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Endemism in terrestrial bird species of continental North Africa

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Abstract. This study reveals the existence of 17 endemic and 6 near-endemic species in the Palearctic Continental North Africa. They represent about 12 % of the 192 terrestrial breeding species considered here. Most of these species (18 out of them) reached the status of separate species after a long period of isolation, North Africa having played the role of refugia during the Quaternary glaciations which have occurred in Europe. The exact status of a few further species is still pending.

Key Words: endemism in birds, Northwest Africa.

Résumé. Cette étude révèle l'existence de 17 espèces endémiques et de 6 espèces 'presque' endémiques dans l'Afrique du Nord continentale paléarctique. Cela représente environ 12 % des 192 espèces terrestres nicheuses considérées ici. La plupart de ces espèces (18 d'entre elles) ont atteint le statut d'espèce distincte après une longue période d'isolation, l'Afrique du Nord ayant joué un rôle de refuge pendant les glaciations quaternaires. Le statut de quelques autres espèces attend encore à être precisé.

INTRODUCTION

After a detailed study of the taxonomic differentiation in the terrestrial breeding birds of North Africa (Isenmann and Thévenot 2018), we revisit in the following the known endemic species of this geographic area. We also add a few species whose endemic status should be clarified. The Atlantic islands off the coast of North Africa (Madeira, Canary and Cape Verde) have been excluded from this study, they had a somewhat different ecological history (Fernandez-Palacios and Whittaker 2008; Fernandez-Palacios *et al.* 2011; Illera *et al.* 2012; Illera *et al.* 2016; Illera *et al.* 2020).

First, we must remember that North Africa (encompassing the four following countries: Morocco, Algeria, Tunisia and Libya as well as their Saharan extensions) is at the southwestern corner of the vast Palearctic zone (Lebreton and Ledant 1980; Blondel 1982; Covas and Blondel 1998; Blondel and Mourer-Chauviré 1998; Roselaar 2006; Newton 2003). The whole of this area can be considered as a large continental island surrounded by the Atlantic Ocean in the west, the Mediterranean Sea in the north and the Saharan desert in the east and in the south. Moreover, the Quaternary glaciations active until South Europe did never reach North Africa. Thus it is assumed that both absence of glaciations and subsequently isolation in a kind of refugia and fragmentation within this refugia have largely influenced the taxonomic status of the species breeding in North Africa, some of these species having more or less maintained or lost their links with their northern Palearctic relatives. We recall that in North Africa, the Palearctic influence extends from the Mediterranean (or the northernmost) part of North Africa southwards to the central part of the Sahara. In the Sahara, repeated events of increasing aridity and more humid periods in the past have led to population fragmentation across the Palearctic Saharo-Arabian desert belt dividing many species in an eastern and a western group, some of them having reached species level (Schweizer 2020). However, the species with links to the Afrotropics are much less numerous and do not show any significant endemism process (Isenmann *et al.* 2010; Isenmann and Thévenot 2018). Indeed, during the Quaternary, the Sahara did not always constitute an

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insurmountable barrier. Its latitudinal extension was subject to considerable changes induced by major climatic variations but even in hyper arid time-period, the Atlantic coastal strip allowed exchanges between the populations of North Africa and those of tropical Africa Furthermore, the Mediterranean is considered as an area of speciation as shown by Husemann *et al.* (2014) in an overview dealing with several zoological groups (mammals, reptiles, butterflies, and dragonflies) and by Thompson (2020) in plants. In birds, a spectacular radiation process is shown by some groups (*Sylvia*-warblers, *Oenanthe*-wheatears, larks). The latter species found there a rich variety of open or poorly wooded habitats or arid areas allowing them to radiate (see Blondel 1982; Blondel *et al.* 1996; Covas and Blondel 1998).

DATA SOURCES

Our basic source of inspiration remained the comprehensive but now ancient overview published by Heim de Balsac and Mayaud (1962) on the birds of North Africa. We have published as senior authors or co-authors books on birds of these countries (Morocco: Thévenot *et al.* 2003; Bergier *et al.* 2017; Bergier *et al.* in prep.; Algeria: Isenmann and Moali 2000; Tunisia: Isenmann *et al.* 2005 and Libya: Isenmann *et al.* 2016). A further book dealed with an important neighboring and mostly Saharan country: Mauritania (Isenmann *et al.* 2010).

We used the rich documentation available in the two European handbooks (Handbuch der Vögel Mitteleuropas, 14 volumes published between 1966 and 1997 and Birds of the Western Palearctic, 9 volumes published between 1977 and 1994) and the 17 volumes of the Handbook of the Birds of the World published between 1992 and 2013. Several other books and internet databases were checked: The Howard & Moore Complete Checklist of the Birds of the World (Dickinson *et al.* 2003, 2013, 2014), The Clements Checklist of the Birds of the World (Clements 2000, 2007; Clements *et al.* 2017, 2019), The IOC World Bird List (Gill and Donsker 2018, Gill *et al.* 2020), the Handbook of the Birds of the World and BirdLife International Illustrated Checklist of the Birds of the World (Del Hoyo and Collar 2014, 2016), the HBW alive (Del Hoyo *et al.* 2019) and the "Birds of the World" (Billermann *et al.* 2020). Finally, two recent books deal one with the systematic of western Palearctic passerines (Shirihai & Svensson 2018) and the other with bird sounds in Morocco and elsewhere in North Africa (Van den Berg and The Sound Approach 2020).

We are aware that some of our taxonomic choices remain our responsibility in so far that taxonomical appreciations change over time, thus reflecting the level of knowledge.

RESULTS

We distinguish the endemic species restricted to Continental North Africa from the near-endemic species which breeding ranges extend to extralimital areas. Moreover, we add a set of species whose relationship to endemism is pending.

