falcons in Arabic falconry

A previous analysis indicated that the number of Saker Falcons used for falconry in the United Arab Emirates (UAE) declined over the period 1993-98, whilst the use of captive-bred falcons increased *(Barton, 2000).* In 2002, the UAE launched a CITES regulated falcon passport scheme in order to ensure that legal trade regulations were in place *(Perry, 2005).* To qualify for a passport, falcons must be legally obtained/imported into the UAE and accompanied by all necessary permits. This process has promoted the use of captive-bred falcons in place of wild-caught falcons, which is reflected in the CITES import trade figures for wild-sourced Saker Falcons for the period 1998–2007 (Figure 1). CITES trade data reveals that in the five-year period 1998-2002, 426 wild-sourced Saker Falcons were imported into the UAE compared with just 101 for the period 2003-07. However, a decline in the importation of wild-sourced Sakers through CITES regulated trade can also be attributed to tighter restrictions imposed by export countries *(CITES, 2004).* In this regard, a similar decline in the number of wild-sourced Sakers can be seen for Saudi Arabia where the use of captive-bred falcons is far less frequent than in the UAE (Table 2).

Since 2003, 57% of wild-sourced Saker Falcons entering the UAE have come from Mongolia, with the majority of the rest coming from Uzbekistan (13%; confiscated birds), Kuwait (11%) and Pakistan (10%). By comparison, Saudi Arabia has necessarily needed to

	UAE			Saudi Arabia		
	Captive-bred	**Wild-sourced**	**% Captive-bred**	**Captive-bred**	**Wild-sourced**	**% Captive-bred**
2003	549	42	92.9	124	783	13.7
2004	659	52	92.7	3	572	0.5
2005	346	2	99.4	2	152	1.3
2006	233	5	97.9	2	37	5.1
2007	105	0	100	0	60	0

Table 2. CITES trade data for the importation of Saker Falcons into the UAE and Saudi Arabia over the period 2003–2007

import wild Sakers Falcons from a larger number of exporting nations to meet their demand for wild-sourced birds. Since 2003, 31% of wild sourced Saker Falcons entering Saudi Arabia have come from Mongolia, with the majority of the rest coming from Russia (21%), Ukraine (8%), Kuwait (7%), Qatar (4%), Mali, Pakistan, Kazakhstan, Turkey (3% each), Syria, Morocco, Jordan, China and Iran (2% each).

The above relates only to CITES trade data, the accuracy of which cannot be verified and furthermore an unreported and illegal trade in Saker Falcons for Arabic falconry exists. In a situation with a limited CITES regulated trade in wild-sourced Sakers, the market demand for falcons can be met either by captive-bred birds or through an illegal, unregulated trade.

The use of captive-bred hybrid falcons in Arabic falconry

In addition to treating sick and injured birds, falcon hospitals in the Middle East frequently give health checks to falcons before they are purchased by prospective owners, consequently they can see many falcons that are available on the open market. Admission records from one falcon hospital illustrate how the proportion of Saker Falcons has declined over the period 2003–07, whilst the proportion of captive-bred hybrids has increased over the same period (Figure 2). Hybrid falcons have been a key driver in promoting the use of captive-bred falcons for falconry. All of the hybrids involved Gyrfalcons crosses, with Gyrfalcon × Peregrine and Gyrfalcon × Saker comprising 71% and 25% of the hybrids admitted respectively. Gyrfalcon hybrids have attributes that make them preferable to pure-species in that they are larger (cf. Peregrine and Saker), more suited to the climate of the Middle East (cf. Gyrfalcon) and can be bred to produce aesthetically pleasing plumage types.

