

Unveiling the taxonomy, systematics, and distribution of the Sooty Falcon (*Falco concolor*): a history of discoveries and misidentifications

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Abstract This paper reviews the history of Sooty Falcon's (*Falco concolor*) research, tracing its classification from specimens collected during 19th century European expeditions, to its current International Single Species Action Plan (2025). Eight preserved specimens serve as the syntypes for *F. concolor*, with those collected from Barqān Island in northwestern Saudi Arabia forming the basis for the species' original description. The classification of Sooty Falcon faced significant challenges due to early confusion with Eleonora's Falcon (*F. eleonorae*) and Grey Kestrel (*F. ardosiaceus*), leading to numerous misidentifications and an excessive number of proposed taxa. Over time, extensive specimen analysis, particularly from Madagascar, clarified its distinct identity, resulting in the rejection of incorrect classifications. Initially grouped with various small falcons, Sooty Falcon was assigned to different sub-genera. However, recent genetic studies confirm its closer relation to the Eurasian and African hobbies. In the 19th century, misidentifications led to incorrect assumptions about the Sooty Falcon's range. Later research confirmed its core breeding areas, particularly in the Red Sea's coral islands. In recent years, knowledge of inland desert populations has improved significantly, but there are still gaps in information for some putative countries.

Keywords: classification, syntypes, identification, exploration, species range

Összefoglalás A tanulmány a hamvas sólyom (*Falco concolor*) kutatástörténetét tekinti át, a 19. századi európai expedíciók során gyűjtött példányoktól kezdve egészen a faj jelenlegi, 2025-ben elfogadott nemzetközi fajmegőrzési akciótervéig. A faj nyolc megőrzött példánya szolgál szüntípus példányként a hamvas sólyom számára, amelyek közül a Szaúd-Arábia északnyugati részén található Barqān-szigeten gyűjtöttek képezték az eredeti leírás alapját. A *F. concolor* rendszertani besorolása számos nehézségbe ütközött a kezdeti időkben, mivel gyakran összetévesztették az Eleonóra-sólyom (*F. eleonorae*) és a szürke vércse (*F. ardosiaceus*) fajokkal. Ez több téves azonosításhoz és szükségtelenül nagyszámú leírt taxonhoz vezetett. Az idők során a sok, különösen nagy arányban Madagaszkárról származó, példány részletes vizsgálata tisztázta a faj önálló voltát, és így a téves rendszertani besorolásokat elvetették. Kezdetben a hamvas sólymot különféle kisebb termetű sólymokkal együtt, több alnembe is sorolták, ám a legújabb genetikai vizsgálatok megerősítették, hogy a faj az eurázsiai és afrikai kabasólymokkal áll közelebbi rokonságban. A 19. században a hibás határozások téves következtetésekhez vezettek a hamvas sólyom elterjedési területét illetően, de a későbbi kutatások feltárták fő költőterületeit, különösen a Vörös-tenger korallszigetein. Az utóbbi években jelentősen bővültek ismereteink a szárazföldi, sivatagi populációkról is, ugyanakkor egyes feltételezett országokból még mindig hiányosak az adatok.

Kulcsszavak: rendszertani besorolás, szintípus, meghatározás, felfedezés, elterjedési terület

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Introduction

The Sooty Falcon (*Falco concolor*) is a medium-sized bird that belongs to the genus *Falco* within the Falconidae family and the Falconiformes order (Ferguson-Lees & Christie 2001). It primarily breeds in arid desert ecosystems across north-eastern Africa and the Arabian Peninsula, including insular habitats within the Red Sea (Leonardi *et al.* 2024). In these xeric environments, the breeding season occurs during the summer, peaking in August (Moreau 1969). During this period, the falcon exhibits specialized predation strategies, targeting small migratory passerines (Jennings 2010). This species is distinguished by its extensive trans-Saharan migratory behaviour, covering significant distances annually (Gschweng 2014, Mellone 2021). In the boreal winter, Sooty Falcons undertake seasonal migrations to south-eastern Africa and the Malagasy biogeographic region. The majority of the population overwinters in Madagascar, while smaller contingents are documented along the littoral zones of Mozambique and South Africa (Gschweng 2014, Mellone 2021).