Endemic species (Table 1)

Table 1. Endemic and near endemic species in North Africa

Endemic species

- Barbary Partridge *Alectoris barbara*
- Maghreb Owl *Strix mauritanica*
- Levaillant's Woodpecker *Picus vaillantii*
- Atlas Horned Lark *Eremophila atlas*
- Long-billed Lark *Galerida macrorhyncha*
- Maghrebian Wren *Nannus kabylorum*
- Cyrenaican Wren *Nannus juniperi*
- Moussier's Redstart *Phoenicurus moussieri*
- Seebohm's Wheatear *Oenanthe seebohmi*
- Maghreb Wheatear *Oenanthe halophila*
- Saharan Scrub Warbler *Scotocerca saharae*
- African Desert Warbler *Sylvia deserti*
- Tristram's Warbler *Sylvia deserticola*
- Algerian Nuthatch *Sitta ledanti*
- Atlas Pied Flycatcher *Ficedula speculigera*
- Maghreb Magpie *Pica mauritanica*
- Atlas Crimson-winged Finch *Rhodopechys alienus*

Near-endemic species

- African Houbara Bustard *Chlamydotis undulata*
- Pharaoh Eagle *Owl Bubo ascalaphus*
- Western Olivaceous Warbler *Iduna opaca*
- African Blue Tit *Cyanistes teneriffae*
- Desert Sparrow *Passer simplex*
- House Bunting *Emberiza sahari*

Barbary Partridge *Alectoris barbara*

The species breeds in North Africa and reaches to the south the Moroccan Atlantic Sahara (Bergier *et al.* 2017) and the Zemmour in northern Mauritania (Isenmann *et al.* 2010) as well as the Tassili and probably the Ahaggar Mountains in the central Sahara in Algeria (Isenmann and Moali 2000). The Barbary Partridge also breeds in Sardinia and Gibraltar (southernmost Iberian Peninsula) where on both sites it is likely to have been introduced. This species is very distinct from other species of the genus *Alectoris* living in Europe (Randi 1996). It is close to the Arabian Partridge *Alectoris melanocephala* occurring in Arabia (Randi 1996;

Randi & Lucchini 1998). Billerman *et al.* 2020 mention 4 subspecies: *A. b. koenigi* in Northwest Morocco and the Canary Islands (in the latter probably after introduction), *A. b. barbara* in Northeast Morocco, North Algeria, North Tunisia, Sardinia (possibly introduced), *A. b. spatzi* in South Morocco, Northern Mauritania, South Algeria, South Tunisia and a large part of Libya and *A. b. barbata* in Northeast Libya (Cyrenaica). The latter subspecies has even been considered as a separate species *Alectoris barbata* (Spano *et al.* 2013). If this statement is correct, the latter should be a supplementary true endemic species in North Africa.

Maghreb Owl *Strix mauritanica*

The birds breeding in the woodlands and urbanized areas of the Maghreb (large size and monomorphic grey plumage) were long considered as the particular subspecies '*mauritanica'* of the Tawny Owl *Strix aluco* (Heim de Balsac and Mayaud 1962). But a mtDNA study suggests that '*mauritanica*' should constitute a separate species showing a strong genetic differentiation dating from the Pleistocene compared to Tawny Owls occurring in the Iberian Peninsula (Brito 2005; Doña *et al.* 2016). Vocal differences with the Tawny Owl have also been found (Robb and the Sound Approach 2015a).

Levaillant's Woodpecker *Picus vaillantii*

The Levaillant's Woodpecker living in wooded habitats of North Africa is separated from the two other clades of Green Woodpecker, the Iberian Woodpecker *Picus sharpei* (geographically and morphologically very close) and the European Green Woodpecker *Picus viridis* since the Pleistocene (Heim de Balsac and Mayaud 1962; Pons *et al.* 2011; Perktas *et al.* 2011; Perktas *et al.* 2015; Pons *et al.* 2019).

Atlas Horned Lark *Eremophila atlas*

The subspecies '*atlas'* of the Horned Lark *Eremopterix alpestris* (Clements *et al.* 2019; Gill and Donsker 2018; Del Hoyo *et al.* 2019, Billerman *et al.* 2020) has a restricted small breeding range at high altitude (High Atlas and to a lesser extent the Middle Atlas in Morocco) (Heim de Balsac and Mayaud 1962, Thévenot *et al.* 2003). The Atlas Horned Lark is therefore in a very isolated position compared to the very distant arctic '*alpestris'* group to which it is sometimes assumed to belong (the wintering range of the arctic birds reaches southwards more or less regularly northern France). The balkanic population '*penicillata*' is also very distant but genetically related (Ghorbani *et al.* 2019). Finally, we follow Drovetski *et al.* (2014) who found that the Atlas Horned Lark constitutes one of the five very differentiated Palearctic clades deserving each a specific status (for a full morphological description, see Van den Berg 2005 and Van Steenis 2014).

Long-billed Lark *Galerida macrorhyncha*

The case of the '*macrorhynca'* and '*randonii'* subspecies of the Crested Lark is enigmatic. Based on investigations by Guillaumet *et al.* (2005, 2006, 2008a, 2008b) and Alström *et al.* (2013), these taxons have been separated from the Crested Lark *Galerida cristata* and named Long-billed Lark or Maghreb Lark. This split has been recognized by Sangster *et al.* (2016), Clements *et al.* (2017), Gill and Donsker (2018) and Billermann *et al.* (2020), but not by Del Hoyo *et al.* (2019) and Shirihai and Svensson (2018). The Long-billed Lark lives in arid habitats in Morocco and Algeria (Guillaumet *et al.* 2010), '*randonii'* in East Morocco and Northwest Algeria and '*macrorhyncha'* in central Morocco and West Algeria south of the Saharan Atlas with a possible southward extension to the Mauritanian Adrar (Isenmann *et al.* 2010). It must be remembered that another subspecies *G. c. senegallensis* occurring in Senegal has also a rather long bill.