Discussion

Direct observation of hybrid breeding events in populations of wild Saker Falcons are likely to be biased towards regions where a significant proportion of breeding pairs are frequently monitored, as in the Pannonian population of Central Europe. Identifying hybrid falcons can be problematic *(Gantlett & Millington, 1992)* and even when breeding pairs are

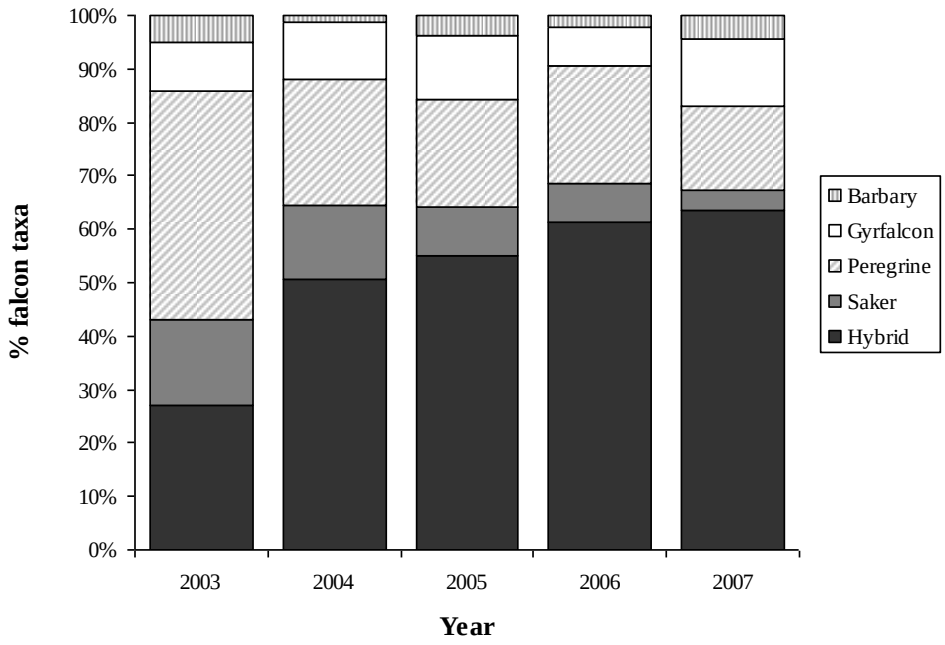

Figure 2. Proportions of five falcon taxa (hybrid, Saker Falcon, Peregrine, Gyrfalcon and Barbary Falcon) admitted to a falcon hospital over the period 2003–2007. The total number of falcons admitted annually was 1999, 454, 481, 513 and 364 from 2003–2007, respectively.

monitored, hybrid falcons could potentially be overlooked. Nevertheless, a disproportionate number of reported cases come from Slovakia in the years 1999-2003. This compares with a single recorded observation in the equally well-monitored population in neighbouring Hungary, where there was a breeding population of 130-150 pairs in the same time period *(Burfield & Bommel, 2004).* There is no evidence in any of the reported cases from Slovakia that escaped falconry birds were involved.

In Slovakia, from 1992–99, the State Nature Conservancy and Veterinary University fostered captive-bred Saker chicks into the nests of pairs in the wild as part of a population reinforcement effort *(Chavko & Adamec, 2003).* Close to the Slovakian border in the Czech Republic *ca*. 350 Peregrines and *ca*. 250 Saker Falcons were bred in captivity and released or fostered to nests as part of an official conservation effort for these species over the period 1990–2002 *(V. Beran* in litt., 2008). In several instances these releases involved fostering captive-bred Peregrine chicks into the nests of wild Sakers *(Horák, 2000).* Consequently, captive-bred Sakers and Peregrines were released to the wild which were either human imprints or else imprinted on the wrong parent species. The principal causes of hybridisation are early life imprinting which determines the future choice of mate and a shortage of

available mates of their own kind *(Hess, 1973: McCarthy, 2006);* both of which could explain the high frequency of hybrids reported in Slovakia. It is worth noting that several cases of hybrid falcons breeding with Peregrines in the wild have involved non parent-reared captive-bred Peregrines rather than wild bred individuals *(Fox, 2004).*

