The boundaries of the Palearctic region

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ABSTRACT Although the western and eastern boundaries of the Palearctic region are widely agreed, there is still much debate about the southern boundary. In an attempt to establish a definitive southern boundary, the distribution of 1,037 breeding passerine species in the Palearctic, and adjacent parts of the Afrotropical and Oriental regions north of 5°N, were analysed. The WorldMap computer program was used to combine these maps, to reveal species richness. The variations in the position of the southern boundary suggested by previous authorities gives rise to three zones: north of the northernmost boundary, which is unequivocally Palearctic; south of the southernmost boundary, which is unequivocally Afrotropical or Oriental; and a border region in between, which is analysed in detail here to establish an objective southern boundary for the region.

In 1973, during initial meetings of the editorial team of a planned handbook of birds in Europe, one of the topics of debate was the title of the forthcoming work. Several people opted for the title 'Birds of the Western Palearctic' because it was short and geographically clearly defined; others thought that the term 'Palearctic' was too little-known in birding circles to attract potential buyers. After long discussion, it was decided that the book should be called *Handbook of the Birds of Europe, the Middle East and North Africa*, and subtitled *The Birds of the Western Palearctic*. Despite the smaller font type given to this subtitle, the handbook soon became widely known under the latter name, or simply as *BWP*. Since then, many birders have become familiar with the terms 'Palearctic' and 'Western Palearctic', although few will claim to know exactly where the boundaries lie.

Although the use of the term 'Palearctic' is now well established, the region is not well defined. The name was introduced by Sclater (1858), who divided the world into a number of zoogeographical regions, each characterised by unique faunal components with geographic ranges restricted to that region. Sclater based his regional system on the distribution of passerine birds, but analyses of other groups of terrestrial animals by subsequent workers, notably Wallace (1876), supported and expanded his scheme. Many books and checklists have now been published on the birds of the Palearctic. Their authors are more or less agreed on the western and eastern borders of the region, which stretch from Iceland and Morocco in the west, across to Japan, Kamchatka and the Chukotskiy Peninsula in northeast Russia in the east, but the number of bird species considered as Palearctic varies widely. This is partly due to differences in taxonomic approach; however, even when Dickinson (2003) is used as the authority on recognised species and races, there is wide variation in the total number of taxa published for the region: the Palearctic handbook of Hartert (Hartert 1903–23; Hartert & Steinbacher 1932–38) included 564 breeding passerine species; Vaurie (1959) included 620 species; Eck (1996) 635 species; and Beaman (1994) 693 species (these counts exclude introduced or accidental breeders). Eck (2004) presented a detailed overview of the differences among the three first-mentioned listings. It is clear that the apparent variation in number of species with time is explained largely by different views of what constitutes the southern limit

of the Palearctic region.

During work on the passerine volume of the forthcoming *Handbook of Geographical Variation and Distribution of Palearctic Birds* (Roselaar & Shirihai in prep.), the need for a well-defined southern border of the Palearctic became evident. It became apparent from the many detailed distribution maps that had been prepared for this work that an analysis of shared distributions could provide the most accurate assessment of the position of this southern boundary.

Methods and maps

The southern border of the Palearctic is established here by comparing separate breeding distribution maps of 1,037 passerine species. These A3-sized maps were compiled when working on species texts for *BWP* from 1987 onwards, but also cover all songbird species which occur outside the Western Palearctic in Eurasia and Africa north of 5°N. The maps are not the same as those used in *BWP* (which were prepared by Euan Dunn, Dorothy Vincent and Mike Wilson) but are, in part, based on the same sources. For the region outside the Western Palearctic, the maps are more detailed than those in *BWP*, and more than 4,000 papers and books on breeding-bird distribution were used to compile them. This literature, too extensive to be listed here, includes the most recently published breeding-bird atlas data for various countries in Europe. Europe is, however, only a small part of the Palearctic, and comparable data for North Africa, Siberia, China, and various central and southern Asian countries is not available; an extensive literature review, covering the past 150 years, was thus necessary to establish breeding ranges for these areas. In addition, the locations named on thousands of specimen labels were checked in several reference collections. The individual species range maps based on these sources will be published in Roselaar & Shirihai (in prep.).

For analysis, the original maps were converted into digital format by the computer program WorldMap version 4.1 (Williams 2000). In terms of longitude, each grid cell was 1° longitude wide, with a total of 220 cells from 30°W east to 170°W covering the entire

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337. Temminck's Lark *Eremophila bilopha*, Tagdilt Track, Boumalne du Dades, Morocco, February 2006. Only Palearctic passerine species extend throughout the Sahara of North Africa, and no Afrotropical species occur. Consequently, it is considered that the entire Sahara belongs to the Palearctic region. Throughout this region, the number of breeding species is particularly low, but larks (Alaudidae) and wheatears *Oenanthe* are well represented. Many species, including Temminck's Lark, have adapted to survive in this harsh environment by exploiting a particular, specialised niche, which enables them to exist alongside otherwise similar species.

Palearctic from the Azores to the Chukotskiy Peninsula. In terms of latitude, 120 grid cells covered an area from 18°N to 86°N. One degree of longitude in the south of this area is wider than one degree of longitude in the north (being c. 104 km wide at 18°N, c. 64 km at 55°N, and c. 10 km at 85°N). Since grid cells of equal area were required for this analysis, the latitudinal grid-cell dimension had to be adapted: cells were c. 39 km 'high' at 18°N, c. 64 km high at 55°N, and c. 400 km high at 85°N. In other words, one degree of latitude at 18°N covers just over three cells, but one cell covers more than three degrees of latitude at 85°N. This has the disadvantage that distribution maps become somewhat distorted, being vertically compressed in the north and stretched in the south. However, the important point is that each grid cell covers an area of 4,062 km^2, which enables the comparison of actual range size of a northern breeder with that of a southern breeder; thus a northern breeding species occurring in 300 grid cells will have a similar breeding range size to that of a southern breeder also occupying 300 grid cells.