Maghrebian Wren *Nannus kabylorum* and Cyrenaican Wren *Nannus juniperi*

A comprehensive study of the phylogeny of the Eurasian wrens (formerly *Troglodytes,* now *Nannus*) shows that they constitute two separate basal lineages in North Africa, one living in the Maghreb (*kabylorum*) and the other (*juniperi*) in Cyrenaica in Eastern Libya corresponding to two different refugia: the Maghrebian (Atlas Mountains) and the Cyrenaican (Jebel Akhdar) (Albrecht *et al.* 2020). These populations are different from those living in Europe, including the Iberian cryptic phylogenetic lineage of *kabylorum*.

Moussier's Redstart *Phoenicurus moussieri*

Previously attributed to a particular genus (*Diplootocus*), this species is now included in the genus *Phoenicurus* but with nesting behaviour remembering that of the genus *Saxicola*. It is a species with no known relatives existing elsewhere in the Palearctic. The breeding range is restricted to open wooded or shrubland areas in mountains and foothills in Algeria, Tunisia and Morocco. In the later country also in plains down to sea level along the Atlantic coast (Heim de Balsac and Mayaud 1962, Thévenot *et al.* 2003). The presumed nesting in northwestern Libya has not yet been confirmed (Isenmann *et al.* 2016). The species is resident but

most of upland birds are partial migrant wintering at lower altitudes or in more southern areas.

Seebohm's Wheatear *Oenanthe seebohmi*

The former subspecies '*seebohmi*' of the Northern Wheatear *Oenanthe oenanthe* has a breeding range restricted to high mountains in Morocco and Algeria (Mayaud 1951; Heim de Balsac and Mayaud 1962) and a wintering range located in Sahelian Africa (15° N - 18° N, eastwards to 9° W in Mauritania, Senegal and Mali, see Isenmann *et al.* 2010). The black throat and other morphological traits make it different from the other subspecies of Northern Wheatear, but genetic differentiation among these subspecies remains weak. The subspecific status is still valid for Aliabadian *et al.* (2007), Clements *et al.* (2019) and Billerman *et al.* (2020), but Svensson (2010), Del Hoyo and Collar (2016) and Shirihai & Svensson (2018) consider it a separate species. A status confirmed by Tobias *et al.* (2010) based on a comparison of morphological, acoustic and ethological traits but not by Wang *et al.* (2020) who found inconsistencies between phenotypes and haplotypes through an analysis of mitochondrial genomes, probably as a consequence of recent introgressive hybridization between taxa. A study of nuclear DNA is needed.

Maghreb Wheatear *Oenanthe halophila*

Morphometric and phylogenetic studies showed that the Mourning Wheater *Oenanthe lugens* is a superspecies covering several species: Mourning Wheatear *Oenanthe lugens* in eastern Egypt, the Middle East and Iran; Arabian Wheatear *Oenanthe lugentoides* in the southern Arabic Peninsula; Maghreb Wheatear *Oenanthe halophila* in North Africa (and allegedly in northwestern Egypt until the Nile valley) and the recently recognized Basalt Wheatear *Oenanthe warriae* (Jordania and Syrian deserts) (Förschler *et al.* 2010; Shirihai *et al.* 2011; Aliabadian *et al.* 2012; Schweizer and Shirihai 2013; Alaei Kakhki *et al.* 2016; Shirihai and Svensson 2018). The Maghreb Wheatear shows several specific morphological traits and a clear sexual dimorphism. Moreover, investigations on the song indicate that it is different from that of Mourning Wheatear *Oenanthe lugens* (Shirihai *et al.* 2011). However, further studies must clarify the exact taxonomic status (see Gill and Donsker 2018; Billerman *et al.* 2020).

Saharan Scrub Warbler *Scotocerca saharae*

We follow Shirihai and Svensson (2018) who separate the Saharan Scrub Warbler from the Levant Scrub Warbler *Scotocerca inquieta*. This split is justified by a gap in their distribution and clear differences in morphology, vocalisations and nuclear and mitochondrial DNA. The Saharan Scrub Warbler occurs in shrubland of the northern Sahara (Morocco eastwards to Libya, in Morocco also in arid and semi-arid plains and rocky mountains up to 2000 m in eastern High Atlas). Two subspecies have been described: '*theresae*' in West Morocco and '*saharae*' (East Morocco to Libya) (Clements *et al.* 2017; Gill and Donsker 2018; Del Hoyo *et al.* 2019; Shirihai and Svensson 2018) but differences between them are not consistent (Bergier *et al.* 2013).

African Desert Warbler *Sylvia deserti*

Differences in song and plumage as well as allopatric ranges contributed to separate the African Desert Warbler from the Asian Desert Warbler *Sylvia nana* (Shirihai *et al.* 2001; Clements *et al.* 2017; Gill and Donsker 2018; Del Hoyo *et al.* 2019; Shirihai and Svensson 2018; Billermann *et al.* 2020; Schweizer 2020). The breeding range is restricted to the northern and central Sahara (Atlantic Saharan Mococco and northern Mauritania eastwards to westernmost Libya).

Tristram's Warbler *Sylvia deserticola*

This species is close to the Dartford Warbler *Sylvia undata* (Blondel *et al.* 1996) which it replaces in predesertic areas of Morocco, Algeria and Tunisia. Two subspecies have been recognized: *S. d. maroccana* in Morocco and northwesternmost Algeria and *S. d. deserticola* in the rest of Algeria and Tunisia (Shirihai *et al.* 2001, Billerman *et al.* 2020); the differences are nevertheless subtly and inconstantly differentiated (Shirihai and Svensson 2018). A third claimed subspecies has been described as *Sylvia ticehursti* under the basis of a single specimen from South Morocco (see Heim de Balsac and Mayaud 1962) but this species is not valid and was probably an aberrant individual of '*maroccana*' (Shirihai and Svensson 2018).