The frequency of reported hybrid events involving Saker Falcons in Slovakia is potentially skewed because of previous conservation management strategies which reduced behavioural barriers to hybridisation. In addition to natural behavioural barriers there are also fertility barriers in hybrid matings; females being the heterogametic sex are less fertile than males following Haldane's Rule *(Haldane, 1922).* Female hierofalcon × Peregrine hybrids are predominantly infertile in back-crosses with Peregrines and hierofalcon taxa; none are known to have been fertile in captivity (*M. Patterson*, pers. comm.), whilst hybrid males have reduced fertility resulting from a high frequency of spermatozoa deformities *(Kaltenpoth & Schulenburg, 1989).* Consequently, pairings involving escaped falconry hybrids are, in addition to being very infrequent, less likely to result in viable offspring than non-hybrid pairs. The low frequency of breeding and reduced fecundity of escaped falconry hybrids indicates that the risk of extinction of the Saker Falcon through genetic introgression via this route is minimal. Furthermore, it is unlikely that hybrid progeny have superior fitness benefits that would overcome these barriers to introgression. Peregrine Falcons have sympatric breeding ranges with all four hierofalcon species and infrequent natural hybrids have been reported *(McCarthy, 2006)*, yet there is no evidence that there has been any natural genetic introgression that has threatened the genetic integrity of any *Hierofalco* taxa examined *(Nittinger et al., 2007; Johnson et al., 2007).* Previously published studies that suggested ancient introgression of Peregrine genes in Saker populations were incorrect and arose as a result of nuclear copies of the cytochrome b gene being sequenced by mistake *(Wink et al., 2004).*

Falconry has a long historical and cultural tradition in Arabic nations *(Al-Nayan, 1976; Al-Timimi, 2007)* and modern Arabic falconry practices result in a large demand for falcons *(Riddle and Remple, 1994; Barton, 2000).* This demand can be met through three routes: (i) captive-bred falcons, (ii) wild-sourced falcons through legal CITES regulated trade and (iii) wild-sourced falcons through unregulated, illegal trade. Restrictions on the availability of falcons through captive-breeding and CITES regulated trade routes can only result in an increased demand for falcons through unregulated, illegal trade. In addition to the potential conservation impact on source populations and the animal welfare problems associated with smuggling this illegal trade also risks introducing zoonotic diseases to the receiving countries. Consequently, there are conservation, animal welfare and biosecurity benefits in promoting the use of captive-bred falcons in Arabic falconry.

In the absence of empirical data on the numbers of falcons entering Arabia, it is difficult to prove that increased use of captive-bred falcons reduces demand for wild caught falcons; in such a scenario, an increase in falcon availability through the production of captive-bred falcons could simply be absorbed by market demand. However, there is a finite demand for falcons in Arabia, at least for captive-bred falcons, as the number of birds reared by falcon breeders is determined by how many they can sell, not as many as they can produce. Furthermore, many falconers in the UAE have switched from using wild-caught

falcons to captive-bred falcons, which represents a reduction in the size of the market for wild-caught falcons.

The argument that captive-breeding should be restricted to the production of pure-bred falcons is an issue closely-linked to the promotion of captive-bred falcons for falconry use. A falconer requires a bird that is fit-for-purpose and will, by preference, obtain the best falcon available to suit that purpose. Captive-bred falcons have advantages in that they tend to be more manageable than wild-sourced falcons but have disadvantages in that they require long periods of intensive fitness training and their production requires specialist skills and facilities. In order to promote the use of captive-bred falcons it is necessary to provide hybrid falcons that have characteristics that outweigh these disadvantages. A prohibition on the use and production of hybrid falcons for falconry is likely to significantly reduce the demand for captive-bred falcons in Arabic falconry and, in the current situation with a highly restricted legal CITES regulated trade, result in an increased demand for wild-sourced illegally traded falcons. Given that for the foreseeable future, in many of the Saker Falcon range states, trans-border controls will never be more than rudimentary, a pragmatic way to influence harvests of wild Sakers is by meeting market demand with captive-bred birds.

The prohibition of hybrid falcon production, in order to minimise the risk of causing extinction of the Saker Falcon, is not supported on observational, genetic or theoretical grounds and conflicts with IUCN guidance on invasive alien species *(Shine et al., 2000).* We suggest that a precautionary approach be adopted with continued production of hybrid falcons for falconry use, better management for the training of hybrid falcons (such as the prohibition of free-hacking training techniques in breeding range countries), an international marking scheme for captive-bred hybrids and closer monitoring of wild populations, especially employing molecular techniques. Although there is no evidence of deliberate release of hybrid falcons to the wild by falconers or breeders, this should never take place. Evidence of hybrid breeding events should be recorded and published and where possible any hybrid adults or their progeny removed from the wild.

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