Species covered

The breeding distributions of all passerine species breeding north of 18°N in Africa, Europe, and Asia were plotted in the WorldMap program. The Cape Verde Islands were included by moving the plots three degrees to the north. No attempt was made to plot distributions in Greenland, the Philippines or Alaska, although these regions are partly visible at the fringe of the map. The taxonomy used in this paper is based on Dickinson (2003); scientific and English names follow the *BB* 'List of Birds of the Western Palearctic' (www.britishbirds.co.uk/bblist.htm), and Dickinson (scientific names) and Beaman (1994) for other regions. Using Dickinson's taxonomy, some 1,037 species came within the area defined above. However, some species have been split since Dickinson was published, and the following were acknowledged as separate species: Richard's Pipit *Anthus richardi* (northern Asia south to northern China) and Paddyfield Pipit *A. rufulus* (southern China southwards); African Stonechat *Saxicola torquatus* (Afrotropics), Common Stonechat *S. rubicola* (western Europe and northern Africa east to the west Caucasus region) and Siberian Stonechat *S. maurus* (Ural Mountains and Caucasus eastward); Eastern Olivaceous Warbler *Hippolais pallida* (Sahara and the Balkans eastward) and Western Olivaceous Warbler *H. opaca* (Iberian Peninsula and northwest Africa); African Desert Warbler *Sylvia deserti* (western Sahara) and Asian Desert Warbler *S. nana* (central Asian deserts); Brown Flycatcher *Muscicapa dauurica* (northern Asia) and Williamson's Flycatcher *M. williamsoni* (mainland southeast Asia); and Golden Oriole *Oriolus oriolus* (Europe east to central Siberia) and Indian Golden Oriole *O. kundoo* (Indian Peninsula north to

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338. Thick-billed Lark *Rhamphocoris clotbey*, Tagdilt Track, Boumalne du Dades, Morocco, February 2006. A number of Saharan specialities, including Thick-billed Lark, Temminck's Lark *Eremophila bilopha* and Red-rumped Wheatear *Oenanthe moesta*, are restricted to the northern fringe of the Sahara and the northern Arabian Peninsula, and show a closer affinity to the Palearctic than to the Afrotropics. Thick-billed Lark is a desert specialist with a nomadic lifestyle, and numbers in any particular region can vary greatly from year to year as it exploits the available food sources.

central Asia, the Tien Shan Mountains and northwest China) (see Wittmann *et al.* 1995; Helbig & Seibold 1999; Sangster *et al.* 1999; Rasmussen & Anderton 2005 and Ottoson *et al.* 2005 for the reasoning behind some of these splits). In addition, seven species were omitted because they have extensive or localised (relict?) ranges in both the Palearctic and the Afrotropical and/or Oriental regions: Oriental Lark *Alauda gulgula*, Red-rumped Swallow *Cecropis daurica*, Long-billed Pipit *Anthus similis*, Zitting Cisticola *Cisticola juncidis*, Clamorous Reed Warbler *Acrocephalus stentoreus*, Large-billed Crow *Corvus macrorhynchos* and House Sparrow *Passer domesticus*. Each of these seven may potentially be split (e.g. Rasmussen & Anderton 2005), but the taxonomic limits in each case are uncertain for the moment.

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339. Long-billed Pipit *Anthus similis*, Fujairah, United Arab Emirates, December 2004. Long-billed Pipit provides a typical example of the difficulties involved in assigning species to a particular zoogeographical region. Although much of the breeding range lies in both the Afrotropical and Oriental regions, several disjunct populations exist along the southern boundary of the Palearctic. Of these, *A. s. captus* breeds in Lebanon, Jordan, Syria and Israel, *A. s. decaptus* breeds in Iraq, Iran, Pakistan and Afghanistan, while *A. s. arabicus* breeds in the Afrotropical mountains of the southwest Arabian Peninsula. Whether *arabicus* or *decaptus* breeds in northern Oman and northernmost UAE has not definitely been established, but the avifauna here is predominantly Palearctic.

Variation in the southern boundary of the Palearctic

Many authors are uncertain where the southern limits of the Palearctic lie; they accept a fairly southern boundary, but include only 'truly Palearctic' species, while excluding 'species of predominantly Oriental or Afrotropical genera' (Vaurie 1959), even if the range falls largely or entirely north of their perceived southern limit. In this analysis, a species is assigned to a certain faunal region if more than half of its breeding range (established from the number of grid cells occupied) falls within the boundary of that region. Beaman (1994) and others also included as Palearctic those species which have an insignificant breeding population in the region, but which otherwise occur extensively within another faunal region; this premise is not adopted here.

For the Western Palearctic, Hartert (1903–23) accepted a southern limit 'through the Sahara, a little bit more to the south in the Nile Valley, but excepting southern Arabia which is purely [Afro]tropical'. Other authors are more precise for the Sahara; Eck (1996) adopted 19°N as the southern border, while Hall & Moreau (1970) and Snow (1978) put the northern limit of the Afrotropical region at 20°N. Vaurie also accepted a southern limit at c. 19°N, but included southward extensions to c. 16°N in the Aïr (northern Niger) and Ennedi (northeast Chad) because some Palearctic taxa occur there (although the vast majority of breeding species are Afrotropical). Voous (1973–77) established the southern border in the western and central Sahara at 21°N, and to the southern Egyptian border in the east, though with southern extensions to 20°N along the Atlantic coastline and at 18°E to include the Banc d'Arguin (Mauritania) and the Tibesti Mountains in northern Chad. The editorial

team of *BWP* adopted the Voous list for taxonomy and species sequence, and also adopted Voous's southern boundary. In contrast, botanists, including Takhtadzhyan (1978) and Cox (2001), draw the southern limit of the Palearctic much farther north, along the southern fringe of the Mediterranean subregion, which approximates to the northern fringe of the Sahara. Although all ornithological authorities include the Cape Verde Islands within the Palearctic, botanists exclude this archipelago (fig. 1).

For the Arabian Peninsula, opinions on the southern border differ widely. *BWP* placed this farther north than earlier authorities, at 28°N. In contrast, Vaurie (1959) drew it, rather imprecisely, 'south to the region of Mecca in the west and to Oman in the east', which is approximately 21°N. Many others include the entire Arabian Peninsula within the Palearctic, including Voous (1973–77), Dowsett & Forbes-Watson (1993), Beaman (1994) and Eck (1996). Martins & Hirschfeld (1994) included the entire peninsula, with the exception of the mountains of southwest Saudi Arabia, Yemen, and southern Oman. Botanists have equally varied opinions; Takhtadzhyan (1978) placed the boundary even farther to the north, and excluded the Syrian Desert from the Palearctic, while Cox (2001) included the entire Arabian Peninsula in the Palearctic.

For Pakistan, ornithologists agree that the mountains of the west and north constitute the boundary between the Palearctic and Oriental regions, and that the Indus Plain lies entirely within the Oriental. However, most are unclear about the lower altitudinal limit for Palearctic birds, apart from Beaman (1994), who defined the boundary in Pakistan at 2,000 m. The coast of Baluchistan, in southwest Pakistan, and the neighbouring region of extreme southern or southeastern Iran are sometimes included in the Oriental region and sometimes in the Palearctic.

