



Population size and breeding performance of the Lanner Falcon *Falco biarmicus* in Sicily: conservation implications

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ABSTRACT

Capsule: We report a significant reduction in population size and breeding success for the Lanner Falcon *Falco biarmicus* in Sicily, its biggest stronghold in Europe, since the latest coordinated survey.

Aims: To provide updated information on current population size of Lanner Falcon in Sicily and to compare breeding parameters with those obtained in previous studies.

Methods: We performed an intensive coordinated field survey and literature review of breeding success parameters across the species range.

Results: Overall, we monitored 126 territories throughout Sicily where the species had been reported in the last 15 years. Lanner Falcons were present only in 60 of them. Mean nest productivity (\pm standard deviation) was 1.09 ± 1.18 fledged young/checked pairs, flight rate was 2.22 ± 0.52 fledged young/successful pairs and breeding success was 49.0%.

Conclusions: Indirect measures aimed at preventing abandonment of occupied territories should be applied, for instance by developing a network of priority areas and slowing down degradation of the pseudo-steppe habitats by agri-environmental schemes. Additionally, direct measures aimed at preventing nest robbery, including the organization of nest guarding activities, and reduction of anthropogenic disturbance and illegal shooting, must be encouraged in order to avoid territory abandonment.

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Long-term studies focused on population size and breeding parameters are essential to adequately estimate population dynamics and demographic trends of endangered species over long periods (Pandolfi *et al.* 2004, Thiollay 2006, Verdejo & López-López 2008, Clutton-Brock & Sheldon 2010, López-López *et al.* 2012). The Lanner Falcon *Falco biarmicus feldeggii* is a medium-sized raptor, which inhabits Mediterranean dry and warm environments, composed by patches of natural habitats (grassland and sclerophyllous vegetation) and agricultural land (arable and agricultural land) (Di Vittorio *et al.* 2015). In the mid-20th century, the species suffered severe declines in Europe, mainly due to poisoning, shooting and trapping for falconry (Kemp & Marks 2017, BirdLife International 2016). Habitat loss due to urbanization, changes of agricultural practices, agricultural intensification and afforestation have also caused a reduction in hunting areas and prey species in Europe (BirdLife International 2016). As a consequence, the

species is included in Annex I of the 2009/147/EC Bird Directive due to small population size and very limited geographical range (Birdlife International 2004).

In Italy, the Lanner Falcon is still threatened by illegal shooting (Snow & Perrins 1998, Ferguson-Lees & Christie 2001) and by nest robbery (Di Vittorio *et al.* 2015). This species also suffers from other human activities, such as rock-climbing and pesticide use, as well as from collisions with electrical power lines (Gustin *et al.* 2000). Sicily holds the largest European population of the Lanner Falcon (AA.VV. 2008, Sarà 2008, Di Vittorio *et al.* 2015). The species extends its range also into continental Italy (Andreotti *et al.* 2008) and is classified as 'vulnerable' in the Italian Red list of birds (Peronace *et al.* 2012). A wide range of prey species (Massa *et al.* 1991), particularly Rock Doves *Columba livia* and Magpies *Pica pica* are available throughout most of the Sicilian range (Greci & Di Vittorio 2004).

Despite all these threats, the Lanner Falcon remains one of the least known species of European falcons,

especially when it comes to population size and trends. BirdLife International (2016) estimated that the majority of the European population (430–830 breeding pairs) lives in Italy and Turkey, where a moderate decline (20% in 12.8 years, two generations) was detected in the recent past (1990–2000). The latest national survey in Italy estimated between 140 and 172 pairs (Amato *et al.* 2014). However, population size in Sicily, one of the main strongholds for the species in Europe, still remains unknown; estimates range from up to 93 breeding territories regularly occupied during the 2000–09 period (Sarà 2014), to 70–80 pairs reported by Amato *et al.* (2014) and 65 pairs estimated in 2014 by Di Vittorio *et al.* (2015).

The aim of this study is to report current population size and breeding parameters of the Lanner Falcon in Sicily, where the species has experienced a dramatic decline in recent decades according to several studies and confirmed as a result of our intensive field survey (Di Vittorio 2007, AA.VV. 2008, Database Gruppo Tutela Rapaci (GTR)). We also compare breeding parameters with those obtained in previous studies in the same island.

Methods

We created a starting database of Lanner Falcon distribution obtained by compilation of three different sources: (i) personal datasets of different Italian ornithologists (Database of GTR); (ii) from the atlas of terrestrial vertebrates of Sicily (AA.VV. 2008) and (iii) from specific field surveys conducted in breeding territories throughout the Sicilian range (Di Vittorio 2007, Di Vittorio *et al.* 2015).