Algerian Nuthatch *Sitta ledanti*

Discovered in 1975 and 1976 on the Babor Mountain (Petite Kabylie, Northeastern Algeria) (Vielliard 1976, 1978, 1980), the species was recorded in five further oak woodlands (*Quercus canariensis*, *Q. afares* and *Q. suber*) south of Jijel (Petite Kabylie) (Isenmann and Moali 2000; Moulaï *et al.* 2017; Moulaï and Mayache 2018; Haddad and Afoutni 2019). The Algerian Nuthatch is closer to the Krüper's Nuthatch *Sitta krueperi* (Turkey, Georgia) than to the Corsican Nuthatch *Sitta whiteheadi* (Pasquet 1998; Pasquet *et al.* 2014). It is a generalist species living in old

deciduous woodlands, not particularly linked to conifers like *Sitta krueperi* or *Sitta whiteheadi*.

Atlas Pied Flycatcher *Ficedula speculigera*

The North African populations of Pied Flycatcher *Ficedula hypoleuca* have long been considered as forming the subspecies '*speculigera*' (Heim de Balsac and Mayaud 1962). These birds are close to *F. h. iberiae* of the Iberian Peninsula but show significant phenotypic differences and probably also a distinct evolutionary history (van den Berg and The Sound Approach 2006; Copete *et al.* 2010; Corso *et al.* 2015b; Robb and The Sound Approach 2015b; Potti *et al.* 2016; Vigano *et al.* 2019). Saetre *et al.* (2001a) and Saetre *et al.* (2001b) consider *F. speculigera* as a separate species (a status not recognized by all authors but adopted by Clements *et al.* 2017; Gill and Donsker 2018; Shirihai and Svensson 2018; Billermann *et al.* 2020). The Atlas Pied Flycatcher breeds in old mature mountainous oak and cedar woodlands in Morocco, Algeria and Tunisia and winters in Sahelian Africa at sites still to be discovered or defined.

Maghreb Magpie *Pica mauritanica*

The '*mauritanica*' subspecies occurring in North Africa (Morocco, Algeria and Tunisia) has long been considered as conspecific with the Eurasian Magpie *Pica pica*. However, the large cobalt-blue bare spot behind eye (already present in some birds in Iberia) and other differences in morphology and plumage and perhaps in voice (Ebels 2003; Kryukov *et al.* 2017; Song *et al.* 2018) suggest that '*mauritanica*' is a separate species (Shirihai and Svensson 2018; Clements *et al.* 2019, Billermann *et al.* 2020). A recent study on lineage divergence of all taxa of *Pica*, by analysis of two mitochondrial genes and two nuclear introns, indicate the fragmentation of *Pica* magpie in six clades related to climatic cooling and aridification during periods of the Pliocene-Pleistocene (1.4-3.1 million yr ago). The northwest African clade is sister to all others, being the most ancient and the first to be isolated. It definitely deserves the status of a species (Song *et al.* 2018). Since the beginning of the 20th century, the species has dramatically declined in Atlantic Saharan Morocco (Bergier *et al.* 2017) and in Tunisia (Isenmann *et al.* 2005). Contrary to the Eurasian Magpie, the Maghreb Magpie avoids human proximity (except as recently discovered near Agadir/Morocco where it is now breeding in parks and garden). It lives in small groups in habitats consisting of various open woodlands and often thorny shrublands. In Tunisia, the species selects thorny jujube *Ziziphus lotus* scrub (Isenmann *et al.* 2005). In Morocco, occurrence is noted up to 1900-2000 m, sporadically reaching 2400-2500 m a.s.l. (Thévenot *et al.* 2003).

Atlas Crimson-winged Finch *Rhodopechys alienus*

This species formerly considered as the subspecies '*alienus*' of the Crimson-winged Finch *Rhodopechys sanguineus*, has a breeding range restricted to the Middle- and High Atlas Mountains in Morocco and the Aurès Mountain in Algeria (Heim de Balsac and Mayaud 1962; Isenmann and Moali 2000; Thévenot *et al.* 2003). The breeding site in Algeria needs to be updated. According to phenotypical studies and its geographical isolation compared to other populations of the Middle East and Asia, it is now often considered as a separate species (Kirwan *et al.* 2006; Tobias *et al.* 2010; Arnaiz-Villena *et al.* 2014; Gill and Donsker 2018; Del Hoyo *et al.* 2019; Shirihai and Svensson 2018) but not by Billermann *et al.* (2020).

Near-endemic species (see Table 1)

The distribution range of the following species overlap the considered area, either to the west (African Blue Tit in the Canary Islands), or to the east (African Houbara Bustard and Pharaoh Eagle Owl in Egypt and the Middle East), the south (Desert Sparrow and House Bunting in the Sahel) and the north (Western Olivaceous Warbler in the Iberian Peninsula). The latter species forms part of the Ibero-Maghrebian endemics but has the majority of its range in North Africa (being restricted in Europe mainly to South Spain). Three further Ibero-Maghrebian species have been omitted because their breeding ranges extend widely in the Iberian Peninsula (Red-necked Nightjar *Caprimulgus ruficollis,* Dupont's Lark *Chersophilus duponti* and Iberian Chiffchaff *Phylloscopus ibericus,* the latter reaching even southwesternmost France).