To the east, the Himalaya forms an obvious division between these two faunal regions but defining the boundary has again proved controversial. Takhtadzhyan (1978) considered the southern border of the Palearctic to lie just above the foothill zone where the subtropical zone and the lower montane zones meet, at c. 2,000 m in Nepal. Martens & Eck (1995) also identified the zone below 2,000 m in Nepal as (sub)tropical, with a temperate zone at 2,000–2,900 m (1,700–3,000 m), the latter dominated by evergreen oak forests including *Symplocus*, *Castanopsis* and *Quercus* spp. at lower elevations, and mixed evergreen and coniferous forest including Himalayan Hemlock *Tsuga dumosa* and Globe Magnolia *Magnolia globosa* over 2,600 m. Both Vaurie (1959) and Voous (1973–77) considered those species which occur upwards from the temperate mixed deciduous forest in the Himalaya and central China to be Palearctic. According to Beaman (1994), this type of forest occurs down to c. 2,000 m in Pakistan and Kashmir; to c. 2,500 m in Himachal Pradesh and Uttar Pradesh, northwest India; to c. 2,800 m from Nepal to Arunachal Pradesh, northeast India, and northern Myanmar; to c. 2,500 m in Yunnan and southern Sichuan provinces, southwest China; and to 2,000 m in central and northern Sichuan Province. The lower altitudinal limit for the Palearctic in Nepal is thus unclear. The same is true in the mountains of central China; Schäfer (1938) stated that the Palearctic zone in central Sichuan Province starts above the coniferous forest (upper montane zone) at 3,500 m, rather than

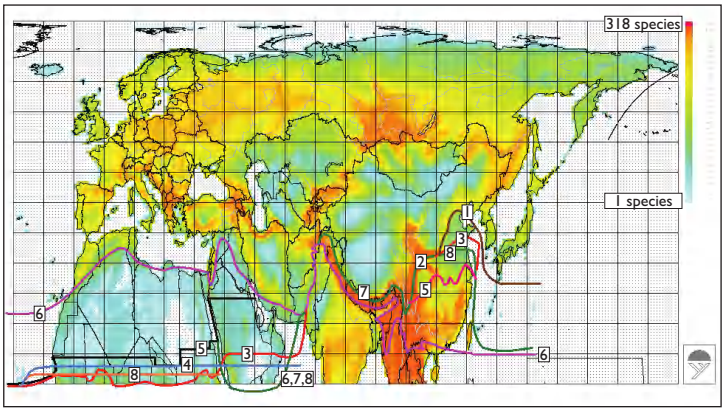

Fig. 1. The southern border of the Palearctic, as suggested by various authors, drawn on a biodiversity map of all passerine species breeding in the area of the map. Line 1: Hartert (1903–23); Line 2: Schäfer (1938); Line 3: Vaurie (1959); Line 4: Hall & Moreau (1970); Line 5: Cramp (1977); Line 6: Takhtadzhyan (1978); Line 7: Beaman (1994); and Line 8: Eck (1996). The key on the right-hand side of this figure (and subsequent figures) shows number of breeding passerine species from high (red) to low (blue).

the 2,000 m adhered to by Beaman.

Opinions on the southern boundary in eastern China differ widely too. Takhtadzhyan (1978) considered the flora of eastern China to be Palearctic, with the exception of the southern lowlands of Guangxi and Guangdong provinces. Voous (1973–77, 1985) took the Yangtze River as the boundary between the Palearctic and Oriental regions, while others have considered eastern China to be predominantly Oriental, with the Palearctic border at c. 33°N (Eck 1996); at 34°N (Beaman 1994); 'south of northern Hubei and Shandong', i.e. c. 32–34°N (Vaurie 1959); or even 'in the region of Beijing', i.e. c. 40°N (Hartert 1903–23).

Hartert (1903–23) considered that Taiwan and the islands to the south of Japan are *rein tropisch* [purely tropical], and thus fall within the Oriental region. However, all other authors incorporate the southern Japanese islands, including the Nansei-shoto (Ryukyu Islands), Kazan-retto (Volcano Islands) and Ogasawara-shoto (Bonin Islands), in the Palearctic, and Taiwan in the Oriental.

The western and eastern borders of the Palearctic are not discussed here: most authors agree that the Palearctic reaches west to Jan Mayen, Iceland and the Azores, and east to the Chukotskiy Peninsula, the Commander Islands (Komandorskiye Ostrova), and Ogasawara-shoto. Only Vaurie (1959) and Voous (1985) included eastern Greenland, while Vaurie (1965) included the whole of Greenland. In an analysis based on breeding ranges of passerines, it makes little sense for Greenland to be included, as the few passerines occurring there have circumpolar ranges, and are thus shared between the Palearctic and Nearctic.

Unequivocally Palearctic birds and a preliminary southern boundary

The first stage of the analysis was to establish two lines: (Line 1) the northernmost southern border of the Palearctic ever proposed (the northern limit of Takhtadzhyan (1978) in the Sahara and Syria, Beaman (1994) in Iran, Pakistan, and the Himalaya, Schäfer (1938) in central China, and Hartert (1903–23) in eastern China and southern Japan); and (Line 2) the southernmost of all boundaries proposed, following Vaurie (1959) for the Sahara, Voous (1973–77), Beaman (1994) and Eck (1996) for the Arabian Peninsula, Takhtadzhyan (1978) and Martens & Eck (1995) along the foothills of the Himalaya at c. 1,700–2,000 m, and the capricious line of Takhtadzhyan through central Myanmar and southern China. All authors agree that birds occurring largely or completely north of Line 1 are unequivocally Palearctic, while those occurring south of Line 2 are truly Afrotropical or Oriental. Fig. 2 shows the combined distributions of all Palearctic passerines breeding predominantly north of Line 1, while fig. 3 shows the distributions of Afrotropical and Oriental species to the south of Line 2.

A parallel can be drawn between these two lines, Line 1 and Line 2, and the lines defining the boundary between the Oriental and Australasian regions in Indonesia. Here, the unequivocal eastern boundary of the Oriental region is formed by Wallace's Line (just east of Borneo and Bali), the unequivocal western border of the Australasian region is Lydekker's Line, just west of New Guinea and Kepulauan Kai (Kai Islands), while the transition zone between these lines ('Wallacea') is divided halfway by Weber's Line (just west of the Moluccas) where the fauna of both regions reaches equilibrium.