In 2016, a team of 20 experts was formed, thanks to which a survey of all known territories of Lanner Falcons occupied in the last 15 years was conducted. In order to check site occupancy, to search for alternative sites nearby and to compute breeding performance, all territories were visited at least three times as follows: (1) from late December to early March to check occupation; (2) from mid-March to late April, during the incubation stage to check egg laying and (3) from early May to mid-June, during brooding and chick fledging, to check pairs that raised young. Observations were made using binoculars and terrestrial telescopes at least 500 m from nesting cliffs to avoid disturbance to the falcons. Given the habit of this bird to move between nesting cliffs, in the cases of apparent absence during the first visits, particular attention was taken to secure the real absence of the territorial pairs or to find the new nesting cliff by monitoring all cliffs in a radius of 2 km of the known nest site. Nest productivity

(fledged young/checked pairs), flight rate (fledged young/successful pairs) and breeding success (successful pairs/checked pairs) were computed following the standard methodology for raptors monitoring (Steenhof & Newton 2007, López-López *et al.* 2007).

Mann–Whitney U tests and Monte Carlo randomizations (9999 simulations) were used to compare productivity recorded in this study with the same parameters reported in a previous study carried out in 2004 (Di Vittorio 2007 and unpubl. data) ($N = 67$ pairs). Analyses were computed in Past 3.0 software (Hammer *et al.* 2001). All tests were two-tailed and statistical significance was set at $P = 0.05$.

Results and discussion

Overall, 126 territories were monitored, located throughout Sicily (Di Vittorio 2007 and GTR database). At least one individual Lanner Falcon was present in 60 territories, whereas the remaining 66 were unoccupied. Most of the field surveyors participating in this study did also survey the study area for previous studies (AA.VV. 2008 and personal databases of the authors), and therefore differences in population size cannot be attributed to different sampling effort. We were unable to estimate reproductive performance in five territories and another eight territories were occupied by only a single individual throughout the breeding season. As a consequence, these 13 territories were excluded from the analyses.

In summary, we recorded 51 young fledged from 47 breeding attempts. Mean productivity (\pm standard deviation) was 1.09 ± 1.18 fledged young/checked pairs, flight rate was 2.22 ± 0.52 fledged young/successful pairs and breeding success was 49.0%. We observed the disappearance (probably due to mortality) of one of the members of the breeding pair during the breeding season in five nesting attempts.

Productivity was lower than compared with that recorded in other studies in Sicily (Table 1), whereas flight rate was similar to that reported by Salvo (1984), Massa (1985), Iapichino & Massa (1989), Massa *et al.* (1991) and Di Vittorio (2007). Our analyses showed a significant reduction in breeding parameters between 2004 (Di Vittorio 2007 and unpubl. data) and 2016 (this study) (Figure 1): productivity ($T = 738$, $z = -3.927$; Monte Carlo $P = 0.0001$), flight rate ($T = 3.18$, $z = -2.680$; Monte Carlo $P = 0.0076$) and breeding success ($T = 9.15$, $z = -3.062$; Monte Carlo $P = 0.0031$). Importantly, the proportion of successful nests reported here (0.49; $N = 47$) is much lower than that

Table 1. Breeding parameters of Lanner Falcon recorded in Sicily according to a range of studies, including this one.

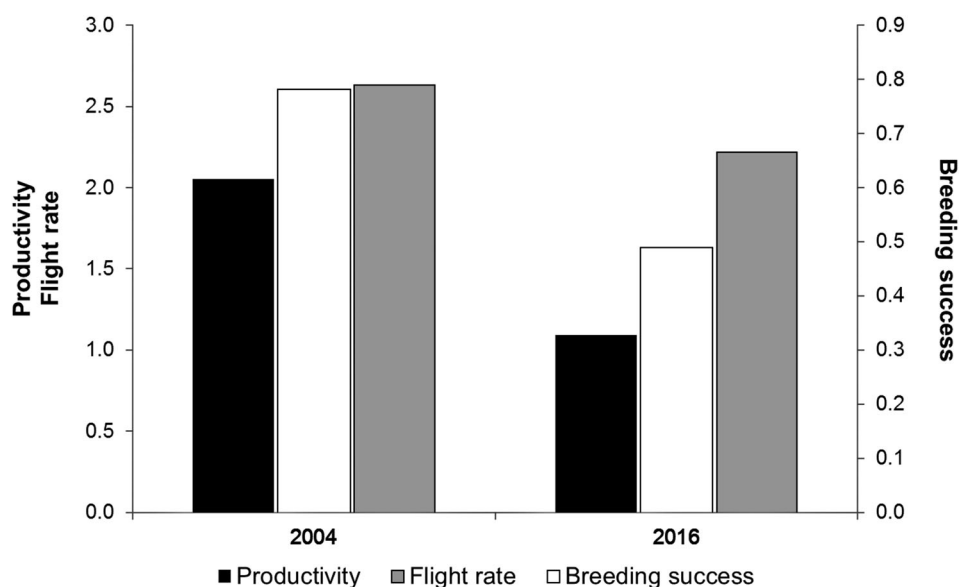
Productivity	Fledged rate	Reproductive success	Number of breeding attempts	Source
2.33			6	Mebs (1959)
	2.40		9	Salvo (1984)
2.3	2.4	0.96	24	Ciaccio <i>et al.</i> (1987)
2.1	2.3	0.94	178	Massa <i>et al.</i> (1991)
1.69	2.31	0.91	70	Salvo (2001)
2.05	2.63	0.79	55	Di Vittorio (2007) and unpubl. data
1.09	2.22	0.49	47	this study