The Sooty Falcon is one of the most recently identified Palearctic species in the genus *Falco* (Leonardi 2025). Unlike other species, which are recorded under various names in historical sources, *F. concolor* is not securely mentioned until the mid-19th century (Leonardi 2025). Additionally, no fossil or sub-fossil evidence of the species has been found (Tyrberg 2008). Apart from the persistent lack of fossils in sub-Saharan Africa, species assemblages in archaeological sites in north-eastern Africa and the Levant, which contain both small and large falcons, do not include the Sooty Falcon (Tyrberg 2008). Since its discovery as a species, the Sooty Falcon has been classified under the taxon *F. horus* and linked to the ancient Egyptian deity Horus (Heuglin 1869, Hartert 1912–1922). Nevertheless, this species is absent from the significant raptor assemblages found in the subterranean animal necropolises of classical antiquity in Egypt (Bailleul-LeSuer 2019). All this evidence probably indicates that the Sooty Falcon persisted, as it does today, in small to medium-sized, isolated populations, making confirmation through fossil evidence challenging (Rull 2009). However, among Egyptian artifacts, three ancient, preserved scenes depict dark small falcons known as *tnhr*, which breed in colonies and on the ground in the eastern parts of the Nile Delta (Krauss 1991).

Since the early 19th century, many expeditions from European countries have travelled to Abyssinia, now Ethiopia and Eritrea (Margariti 2022). Funded by museums and natural history institutions, these expeditions used the Nile and the Red Sea as main routes (Steinheimer 2005, Friis 2013, Margariti 2022). This paper examines the history of discovering and identifying the species based on specimens collected during these trips. It also reviews past knowledge of the species' distribution through an extensive bibliographic review, compiled during the preparation of the International Single Species Action Plan for the Sooty Falcon (Leonardi *et al.* 2024).

Falco concolor syntypes

Eight preserved specimens serve as the syntypes defining the species *Falco concolor*. These specimens originate from three major natural history expeditions conducted in the early



Figure 1. Male (A) and female (B) Sooty Falcon specimens collected by E. Rüppell on Barqān Island (Saudi Arabia, source: SysTax 2024). Illustration from Hemprich & Ehrenberg (1829), likely based on specimens collected during their journey along the Red Sea coast (source: <https://www.biodiversitylibrary.org/bibliography/107403>)

1. ábra Hím (A) és tojó (B) hamvas sólyom példányok, amelyeket E. Rüppell gyűjtött a Barqān-szigeten (Szaúd-Arábia, forrás: SysTax 2024). Az illusztráció Hemprich és Ehrenberg (1829) művéből származik, és feltehetően a Vörös-tenger partvidékén tett utazásuk során gyűjtött példányok alapján készült

19th century across North-eastern and Eastern Africa. An expedition, led by Eduard Rüppell (1794–1884) between 1823 and 1825, explored the Sinai Peninsula, Nubia, Kordofan, and Arabia Petraea (Friis 2013). Rüppell visited several locations along the Red Sea coast, reaching Massawa (Eritrea) late in 1826 (Steinheimer 2005, Friis 2013). During this journey, two key specimens – a male and a female – were collected on Barqān Island (Jazīrat Barqān (الكراب قريزج), northwestern Saudi Arabia. These two specimens are currently housed at the Naturalis Biodiversity Centre in Leiden (Kamminga & Creuwels 2024) (Figure 1A, B). They were later utilized by Coenraad J. Temminck (1778–1858), the then-director of the Leiden Museum, to provide the original description of *Falco concolor* (Temminck & Laugier 1820–1839). Rüppell's subsequent expedition, conducted between 1830 and 1834 funded by the Senckenberg Nature Research Society, likely included excursions to the Dahlak Archipelago (Eritrea), where the Sooty Falcons breed (Clapham 1964, Friis 2013).