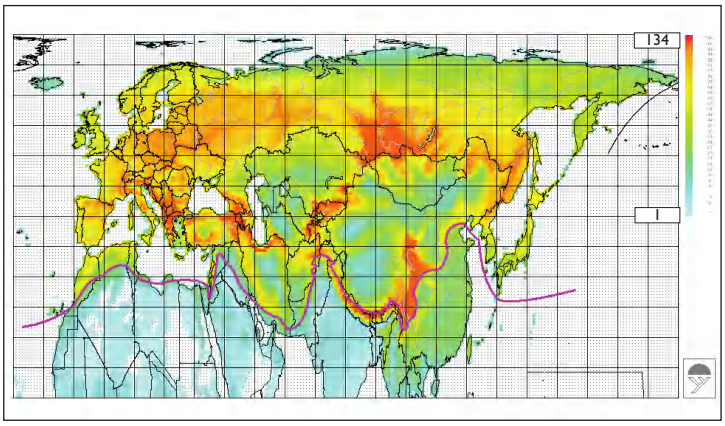

Fig. 2. Northernmost suggested border of the southern Palearctic (Line 1), and distribution of all unequivocally Palearctic passerines (breeding predominantly north of the line). This line follows southern border of Takhtadzhyan (1978) in the west, Beaman (1994) in the centre, and Schäfer (1938) and Hartert (1903–23) in the east.

Fig. 2 shows that a

few widespread Palearctic species also occur widely throughout the Sahara and Arabian Peninsula (Crested Lark *Galerida cristata*, Eastern Olivaceous Warbler and Southern Grey Shrike *Lanius meridionalis*) while one, Rufous Bush Robin *Cercotrichas galactotes*, has a separate population in the Sahel zone. However, even these few species breed in more grid cells to the north of Line 1 than to the south; the same applies to a few species which are widespread in the plains of the Indian Peninsula (Crested Lark, Southern Grey Shrike, Great Tit *Parus major*) and 22 species in the plains of eastern China (e.g. Barn Swallow *Hirundo rustica*, White Wagtail *Motacilla alba*, Wren *Troglodytes troglodytes*, Brown Dipper *Cinclus pallasii*, Siberian Stonechat, Blue Rock Thrush *Monticola solitarius*, Blackbird *Turdus merula*, Great Tit, Coal Tit *Periparus ater*, Eurasian Nuthatch *Sitta europaea*, Brown Shrike *L. cristatus*, Eurasian Jay *Garrulus glandarius*, Magpie *Pica pica*, Tree Sparrow *Passer montanus*, Chestnut-eared Bunting *Emberiza fucata* and Meadow Bunting *E. cioides*). In addition, Taiwan has 29 truly Palearctic species (including Barn Swallow, Asian House Martin *Delichon dasypus*, White Wagtail, Grey Wagtail *Motacilla cinerea*, Wren, Alpine Accentor *Prunella collaris*, Brown Dipper, Varied Tit *Parus varius*, Coal Tit, Eurasian Jay, and Nutcracker *Nucifraga caryocatactes*).

Conversely, some Afrotropical species breed to the north of Line 2: Plain Martin *Riparia paludicola*, Common Bulbul *Pycnonotus barbatus* and Black-crowned Tchagra *Tchagra senegalus* are Afrotropical species breeding in the Palearctic only in northwest Africa. Others extend well north to reach southern Algeria (e.g. Red-billed Firefinch *Lagonosticta senegala*, perhaps aided by recent introductions), or into southern Egypt via the Nile valley (e.g. African Pied Wagtail *M. aguimp*) (fig. 3). Many Afrotropical passerines also extend into southwest Arabia, and some reach north into the Levant region (e.g. Black Bush Robin *Cercotrichas podobe*, Blackstart *Cercomela melanura* and Fan-tailed Raven *Corvus rhipidurus*).

The number of Oriental species extending into the Palearctic is even greater, with several ranging from the Indian subcontinent west or northwest to Iraq and southern Turkey (e.g. White-cheeked Bulbul *P. leucogenys*, Common Babbler *Turdoides caudata* and Yellow-throated Sparrow *Petronia xanthocollis*). Other Oriental species have skirted around the western flank of the Tien Shan Mountains and pushed north into central Asia, with some reaching southern or even central Kazakhstan (e.g. Pied Stonechat *Saxicola caprata*, Asian Paradise-flycatcher *Terpsiphone paradisi*, Indian Golden Oriole, Long-tailed Shrike *Lanius schach* and Common Myna *Acridotheres tristis*, although the recent range extension of the last species in this region is probably due to introductions). To the east, Oriental species also extend into the Palearctic, in northeast China (e.g. Black *Dicrurus macrocercus*, Ashy *D. leucophaeus* and Hair-crested Drongo *D. hottentottus* and Red-billed Blue Magpie *Urocissa erythrorhyncha*), with some even reaching the Russian Far East (e.g. Black-naped Oriole *O. chinensis* and Asian Paradise-flycatcher). Despite their northerly distributions, even those species which extend farthest north occupy more grid cells in the Oriental region than in the Palearctic. For example, Indian Golden Oriole occupies 788 grid cells in the Indian Peninsula (Oriental region) and 502 in the Palearctic section of its

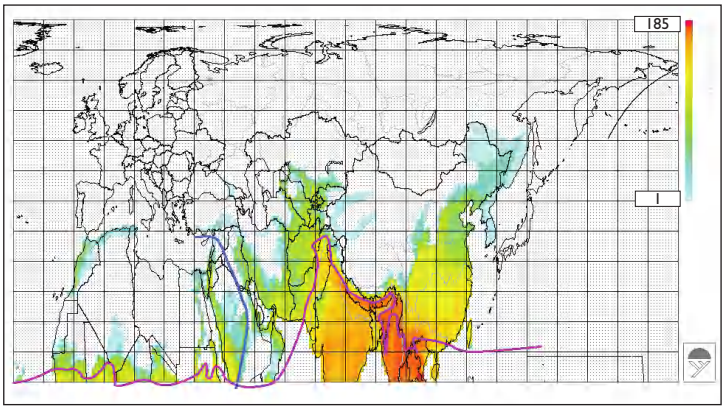

Fig. 3. Southernmost suggested border of the southern Palearctic (Line 2), and distribution of all unequivocally Afrotropical and Oriental passerines (breeding predominantly south of the line). This line follows southern border of Vaurie (1959) in the Sahara; Voous (1973–77), Beaman (1994) and Eck (1996) in Arabia; and Takhtadzhyan (1978) further east. The vertical blue line through Arabia represents the boundary between the Afrotropical and Oriental regions based on the distribution of passerine breeding species.

range, which extends from the Tien Shan Mountains east into the Xinjiang Uygur Autonomous Region in westernmost China.

By comparing the number of Palearctic and Afrotropical/Oriental species in each grid cell in figs. 2 and 3, a line of equilibrium between these regions becomes apparent (fig. 4). To the north of this line Palearctic species predominate, to the south of it Afrotropical and Oriental species predominate. This line roughly follows a latitude of 19ºN in the Afrotropics, lies close to the boundary followed by *BWP* in Arabia, to Beaman's (1994) line through western and central Asia, and to Voous's (1973–77) line across eastern China. However, this preliminary line was based on birds breeding largely to the north of Line 1 and south of Line 2, and thus excludes the species occurring predominantly *between* these lines in the Sahara, the Arabian Peninsula, the Himalaya between 2,000 and 2,800 m, central China between 2,000 and 3,500 m, and throughout the lowland plains and hills of eastern China. The species in each of these regions are discussed below, before an attempt is made to establish a definitive southern limit to the Palearctic.