African Houbara Bustard *Chlamydotis undulata*

The highly threatened African Houbara Bustard breeding in North Africa has been separated from the Macqueen's Bustard *Chlamydotis macqueenii* breeding in Arabia and Central Asia (the two species are separated by a distribution gap). Although the differentiation seems to be of recent origin (Upper and Middle Pleistocene), there are marked ethological differences (Granjon *et al.* 1994; Gaucher *et al.* 1996; Korrida and Schweizer 2014; Schweizer 2020). In North Africa, two subspecies have been described: *C. u. undulata* on the mainland (from Morocco eastwards to Libya and beyond until the Nile valley) and *C. u. fuertaventurae* on the Canarian

Island of Fuerteventura (Idaghour *et al.* 2004; Alonso *et al.* 2020).

Pharaoh Eagle Owl *Bubo ascalaphus*

Formerly considered as a subspecies of the Eurasian Eagle Owl *Bubo bubo*, the subspecies *ascalaphus* is now a separate species based on differences in morphology and voice (Robb and the Sound Approach 2015a) whereas differences in genetics are not very marked. Heim de Balsac & Mayaud (1962) have already suggested a species status for this subspecies (see Wink *et al.* 2009). Two subspecies have been described: *B. b. ascalaphus* for the Mediterranean North Africa and *B. b. desertorum* for the deserts of North Africa eastwards to Egypt and even Jordania and Irak, but there is an important variability involving pale and dark specimen all over North Africa (Heim de Balsac & Mayaud 1962). It is now considered as monotypic with paler birds towards the south (Holt *et al.* 2020).

Western Olivaceous Warbler *Iduna opaca*

This species has a very restricted range covering the Mediterranean parts of North Africa and South Spain. It has recently been separated from the Olivaceous Warbler species complex *Iduna pallida* (Ottosson *et al.* 2005; Dickinson and Christidis 2014; Shirihai and Svensson 2018). Migratory, winters in West Africa mainly in Sahel zone from Senegambia east to Chad (Billerman *et al.* 2020).

African Blue Tit *Cyanistes teneriffae*

The 'Blue Tits' of North Africa (Canary Islands across continental North Africa eastwards to Cyrenaica in Libya) have first been considered as forming the subspecies '*ultramarinus*' of the Blue Tit (Heim de Balsac and Mayaud 1962). Recent studies showed that the latter encompasses several 'subspecies (or species)' described under *Cyanistes teneriffae*. In fact, '*teneriffae*' recovers the insular populations on the Canary Islands (5 described subspecies) and the populations of continental North Africa (*ultramarinus* and *cyrenaicae*). All these subspecies have been suggested to have reached species rank (Billerman *et al.* 2020). Among the continental populations, the easternmost subspecies *C. t. cyrenaicae* (occurring in Cyrenaica/Libya) is particular (Martin 1991; Salzburger *et al.* 2002; Kvist *et al.* 2005; Dietzen *et al.* 2008; Illera *et al.* 2011; Päckert *et al.* 2013; Stervander *et al.* 2015; Gohli *et al.* 2015; Shirihai and Svensson 2018).

Desert Sparrow *Passer simplex*

The distribution of the species has been reduced to Africa since the split with the Zarudny's Sparrow *Passer zarudny* from Central Asia. *Passer simplex* is polytypic with two subspecies, one '*saharae*' in the north of the Sahara (from southern Morocco east to Libya and south to Mauritania) and the other '*simplex*' in the south of the Sahara (from Mali to Chad, South Egypt and Soudan) (Kirwan *et al.* 2009; Sangster *et al.* 2013; Gill & Donsker 2018; Shirihai & Svensson 2018; Clements *et al.* 2019; Billermann *et al.* 2020; Schweizer 2020; see also Mayaud 1960).

House Bunting *Emberiza sahari*

The House Bunting has been recognized as a separate species from the more oriental Striolated Bunting *Emberiza striolata* (Kirwan & Shirihai 2007; Olsson *et al.* 2013; Schweizer *et al.* 2018; Schweizer 2020). The House Bunting is a Saharo-Sahelian species occurring in the whole North Africa (from Morocco eastwards to Libya); more to the south, the distribution is rather discontinuous (from Mauritania eastwards to northwestern Chad). Recently, the species has considerably extended its breeding range towards the north reaching the Mediterranean coast in Morocco (Azaouaghe *et al.* 2020) and in Algeria (Moulaï 2019).

Taxons whose relationship to endemism is pending (Table 2)

Table 2. 'Taxons' whose relationship to endemism is pending

- Great Spotted Woodpecker *Dendrocopos major* (*mauritanus, numidus*)
- Eurasian Jay *Garrulus glandarius* (*minor, whitakeri, cervicalis*)
- Coal Tit *Periparus ater* (*atlas, ledouci*)
- Short-toed Treecreeper *Certhia brachydactyla* (*mauritanica*)
- White/Pied Wagtail *Motacilla alba* (*subpersonata*)
- Great Grey Shrike *Lanius excubitor* (*elegans, algeriensis*)
- Common Chaffinch *Fringilla coelebs* (*africana, spodiogenys, harterti*)
- Common Crossbill *Loxia curvirostra* (*poliogyna*)

Great Spotted Woodpecker *Dendrocopos major*

Two subspecies of the Great Spotted Woodpecker are recognized in North Africa. *D. m. mauritanus* in Morocco and *D. m. numidus* in Algeria and Tunisia (Heim de Balsac and Mayaud 1962, Del Hoyo and

Collar 2014). When working on a large sample of birds from Eurasia and North Africa, Perktas and Quintero (2013) found the existence of 4 very distinct clades. Within the Eurasian-North African clade, the *mauritanus* subspecies which should be intermediary between *D. m. ibericus* (Iberian Peninsula) and *D. m. numidus* was genetically closer to the former while the '*numidus*' birds of Algeria and Tunisia were genetically and morphologically well differentiated from those of Morocco and South Europe. They might therefore form a distinct species: *D. numidus*.