During his second journey, he collected two additional specimens, which are now housed at the Senckenberg Museum in Frankfurt (SysTax 2024). Another expedition, carried out during the same period as Rüppell's first, was conducted by two Prussian researchers,

Wilhelm Hemprich (1796–1825) and Christian Ehrenberg (1795–1876). Supported by the Museum für Naturkunde in Berlin, the expedition initially focused on Egypt and Nubia but later extended to the Sinai Peninsula and the shores of Eritrea (Margariti 2022). During this journey, Hemprich and Ehrenberg collected four additional syntypes, including two labelled as coming from Sudan and Ethiopia, all of which are now housed at the Museum für Naturkunde in Berlin (Freiherr von Erlanger 1904, SysTax 2024). Theobald J. Krüper (1829–1921) later reported examining these four specimens multiple times, noting that they also originated from Barqān Island (Krüper 1864). Additionally, Hemprich and Ehrenberg produced an illustration of these specimens for their 1829 publication, which identified the same Red Sea Island as the source (Hemprich & Ehrenberg 1829) (*Figure 1C*).

Taxonomy

The use of syntypes to establish a stable taxonomy and nomenclature for this falcon species has been a complex and non-linear process. C. J. Temminck's initial description of the species resulted in persistent confusion between *F. concolor* and two other species: *F. eleonora* and *F. ardosiaceus* (Kaup 1847). Indeed, the illustration accompanying the text (Pl. Col. 330), based on a specimen from the Jardin des Plantes in Paris, depicts *F. ardosiaceus*, which does not correspond to Temminck's detailed description, which was instead based on syntypes from the Leiden Museum (Temminck & Laugier 1820–1839, Kaup 1847). Due to this erroneous interpretation, the species' presumed range was thought to encompass parts of Mediterranean Europe, North Africa, and Senegal (Temminck & Laugier 1820–1839, Kaup 1847, Swainson 1862). In the subsequent decades, the initial misidentification led to a proliferation of errors in observations, including the proposal of several presumed new species and subspecies, many of which were erroneously attributed to *F. eleonora* (Krüper 1862, 1864). The confusion with *F. ardosiaceus* was relatively short-lived, largely due to its distinctively shorter wings compared to *F. concolor* (Kaup 1847, Krüper 1862, 1864). However, errors involving *F. eleonora* became increasingly frequent following della Marmora's discovery of a dark morph that closely resembled *F. concolor* (Warthausen 1860, Verreaux & des Murs 1862, Krüper 1864). While examining specimens collected in northwestern Saudi Arabia in Frankfurt, C. Ehrenberg classified them as a subspecies of *F. eleonora*, naming them *F. e. schistaceus* (Hemprich & Ehrenberg 1829) (*Figure 1C*). The repeated misclassification of the three species, combined with the two morphs of Eleonora's Falcon, resulted in an overabundance of taxa. These included *F. eleonora* in Sardinia, *F. concolor* in Senegambia and Abyssinia, and other species such as *F. arcadicus* in Greece, *F. tibialis*, *F. dichrous*, *F. clypeatus* and *F. cyanostolos* (Heuglin 1851, Freiherr von Erlanger 1904). The acquisition of numerous new specimens from wintering areas, especially in Madagascar, has substantially improved the accuracy of key identification character assessments and comparative analyses (Pollen & van Dam 1868, Sibree 1891). This revision led to the abandonment of all other presumed species and subspecies (Graf Zedlitz & Schalow 1914, Hartert 1912–1922). Ultimately, *F. concolor* was recognized as a non-European species but as native to the Red Sea and the East African coast (Kaup

1847, Krüper 1862, 1864). Errors related to plumage patterns have been fully overcome, but confusion persists when identifying darker individuals that could be mistaken for the dark morph of the Eleonora's Falcon (Frumkin & Clark 1988). Despite this, significant differences exist between the two species in terms of wing and tail measurements, as well as their tail/wing ratios with the Sooty Falcon being the smaller of the two (Stresemann 1955, Ferguson-Lees & Christie 2001).

Systematics

F. concolor has been repeatedly included with various species of small falcons. Over time, it has been placed in different genera and subgenera, including *Aesalon* (merlins), *Tinnunculus* (kestrels), and *Hypotriorchis* (hobbies) (Kaup 1847, Bonaparte 1850, Freiherr von Erlanger 1904, Hartert 1912–1922). More recently, the Sooty Falcon and the Eleonora's Falcon were considered to form a superspecies (Ferguson-Lees & Christie 2001). However, recent genetic studies on the genus *Falco* have shown that the Sooty Falcon is more closely related to the Eurasian (*F. subbuteo*) and African (*F. cuvieri*) hobbies (Fuchs *et al.* 2015).