Saharan species

Eighteen species occur primarily in the Sahara, mainly larks (Alaudidae) and wheatears *Oenanthe*, together with Pale Crag Martin *Ptyonoprogne obsoleta*, African Desert Warbler, Fulvous Babbler *Turdoides fulva*, Brown-necked Raven *C. ruficollis*, Desert Sparrow *Passer simplex*, Trumpeter Finch *Bucanetes githagineus* and House Bunting *Emberiza striolata* (fig. 5). Since only truly Palearctic species extend throughout the Sahara (fig. 2) and no Afrotropical species occur here (fig. 3), it is considered that the Sahara in its entirety belongs to the Palearctic. Furthermore, approximately half of all Saharan species extend into the Palearctic regions of Iran and/or Kazakhstan, while of the four species extending to the Oriental region in the deserts of Pakistan or northwest India, two also breed north to Kazakhstan. In addition, a number of species are restricted to the northern fringe of the Sahara and the northern Arabian Peninsula, thus nearer to the Palearctic than to the Afrotropics (e.g. Thick-billed Lark *Rhamphocoris clotbey*, Temminck's Lark *Eremophila bilopha* and Red-rumped Wheatear *O. moesta*). The only species restricted to the southern fringe of the Sahara is Black-crowned Sparrow-lark *Eremopterix nigriceps*; this and the widespread

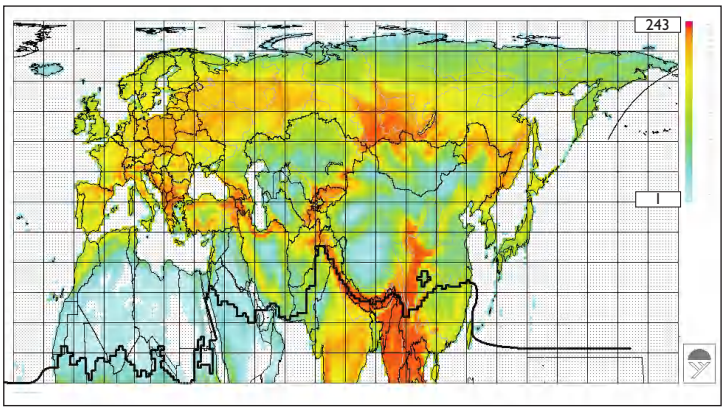

Fig. 4. Preliminary southern border of the Palearctic, separating unequivocally Palearctic and unequivocally Afrotropical and Oriental passerine species, based on number of species in each grid cell as counted from figs. 2 & 3 (line drawn where number for each region is in equilibrium). Map and southern boundary ignore those species breeding predominantly between Line 1 and Line 2.

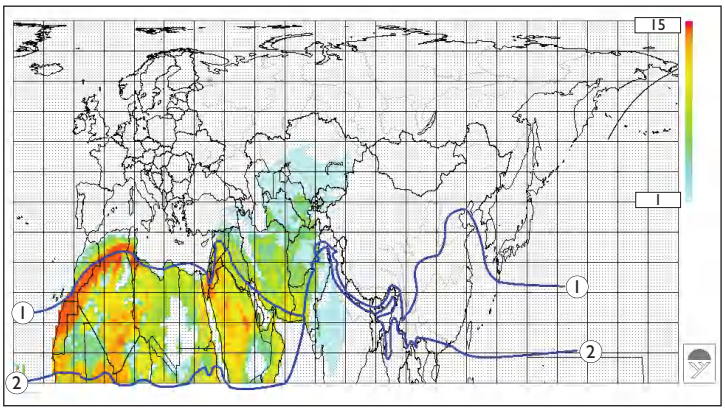

Fig. 5. Distribution of species with a breeding range falling predominantly between Line 1 and Line 2 in the Sahara and Cape Verde Islands. For definitions of these Lines, see figs. 2 & 3.

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340. White-throated Redstart *Phoenicurus schisticeps*, Jiuzhaigou, Sichuan Province, China, July 2006. Redstarts reach their greatest diversity in the mountains bordering the southern fringe of the Palearctic in the Himalaya and western/central China, where they occupy a wide range of habitats. White-throated Redstart typically breeds in scrub forest on rocky slopes and along forest edge above 3,200 m from Nepal to Bhutan, and in western China.

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341. Indian Blue Robin *Luscinia brunnea*, Jamboti, Karnataka, India, April 2006. Although the stunning Indian Blue Robin is a common and widespread summer visitor to the Himalaya and mountains of western/central China, it is secretive, usually keeps close to the ground, and sings from deep within cover. Like many species in this region, it breeds in temperate forest between 2,400 and 3,200 m, in and above the zone of overlap between the Oriental and Palearctic regions.

House Bunting are the only Saharan species which extend exclusively to north-west India. These two are perhaps the only Saharan species of southern origin, because other *Eremopterix* species are restricted to the Afrotropical and the Oriental regions, while the relationships of House Bunting appear to be with the Afrotropical buntings such as Cinnamon-breasted *Emberiza tahapisi* and Cape Bunting *E. capensis*. Clearly, the Saharan passerine fauna is predominantly Palearctic. Alternatively, if a faunal region is defined as an area which has more endemic species than species shared with other regions, the Sahara and Syrian deserts may form a valid zoogeographical unit, the 'Eremian' region, because 18 passerines are endemic to the Sahara and Syrian (semi-)deserts, sharing their range with just three Palearctic and no Afrotropical species.

The Cape Verde Islands belong to the Palearctic because, of the ten breeding passerines there, Palearctic species predominate. Of these ten, three are shared with the Palearctic (Spectacled Warbler *Sylvia conspicillata*, Blackcap *S. atricapilla* and Spanish Sparrow *Passer hispaniolensis*); four are Saharan (and thus also Palearctic – Bar-tailed Desert Lark *Ammomanes cinctura*, Hoopoe Lark *Alaemon alaudipes*, Brown-necked Raven and Black-crowned Sparrow-lark); and three are endemic. Of the last group, Raso Lark *Alauda razae* seems likely to

have Palearctic affinities, while the other two are more likely to be Afrotropical (Cape Verde Warbler *Acrocephalus brevipennis* is morphologically close to Greater Swamp Warbler *A. rufescens*, and Cape Verde Sparrow *P. iagoensis* to an African sparrow group including Rufous Sparrow *P. motitensis*).