Eurasian Jay *Garrulus glandarius*

No less than 3 subspecies occur in North Africa: *G. g. minor* (High Atlas in Morocco and Saharan Atlas in Algeria), *G. g. whitakeri* (North Morocco and North West Algeria) and *G. g. cervicalis* (North and East of Algeria and Tunisia) (Heim de Balsac and Mayaud 1962). The three North African subspecies form the '*cervicalis*' group distinct from the '*glandarius*' group in Europe and the '*atricapillus*' group in the Middle East (Clements *et al.* 2017; Del Hoyo *et al.* 2019; Shirihai and Svensson 2018). The '*cervicalis*' group (Black-crowned Jay) may even be considered a separate endemic species but this needs a comprehensive taxonomic revision.

Coal Tit *Periparus ater*

Two subspecies of the Coal Tit occur in North Africa: *P. a. atlas* in Morocco and, further east, *P. a. ledouci* in Algeria and Tunisia (Heim de Balsac and Mayaud 1962; Tietze *et al.* 2011; Pentzold *et al.* 2013; Tritsch *et al.* 2018). The songs of the North African subspecies are different from those of Europe (Pentzold *et al.* 2016), a trait that underlines that the split is ancient. Note that '*ledouci*' is breeding exclusively in soil holes and not in trees as it is usual in Coal Tits.

Short-toed Treecreeper *Certhia brachydactyla*

The subspecies '*mauritanica*' recognized in North Africa (Heim de Balsac and Mayaud 1962) shows a marked genetical and morphological differentiation (song also differs from those of all other Short-toed Treecreepers) (Tietze *et al.* 2006; Tietze *et al.* 2008; Tietze and Martens 2009) which would suggest a separate species (Del Hoyo *et al.* 2019, Billerman *et al.* 2020).

White/Pied Wagtail *Motacilla alba*

The subspecies *M. a. subpersonata* has a restricted area in Morocco where however a recent spatial dynamism has been detected (Heim de Balsac and Mayaud 1962; Thévenot *et al.* 2003; A. Mehadji *Maghreb Ornitho*). This subspecies holds a very isolated and distinctive position within the White/Pied Wagtail subspecies complex (Li *et al.* 2016; Harris *et al.* 2018; Semenov *et al.* 2018; Pirayesh Shirazinejad *et al.* 2019). Has this subspecies already reached species status (Van den Berg and the Sound Approach 2020)?

Great Grey Shrike *Lanius excubitor* ['*elegans*' group]

The *Lanius excubitor* complex encompasses 3 clades. One of them, the North African clade *elegans* (Desert Shrike) groups together *L. e. algeriensis* in the north of North Africa, *L. e. elegans* in the Sahara and *L. e. leucopygos* south of the Sahara and in the sub-Saharan Africa (and *L. e. koenigi* on the Canary Islands). The two other clades are the '*meridionalis*' clade of the Iberian Peninsula and Mediterranean France and the '*excubitor*' clade of Eurasia. This latter clade is curiously genetically close to the '*elegans*' clade (Olsson *et al.* 2010; see also Eck 1990, Gonzalez *et al.* 2008; Klassert *et al.* 2008; Padilla *et al.* 2014; Shirihai & Svensson 2018). After the split between '*excubitor*" and '*meridionalis*', the North African clade '*elegans*' was first considered as conspecific with *'meridionalis'* mainly on the basis of geographical proximity (Clements *et al.* 2017; Gill & Donsker 2018) but subsequently after genetical studies it was included again in the *'excubitor'* clade (Del Hoyo *et al.* 2019; Clements *et al.* 2019). Finally, the status of the Desert Shrike is still pending.

Common Chaffinch *Fringilla coelebs*

The common Chaffinch complex shows complicated geographical variation. It is generally considered to form at least four groups, "coelebs" (European and Asian races), "spodiogenys" (African races), "maderensis" (Azores/Madeiran races), and "canariensis" (Canarian races). The "spodiogenys" group of continental North Africa consists of 3 subspecies: *F. c. africana* (Morocco across Algeria eastwards to Northwest Tunisia), *F. c. spodiogenys* (Northeast Tunisia to Tripolitania/West Libya) and *F. c. harterti* (Cyrenaica/East Libya). There are substantial genetic variations among the three subspecies, '*harterti*' being the most differentiated one. Curiously '*africana*' is genetically more closely related to European '*coelebs*' than to '*spodiogenys*'. But on the other hand, strong differences in call and song exist between '*coelebs*', '*africana*' and '*spodiogenys*', each having its diagnostic flight calls (the vocalizations of the recently described '*harterti*' have not been studied) (Marshall and Baker 1988; Svensson 2015; Corso *et al.* 2015a; Perktas *et al.* 2017; Shirihai and Svensson 2018; Van den Berg and

The Sound Approach 2020). Further study is required to determine if '*harterti'* and '*spodiogenys'* merit separate species status.

Common Crossbill *Loxia curvirostra*

North Africa has its particular subspecies: *L. c. poliogyna* (Shirihai and Svensson 2018). The birds are less coloured, slightly smaller in size but with a stronger bill largely adapted to cones of Aleppo Pine *Pinus halepensis*. Genetic and palaeoecological studies suggest that *P. halepensis* expanded into the western Mediterranean only 10-14 kya, thus divergence of *poliogyna* subspecies likely occurred quite recently. Stable food resources produced by the Aleppo Pine is likely to have reduced dispersal of *poliogyna*'s populations. This tendency to sedentarity associated with geographic isolation contributed to a clear genetic differentiation of '*poliogyna*' which forms a strongly supported monophyletic group (Parchman *et al.* 2018) potentially warranting species designation (Billerman *et al.* 2020).