Distribution

In the 19th century, the first proposed distributions of this species were influenced by misidentifications with other similar falcons (Heuglin 1851). As a result, regions such as Greece, Dalmatia, and the coasts of Morocco and Algeria – typical habitats of Eleonora's Falcon – and Senegambia, where the Grey Kestrel resides, were mistakenly believed to fall within its range (Temminck & Laugier 1820–1839, Lesson 1831, Temminck 1840, Heuglin 1851, Tristram 1859). As more observations were collected during expeditions, the Sooty Falcon was ultimately excluded from both the European and West African avifauna (Schlegel 1844). Nevertheless, the presumed distribution range of the species did not distinguish between nesting and wintering areas until the end of the 19th century. The species' southern range was considered to be limited to the 16°N, aligning with the Dahlak Archipelago in Eritrea (*Figure 2*) (Heuglin 1859). This boundary was later extended beyond 27°N (Barqān Island), while the southern limit was set at the latitude of the Somali coast and further expanded to reach Madagascar (*Figure 2*) (Heuglin 1869). Overall, observations of this falcon were predominantly tied to the coast, with few recorded in the desert areas of the interior (*Figure 2*). It was known to occur in several inland regions, including southern Egypt, in the Mokattam Mountains south of Cairo, northern Sudan, along the Blue Nile in Sudan and Ethiopia, as well as in the islands of the Red Sea (Finsch & Hartlaub 1870, Shelley 1871). Its presence was also confirmed in the Dahlak Archipelago (Eritrea), the Hanish Archipelago (Yemen), Amphila Bay (Eritrea), Mozambique, and Madagascar (Pollen & van Dam 1868, Finsch & Hartlaub 1870). Moreover, it is also reported for the first time in Oman through museum collections (Sharpe 1886).