Arabian species

The overwhelming majority of the breeding birds of south and southwest Arabia are shared with the Afrotropics; 24 of the 70 Afrotropical species falling within the geographical boundaries used in this analysis also occur in southwest Arabia (see fig. 3), while of the Palearctic species only Magpie extends to the same area (fig. 2). Consequently, all ten endemic Arabian species (fig. 6), which are found in the southwest of the peninsula, are considered to be Afrotropical. This is reinforced by examining the relationships of these ten species: eight (White-spectacled Bulbul *Pycnonotus xanthopygos*, Yemen Thrush *T. menachensis*, Yemen Parisoma *Parisoma buryi*, Arabian Babbler *T. squamiceps*, Tristram's Starling *Onychognathus tristramii*, Arabian Waxbill *Estrilda rufibarba*, Olive-rumped Serin *Serinus rothschildi* and Yemen Serin *S. menachensis*) show a close morphological resemblance to related Afrotropical or, in some cases, Oriental species. Only two endemics appear to be of Palearctic origin – Yemen Accentor *Prunella fagani* (geographically isolated from a group of accentors of similar appearance, including Radde's Accentor *P. ocularis* of the mountains of Turkey and northern Iran) and Yemeni Linnet *Carduelis yemensis* (related to Linnet *C. cannabina*). No passerines are endemic to the interior deserts and coastal plains of Arabia. Since the species occurring throughout these areas of the Arabian Peninsula are shared with the Sahara, the lowlands are best considered Palearctic, and the mountains of the southwest as Afrotropical.

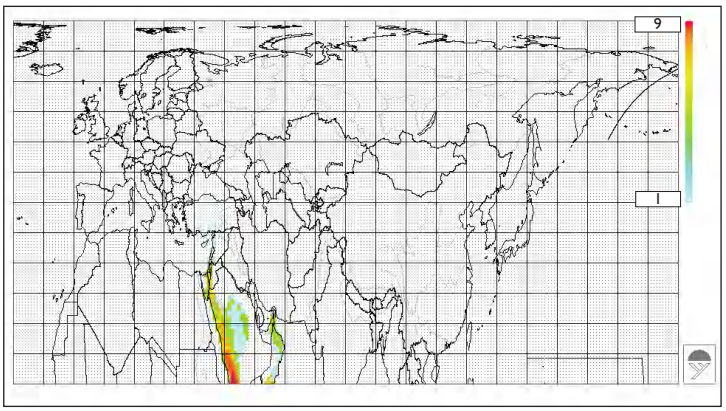

Fig. 6. Distribution of species with a breeding range falling predominantly between Line 1 and Line 2 in the Arabian Peninsula (ten Arabian endemics). For definitions of these Lines, see figs. 2 & 3.

Mid-altitude species of the Himalaya and central China

For the zoogeographical affinities of species in the Himalaya, an analysis was made of species occurring in Nepal, based on the altitudinal distribution of breeding records supplied by Martens & Eck (1995), supplemented by data from Grimmett *et al.* (1998), the latter mainly for species occurring at lower elevations (a zone less well covered by Martens & Eck). A total of 104 Nepalese bird species which are widespread in the plains and hills of the Indian Peninsula are considered as Oriental; these are augmented by a few species endemic to the Himalayan foothills (if occurring entirely below 2,000 m), and by 69 Oriental species from the plains and hills of mainland southeast Asia, many of which extend westwards through the eastern Himalaya, and occur in Nepal mainly between 1,000 and 2,000 m. Palearctic taxa are represented in Nepal by 65 species which are widespread in the Palearctic north of 35°N; these occur mostly above 2,800 m, but some are restricted to the lowlands or foothills (see fig. 2). These are augmented by 70 endemic species of the southern and eastern fringes of the Tibetan Plateau, which occur predominantly above 2,800 m in Nepal, the altitudinal lower boundary of the Palearctic of Beaman (1994). The distribution of species largely confined to the zone between 2,000 and 2,800 m in Nepal is plotted in fig. 7 (these are the birds not used in the preliminary analysis for figs. 2 and 3). Fig. 7 shows clearly that most species breeding at this altitude in Nepal also extend into the eastern Himalaya, and many also occur in the hills of south and east Assam, India, the mountains of northern, northeastern and western Myanmar, and into western Yunnan Province, China. A smaller number of these Nepalese species also

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342. Chestnut Thrush *Turdus rubrocanus*, Jiuzhaigou, Sichuan Province, China, July 2006. Two races of Chestnut Thrush breed in the mountains fringing the southern boundary of the Palearctic. The nominate, pale-headed, form breeds at 2,300–3,300 m in the Himalaya, from E Afghanistan to Arunachal Pradesh, India, and the dark-headed form *T. r. gouldi* (illustrated) breeds at 2,800–3,800 m in montane forest in western/central China.

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343. Plain-backed Thrush *Zoothera mollissima*, Emei Shan, Sichuan Province, China, April 2005. Within the Palearctic, *Zoothera* thrushes reach their greatest diversity in the eastern Himalaya, where seven species breed, these species having ranges in the Oriental as well as the Palearctic region. Plain-backed Thrush is an altitudinal migrant, breeding entirely within the Palearctic, mostly between 3,000 and 4,300 m, but descending into the Oriental region in winter, where it occurs between 1,400 and 2,800 m.

extend south into the mountains of northern Thailand, northern Laos, and northwestern Vietnam, while others reach north to Sichuan, Gansu, and southern Shaanxi provinces in central China, or reappear in the hills of south-central China east to the hills of Fujian Province in eastern China, and some even reach Taiwan. In contrast to the Oriental species which predominate at 1,000–2,000 m in Nepal (see above), very few of those species at 2,000–2,800 m extend to the hills of mainland southeast Asia or Hainan Island, China.

When the number of species per 100 m of altitude is plotted for the same unequivocally Palearctic and Oriental species used in figs. 2 and 3, it becomes clear that some Palearctic species extend down below 100 m while some Oriental species reach up to 3,200 m, even though their main distributions are (respectively) above 2,800 m/below 2,000 m (fig. 8). The elevation at which Palearctic and Oriental passerines appear to reach an equilibrium is approximately 2,400 m. Therefore, all 68 species with a main breeding distribution between 2,000 and 2,800 m are, for further analysis, divided into species occurring predominantly at 2,400–2,800 m (36 species, classed as Palearctic), and those predominantly at 2,000–2,400 m (32 species, Oriental).