Furthermore, several other species must be genetically revisited to define more precisely their taxonomic status. Among them, seven species of Afrotropical origin whose breeding ranges extend over the whole North Africa (Black-crowned Tchagra *Tchagra senegalus cucullatus*) or are (or were) restricted to northwestern Morocco, should be also worth to be considered because each of them has or had a particular subspecies there. Four of these Afrotropical species still occur: Double-spurred Francolin *Pternistis bicalcaratus ayesha* (only one population survives), Marsh Owl *Asio capensis tingitanus*, Black-crowned Tchagra and Brown-throated Martin *Riparia paludicola mauritanica*. The three remaining are now vanished: Dark-chanting Goshawk *Melierax metabates theresae*, Helmeted Guineafowl *Numida meleagris sabyi* and Arabian Bustard *Ardeotis arabs lynesi*.

Two further subspecies show a breeding range restricted to Algeria and Tunisia in North Africa, the Eurasian Wryneck *Jynx torquilla mauretanica* and the Lesser Spotted Woodpecker *Dryobates minor ledouci*.

Comments

The 17 endemic and the 6 near-endemic species can be divided into three sets of species. They represent 11.9 % of the 192 terrestrial species considered here (see Isenmann and Thévenot 2018).

*The first set involves a single species, the Moussier's Redstart, which can be considered as a kind of super endemic species with no known relatives in the Palearctic zone.

*A second set involves 4 species with relatives in other parts of the Palearctic:

-Barbary Partridge close to other *Alectoris* partridges,

-Long-billed Lark close to the Crested Lark *Galerida cristata*

-Tristram's Warbler close to the Dartford Warbler *Sylvia undata*,

-Algerian Nuthatch close to two small '*Sitta'* species, *Sitta whiteheadi* in Corsica, and *Sitta krueperi* in Turkey and Georgia.

*A third set involves 18 species which have long been considered as being subspecies of Palearctic species. Modern investigations showed (or confirmed in the case of the Levaillant's Woodpecker) that these latter subspecies have reached the status of separate species after a long time-period of isolation. Among them 11 are vicariants of Mediterranean, European or 'Boreal' species (Levaillant's Woodpecker, Maghreb Owl, Atlas Horned Lark, Maghrebian Wren, Cyrenaican Wren, Seebohm's Wheatear, Western Olivaceous Warbler, Atlas Pied Flycatcher, African Blue Tit, Maghreb Magpie, Atlas Crimson-winged Finch) and the 7 other vicariants of Saharo-Arabic or Saharo-Sindian species (African Houbara Bustard, Pharaoh Eagle Owl, Maghreb Wheatear, Saharan Scrub Warbler, African Desert Warbler, Desert Sparrow and House Bunting).

DISCUSSION

In his study on the biogeography of mammals and birds in North Africa, Heim de Balsac (1936) recognized four endemic bird species in this geographic area (Barbary Partridge, Moussier's Redstart, Tristram's Warbler and Dupont's Lark). In fact, only three of them were really endemic, it was not known at the time that the Dupont's Lark also occurred in the Iberian Peninsula (de Juana & Garcia 2015; Vögeli *et al.* 2017).

To these three species, we found further 20 species eligible to be endemic. One of them was only recently discovered in 1975: the Algerian Nuthatch which lives in a restricted area of mountainous oak woodlands in northern central Algeria. Most of the 19 other 'newly recognized' endemic species have been detected by modern genomic studies showing that they became good species after a long evolutionary time of isolation from their mainly European counterparts.

In fact, in birds, we showed that a high proportion of genomic cuts occurred between the Iberian

Peninsula and the Maghreb with an additional number of a few subspecies common to Spain and the Maghreb where the taxonomic splits occurred more to the north in the Iberian Peninsula (Isenmann and Thévenot 2018). This means that during the Quaternary glaciations, the North African continental area has played a role of refugia for many species (e.g. Blondel 1990; Covas and Blondel 1998; Albrecht *et al.* 2020; for plants, see Thompson 2020). All the endemic traits shown in bird species and subspecies in northern North Africa are finally the results of latitudinal range movements during the glaciation events. In southern North Africa, repeated periods of increasing aridity across the Saharo-Sindian desert belt, making extremely dry areas uninhabitable even for birds adapted to dry conditions, resulted in longitudinal range fragmentations and to east/west taxonomic splits. Moreover, topographic heterogeneity exemplified by a strong orographic complexity and the presence of large rivers in the Maghreb are suspected to have played a supplementary role in shaping the phylogeographic pattern of a few species within this geographic area. In that respect, it must be pointed out the west-east cut shown by species such as the Great Spotted Woodpecker, the Coal Tit and the 'Jays'. Furthermore, there is also a disjunction between some true Maghrebian species and the Cyrenaican Jebel Akhdar as shown by the following species (Barbary Partridge, 'Wrens', African Blue Tit, Common Chaffinch) (e.g. Albrecht *et al.* 2020). This west-east disjunction is also known in other zoological groups such as small Mammals, Amphibians and Reptiles (see Husemann *et al.* 2014; Nicolas *et al.* 2015; Stoetzel *et al.* 2019).

In contrast to what happened with the Palearctic, the relationship with the Afrotropics remained poor or weak in birds and did not favour the emergence of any endemic species (see Snow 1978; Fjeldsaa 2003; Lindner *et al.* 2012; see Blondel 1990 and 2019 for forest birds in particular). Moreover, some of the rather few Afrotropical birds present in the Maghreb are now extinct or near-extinct (Common Ostrich *Struthio camelus*, Double-spurred Francolin, Lappet-faced Vulture *Torgos tracheliotus*, Dark Chanting Goshawk, Helmeted Guineafowl, Arabian Bustard).

If we consider the habitat type in which the 23 endemic or near endemic hitherto known species live, 14 species are rather related to open or shrubby habitats and the remaining 9 to more or less wooded habitats.