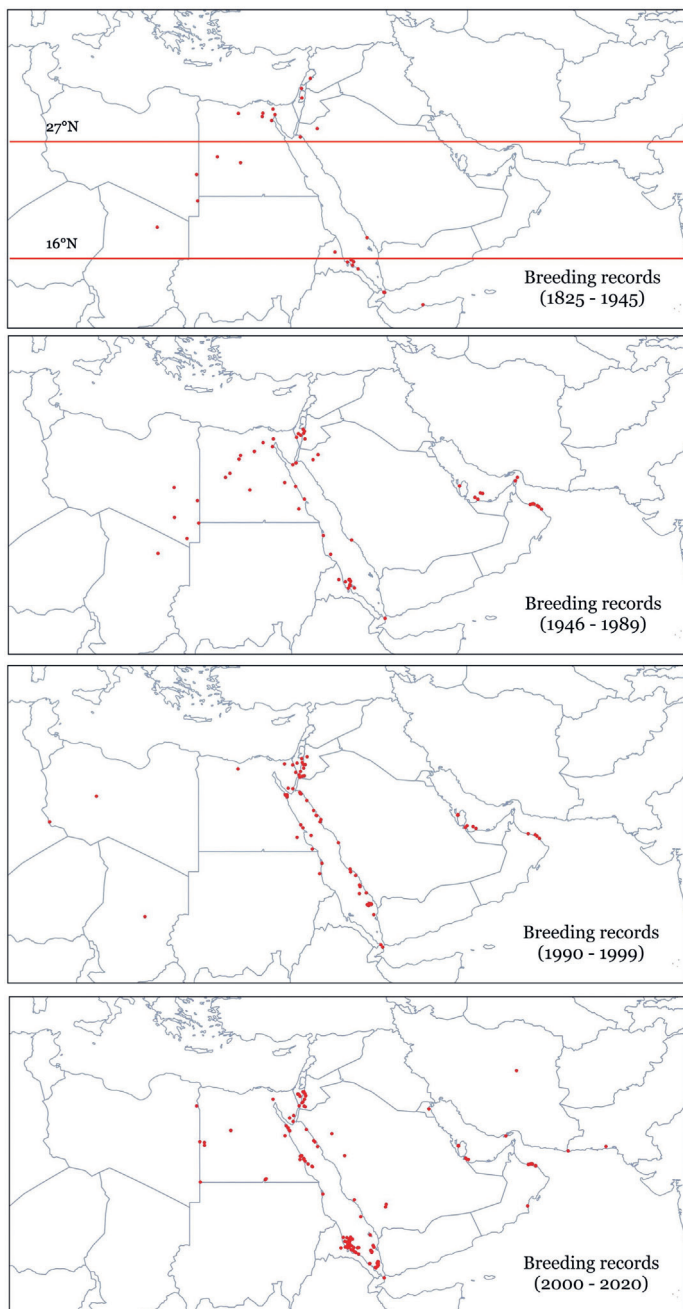


Figure 2. Confirmed breeding records of Sooty Falcons from 1825 to 2020. The data were gathered through bibliographic research and questionnaires developed during the preparation of the ISSAP for the Sooty Falcon (Leonardi *et al.* 2024)

2. ábra A hamvas sólyom bizonyított költési adatai 1825 és 2020 között. Az adatok irodalmi források feldolgozásával és a hamvas sólyom nemzetközi fajmegőrzési akciótervének (ISSAP) előkészítése során kidolgozott kérdőívek segítségével kerültek összegyűjtésre (Leonardi *et al.* 2024)

At the beginning of the 20th century, it became clear that the observations in Madagascar were related to migratory movements and wintering (Hartert 1912–1922). Observations of breeding populations once extended to inland desert areas to the west, as well as the Gulf of Oman and Persian Gulf to the east, but data collection has significantly declined over time (*Figure 2*). Comprehensive reviews conducted in the mid- and late 1970s, which included the first published distribution maps, identified fewer than 30 known breeding sites (Wunderlich 1977, Walter 1979). In Israel, the Sooty Falcon was regarded as a very rare species, with only a handful of nesting pairs (H. Mendelssohn in Wunderlich 1977). Conversely, the discovery of hundreds of nesting pairs in island groups like the Dahlak Archipelago in Eritrea has established the coral islands of the Red Sea as the core breeding area for the Sooty Falcon (Clapham 1964, Wunderlich 1977). Moreau (1969) suggested searching for Sooty Falcons along the eastern coast of the Red Sea, the Persian Gulf, and the coasts of Oman and Makran (Yemen), noting that potential habitats might also extend to the southern coast and the interior of the Arabian Peninsula. In the following decades, extensive exploration focused on island groups and coastal areas (*Figure 2*), but also extended to desert regions. Breeding populations of Sooty Falcons were discovered in the Daymaniyat and Fahal Islands (Oman), Zabarjad and Wadi el Gemal Islands (Egypt), the western coast of Saudi Arabia, but also in desert areas of Israel (Walter 1979, Frumkin & Pinshow 1983, Baha El Din 1984, Frazier & Salas 1984, Gaucher *et al.* 1995). Walter (1979) hypothesized that only a few additional breeding locations could be found on islands in the southwestern Arabian Gulf, such as Bahrain and the United Arab Emirates. Indeed, at their peak recorded numbers, Bahrain and the UAE hosted 15 and 25 breeding pairs, respectively (Nightingale & Overy 1987, Shah *et al.* 2008). In recent years, there has been a significant improvement in the understanding of the populations breeding in the inland desert areas of Saudi Arabia (Foster *et al.* 2026, Martins *et al.* 2026) Libya (Buirzayqah *et al.* 2026) and Egypt (Habib *et al.* 2026). However, data gaps and a lack of updates persist for countries like Yemen, Djibouti, and Iran (Leonardi *et al.* 2024). Additionally, while nesting populations are known in Sudan (e.g. the Suakin Islands) and Pakistan, there is no information available on their population sizes (Moore & Balzarotti 1983, M S. H. Khan in Leonardi *et al.* 2024).

Conclusions

Research on the Sooty Falcon has been heavily influenced by the environmental conditions in which the species lives, leading to a significant bias (*Figure 2*). Consequently, the most reliable information comes from coastal areas and islands, which are easier to explore. In contrast, desert regions present greater challenges, as nesting pairs are widely dispersed across vast and less accessible areas. Prioritizing the proposal and support of local surveys is crucial, but a global perspective on the distribution and population trends of nesting pairs remains essential (Leonardi *et al.* 2024). In this context, as part of the ISSAP preparation for the species, comprehensive studies have been supported, focusing on both its potential distribution (Leonardi *et al.* 2026a) and the current status of its nesting populations (Leonardi *et al.* 2026b).

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