A similar analysis was undertaken using altitudinal data from Schäfer (1938), who carried out a transect

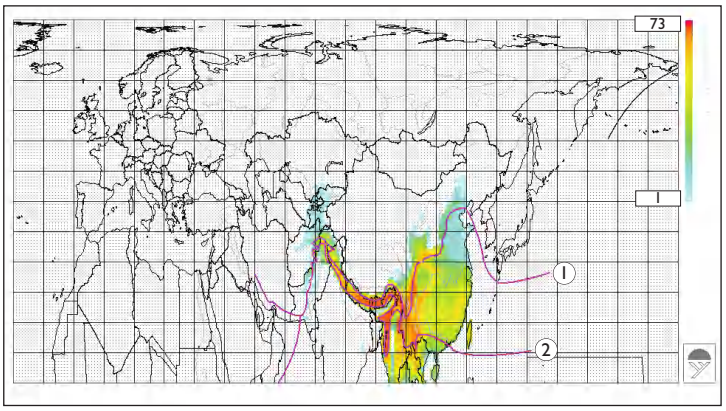

Fig. 7. Distribution of species with a breeding range falling predominantly between Line 1 (at c. 2,800 m) and Line 2 (at c. 2,000 m) in Nepal. For definitions of these lines, see figs. 2 & 3.

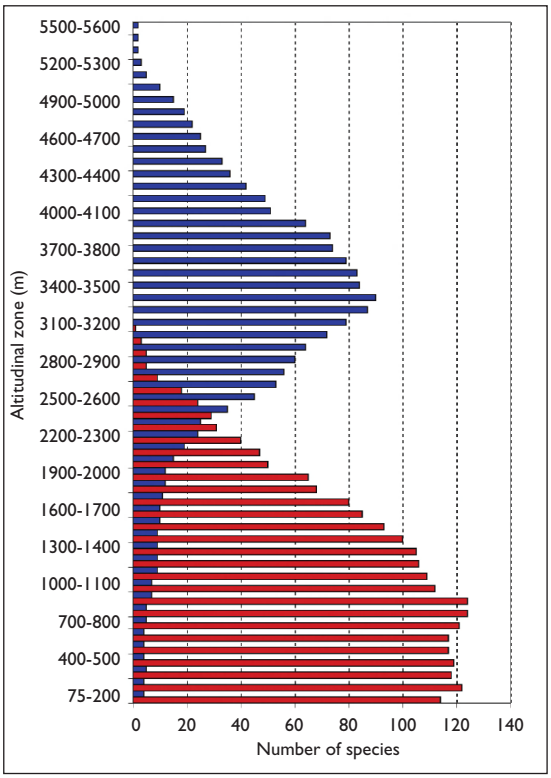

Fig. 8. Number of passerine species per 100 m change in elevation in the Himalaya, Nepal, based on unequivocally Palearctic and Oriental birds (those mapped in fig. 2 and fig. 3, respectively). Nepalese species with a distribution predominating between 2,000 m and 2,800 m are excluded (see fig. 7 for the horizontal distribution of these species). Key: blue = 135 Palearctic species; red = 185 Oriental species.

in central China. Starting in the Red Basin, an extension of the eastern lowland plain into central Sichuan, he surveyed bird distribution continuously to the Tibetan Plateau in eastern Qinghai Province. He found a strong turnover in species composition at 2,000–2,600 m, with species of the (sub)tropical lowland plain occurring up to 2,000 m (2,600 m), and Palearctic ones mainly from (2,000 m) 2,500 m upwards, but with 20 species of the latter group below 1,000 m. Based on his data, an equilibrium between Palearctic and Oriental passerines occurs at c. 2,300–2,400 m. Therefore, mid-altitude endemics with a main altitudinal range of 2,000–2,400 m in central China are considered as Oriental, while those inhabiting the bamboo (Bambuseae) jungle and cloud forest at 2,400–3,800 m are Palearctic.

Eastern China

Of the 37 species which occur predominantly between Line 1 and Line 2 in China, and below 2,400 m, remarkably few occur beyond eastern China (fig. 9). To establish whether these species are essentially Palearctic or Oriental, it is necessary to review the remaining passerine fauna in this area. Of the unequivocal Palearctic species (fig. 2), 37 extend into the plains and/or hills of eastern China, as do 50 unequivocally Oriental species, which occur predominantly south of Line 2 (fig. 3). In addition, several species found at mid elevations in the Himalaya also extend into eastern China; 17 occur mainly at 2,400–2,800 m in the Himalaya and are considered Palearctic, and 12 breed predominantly at 2,000–2,400 m and are treated as Oriental. This gives a combined total of 54 Palearctic and 62 Oriental breeding species in the area of eastern China under discussion (see table 1).

Clearly, the avifauna of eastern China is of mixed origin, but Oriental species predominate (table 1). Consequently, eastern China is here considered to belong to the Oriental region, as are its 37 endemic bird species, even though the difference in number of Oriental and Palearctic species is small. The

Table 1. Number of Palearctic, Oriental, and endemic passerine species of some regions and islands in East Asia.

	Palearctic	Oriental	endemic	
Eastern China	54	62	37	Oriental species predominate
Taiwan	33	46	12	Oriental species predominate
Nansei-shoto (Ryukyu Islands)	11	2	3	Palearctic species predominate
Daito (Borodino) Islands	8	0	0	Palearctic species predominate
Ogasawara-shoto (Bonin Islands)	6	0	3	Palearctic species predominate
Kazan-retto (Volcano Islands)	4	0	0	Palearctic species predominate

endemics include some interesting species restricted to the hills of Sichuan, southern Gansu and/or southern Shaanxi provinces, such as Martens's Warbler *Seicercus omeiensis*, Emei Leaf Warbler *Phylloscopus emeiensis*, Emei Shan Liocichla *Liocichla omeiensis*, and Slaty Bunting *Latoucheornis siemsseni.*

Taiwan

A total of 91 passerine species breed regularly in Taiwan. This includes 29 species with widespread distributions within the Palearctic and 29 similarly widespread Oriental species (figs. 2 & 3). A further 21 species are shared with the mid-altitude range of the Himalaya in Nepal, or with eastern China – a range spanning a region in which the avifauna of the Palearctic and Oriental regions reaches equilibrium. Following analysis of these regions (see above), 17 species are considered to be Oriental and four Palearctic. The Taiwan avifauna is thus mixed, but Oriental species predominate (table 1). This resembles the regional affinities of species in eastern China and, similarly, there is no clear altitudinal divergence among species, with some Palearctic species restricted to the lowlands, and some Oriental species breeding higher up in the mountains. Since Oriental passerines predominate, the 12 endemics are all attributed to the Oriental region. These include species from predominantly Palearctic genera (including Collared Bush Robin *Luscinia johnstoniae* and Flamecrest *Regulus goodfellowi*), although these are not particularly close to any Palearctic species. Other endemics show a morphological resemblance to more widespread Oriental counterparts (e.g. Styan's Bulbul *Pycnonotus taivanus* with Light-vented Bulbul *P. sinensis*, Taiwan Whistling Thrush *Myophonus insularis* with Blue Whistling Thrush *M. caeruleus* and Steere's Liocichla *Liocichla steerii* with Emei Shan Liocichla).