reported by Ciaccio *et al.* (1987) (years 1981–84, 0.96, $N = 24$), Massa *et al.* (1991) (years 1981–88, 0.94, $N = 178$) and Di Vittorio (2007 and unpubl. data) (year 2004, 0.79, $N = 55$). Another warning signal that could account for a negative demographic trend of the species in Sicily is the high number of territories occupied by one individual for the entire breeding season or at least during part of it ($N = 13$). This might suggest high levels of adult mortality and low turnover rate (i.e. low replacement by young individuals) possibly due to a scarcity of floaters in the population.

The current situation of the Lanner Falcon in Sicily, as elsewhere in Italy, is very fragile, since the species is declining dramatically and it is evident in a decline in productivity and in breeding success. Management and conservation of the Lanner Falcon in Italy is complex, as a result of the occurrence of coincidental factors such as habitat reduction, agricultural intensification,

disturbance in breeding areas and nest robbery operated by traffickers and falconers. In fact, a network of illegal trafficking of chicks from nests and egg robbery was discovered in Sicily in 2010. Similar issues have reduced the population size of the Saker Falcon *Falco cherrug* in Central and Eastern Europe (Horák 2000, Levin 2000, Moseikin 2000, Bailey *et al.* 2001, Galushin *et al.* 2001, Karyakin 2001, 2005, 2008, Fox 2002, ERWDA 2003, Levin *et al.* 2010). The robbery of Saker Falcon nests for falconry purposes is considered to be amongst the main reasons for its population decline, in addition to an array of other negative factors, including habitat degradation, increase of anthropogenic pressure on natural sites, a worsening food supply, disturbance, poisoning, electrocution and direct persecution (Iankov & Gradinarov 2012).

To prevent nest robbery, it would be necessary to organize nest guarding activities, especially in the most at-risk sites, which are characterized by easy accessibility to cliffs, a history of past nest robbery and territories with low productivity over long time periods. In fact, nest guarding has been shown to be a potential solution to avoid this problem, yielding positive results in other countries and for other raptor species (Bagyura *et al.* 2004, GTR unpubl. data). In addition, disturbance at nest sites during sensitive parts of the breeding period, either intentional or accidental, due to agricultural or forestry activities, hunting, uncontrolled tourism, cliff climbing, road construction, bird watching and photography (Bagyura *et al.* 2004, Beran *et al.* 2012) could be causing breeding failure and can cause nest site abandonment (Di Vittorio *et al.* 2015, Sarà *et al.* 2016).

**Figure 1.** Comparison of breeding parameters for Lanner Falcons on Sicily between 2004 (Di Vittorio 2007 and unpubl.) and 2016 (this study).

Another important cause of the Lanner Falcon population decrease is habitat change, which is caused by the rapid decline in traditional husbandry and agriculture in hilly and rugged areas. As a consequence, it is causing extensive habitat degradation, especially of the characteristic cereal-steppe habitat selected by this falcon within its Mediterranean range (Bassi *et al.* 1992, Leonardi 1994, Morimando *et al.* 1997, Sarà 2014, Di Vittorio *et al.* 2015). Maintenance of cereal steppes habitats, promoting conversion to grassland, rotation of culture and other traditional practices, while reducing anthropogenic disturbance and infrastructure building (Sarà 2014), could be alternative management strategies to halt habitat degradation for Lanner Falcons. Translated into conservation actions, this would suggest selecting management strategies that favour a decrease in abandonment of occupied territories (Sarà *et al.* 2016), increasing breeding success and encouraging colonization of empty sites.

In conclusion, measures aimed at preventing abandonment of occupied territories should be applied, for example by developing a network of priority areas to slow down the degradation of the pseudo-steppe habitats by agri-environmental schemes (Sarà 2014). Furthermore, management strategies should be adopted to encourage occupation and territory fidelity so as to increase breeding success (Sergio & Newton 2003) and recruitment by means of specific actions (Jiménez-Franco *et al.* 2011), such as (i) preventing the illegal nest robbery and human disturbance near nesting sites in the breeding season; (ii) reducing potential high mortality of adults and juveniles (mainly by shooting); and eventually (iii) development of a captive breeding programme for the release of young to facilitate the recruitment and occupation of deserted sites in suitable areas.

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