Finally, the rather strong relationships shown by birds between Europe and North Africa is exemplified by the emergence in North Africa of a number of particular subspecies that have progressively reached full species rank through geographic isolation or fragmentation. This is assumed to be a direct consequence of quaternary glaciation which markedly isolated the southernmost Palearctic interglacial refugia in North Africa.

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Endemic species in North Africa

Atlas Crimson-winged Finch *Rhodopechys alienus*, Oukaimeden (High Atlas) Morocco. H. Bousadik

Moussier's Redstart *Phoenicurus moussieri*, Massa (Souss) Morocco. H. Bousadik

Long-billed Lark *Galerida macrorhyncha macrorhyncha*, Ouarzazate (Dadès-Draa) Morocco. H. Bousadik

Cyrenaican Wren *Nannus juniperi*, Wadi Al-Kuf (Cyrenaica) Libya. J. Hering

Maghreb Magpie *Pica mauritanica*, Sidi Bou Rhaba (Rharb) Morocco. H. Bousadik

Atlas Horned Lark *Eremophila atlas*, Oukaimeden (High Atlas) Morocco. H. Bousadik

Seebohm's Wheatear male *Oenanthe seebohmi*, Zerouka (Middle Atlas) Morocco. H. Bousadik

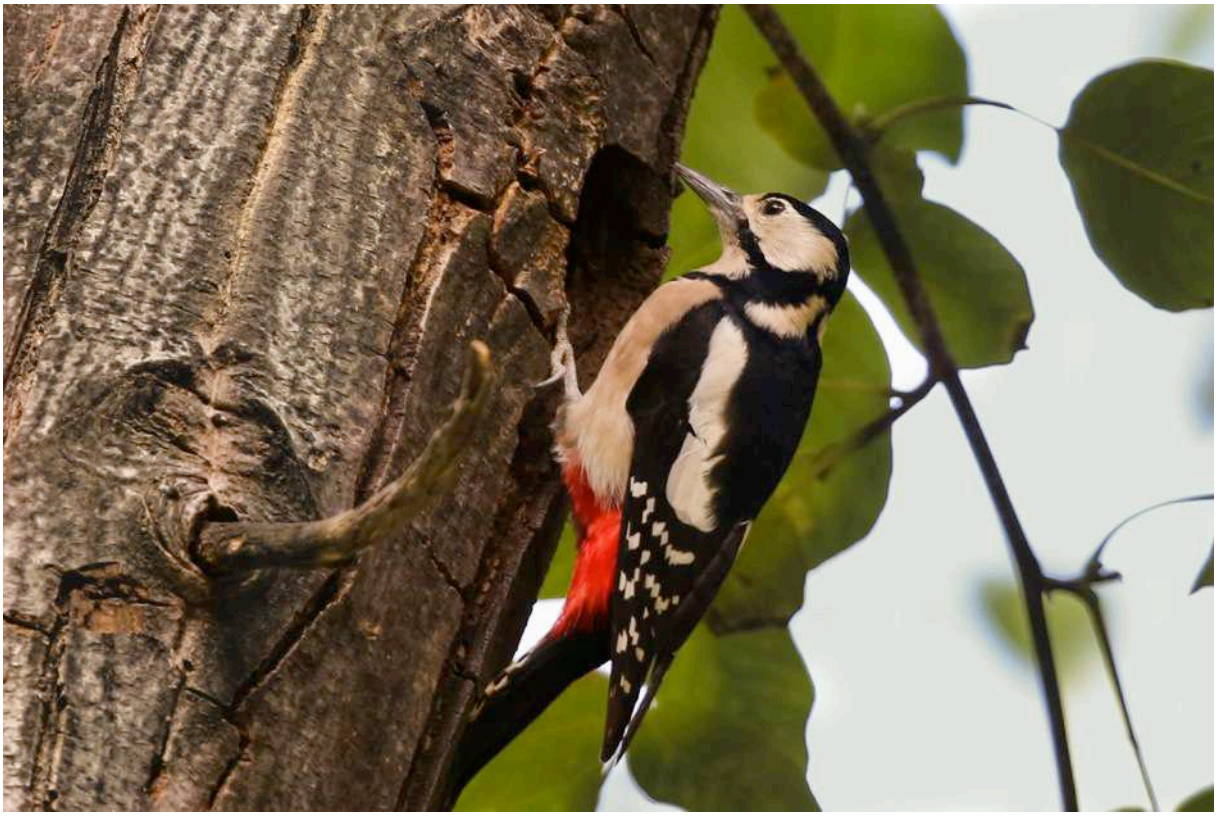
Near endemic species

Desert Sparrow males (above) and female (below) *Passer simplex saharae*, Oued Jenaa (Oued Ad Deheb) Morocco. H. Bousadik

House Bunting *Emberiza sahari*, Marrakech (Haouz) Morocco. H. Bousadik

African Blue Tit *Cyanistes teneriffae cyrenaicae*, Wadi al-Kuf (Cyrenaica) Libya. J. Hering

Pending endemic species



Great Spotted Woodpecker female *Dendrocopos major mauritanus*, Asni (High Atlas) Morocco. H. Bousadik

[Black-crowned] Eurasian Jay *Garrulus glandarius whitakeri* [*cervicalis* group], Azrou (Middle Atlas) Morocco. H. Bousadik

Common Chaffinch female (above) and male (below) *Fringilla coelebs africana*, Morocco. H. Bousadik

[Desert] Great Grey Shrike, *Lanius excubitor elegans*, Graret Labiar (Oued Ad Deheb) Morocco. A. Qninba

[Desert] Great Grey Shrike, *Lanius excubitor algeriensis*, Amizmiz (High Atlas) Morocco. H. Bousadik