The Lanyu Islands, close to southeast Taiwan, are poor in breeding species, but among these are some shared with the Philippines (Lowland White-eye *Zosterops meyeni* and Pacific Swallow *H. tahitica*). More detailed research is necessary before the islands' zoogeographic position can be established.

Southern Japanese islands

Of the passerines found on the Nansei-shoto (Ryukyu Islands), most are shared with the main islands of Japan, and thus belong to the Palearctic; only Light-vented Bulbul and Pacific Swallow are unequivocally Oriental. The relationships of the three endemic passerines appear to lie with Palearctic species also: Ryukyu Robin *Luscinia komadori* appears closely related to Japanese Robin *L. akahige* or Rufous-headed Robin *L. ruficeps* of central China; Amami Thrush *Zoothera major* is a close relative of White's Thrush *Z. aurea* of the northern Palearctic and Scaly

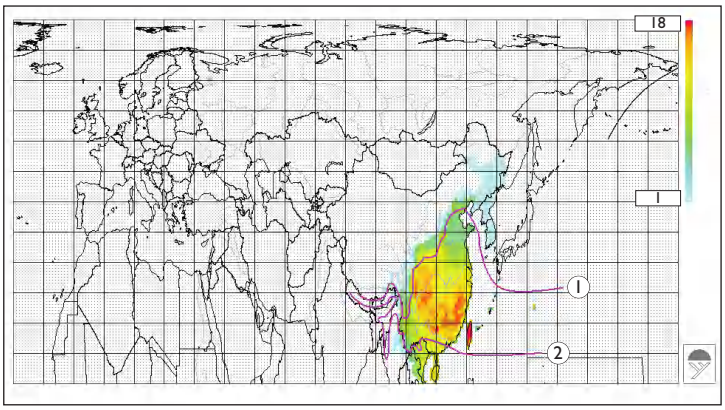

Fig. 9. Distribution of species with a breeding range falling predominantly between Line 1 and Line 2 in eastern China (37 species, virtually endemic to eastern China). For definitions of these lines, see figs. 2 & 3.

Thrush *Z. dauma* of the Himalaya; and Lidth's Jay *G. lidthi* is morphologically close to Black-headed Jay *G. lanceolatus* of the western Himalaya.

Eight passerines breed on the Daito (Borodino) Islands. All of these (Brown-eared Bulbul *Microscelis amaurotis*, Wren, Blue Rock Thrush, Japanese Bush Warbler *Cettia diphone*, Varied Tit, Japanese White-eye *Zosterops japonicus*, Bull-headed Shrike *Lanius bucephalus*, and Tree Sparrow) are shared with the main islands of Japan and are Palearctic. Six of the nine species breeding, or formerly breeding, on the Ogasawara-shoto (Bonin Islands) are also shared with the main islands of Japan, but the other three are endemic (Bonin Thrush *Zoothera terrestris*, Bonin Honeyeater *Apalopteron familiare*, and Bonin Grosbeak *Chaunoproctus ferreorostris*) and the nearest relatives of these species are not yet satisfactorily established. The four passerines breeding regularly on the Kazan-retto (Volcano Islands) are also shared with the main islands of Japan. Together, the islands in southern Japan have Palearctic taxa predominating and thus are included in the Palearctic (table 1).

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344. Elliot's Laughing-thrush *Garrulax elliotii*, Huanglong, Sichuan Province, China, April 2005. Although most laughing-thrushes are confined to the Oriental region, several species breed in the Himalaya and western China between 2,000 and 2,800 m, where Palearctic and Oriental faunas overlap. Elliot's Laughing-thrush is one of few species of laughing-thrush that is entirely restricted to the Palearctic, where it breeds mainly at 2,000–4,000 m in the mountains of central China from Qinghai east to Gansu Province, and south to northern Yunnan Province.

A definitive southern boundary of the Palearctic

After establishing the affinities of species that occur predominantly between Line 1 and Line 2 (figs. 2–9), a revised line can be determined according to whether Palearctic or Afrotropical and/or Oriental species predominate in each grid cell (see fig. 10). Owing to the inclusion of the (semi-)desert region of the Sahara in the Palearctic, this revised line takes a slightly more southerly track than the preliminary line (fig. 4) in Africa (at c. 19°N, but north to Gebel Elba at c. 22°N in the extreme east). Within the Arabian Peninsula, the revised southern boundary includes the entire region except the mountains of the south and southwest (Afrotropical) and the coastal plain of northern Oman (Oriental). The preliminary and revised lines are similar across the Indian subcontinent. Both include the coastal plain of southern Iran and southern Baluchistan within the Oriental region, the mountains of western Pakistan in the

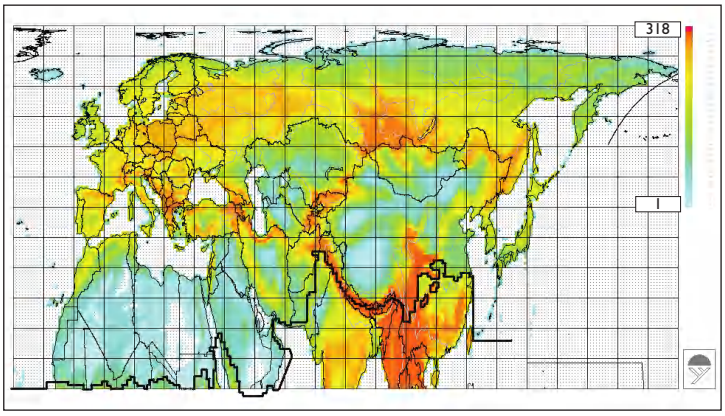

Fig. 10. Definitive southern border of the Palearctic region, based on distribution of all passerine species breeding within the area of the map (species richness shown). The line is drawn where number of breeding Palearctic and Afrotropical/Oriental species reaches an equilibrium.

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345. Black-browed Tit (Père Bonvalot's Tit) *Aegithalos bonvaloti*, Cang Shan, Dali, Yunnan Province, China, September 2005. This attractive 'long-tailed tit' breeds up to 3,400 m in the mountains of northern Yunnan and central Sichuan provinces, China, which form the boundary between the Palearctic and Oriental regions in central China.

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346. White-capped Water Redstart *Chaimarrornis leucocephalus*, Siguniang Shan, Sichuan Province, China, June 2006. White-capped Water Redstart inhabits fast-flowing streams of the Himalaya and hill ranges east to eastern China, where it breeds mostly between 1,800 and 4,600 m. Within such a wide altitudinal range, it occupies suitable habitat in both the Palearctic and Oriental regions, but its main distribution lies within the Palearctic.

Palearctic (including the Safed Koh in northwest Pakistan), although the Jalalabad valley, just north of the Safed Koh in Afghanistan, is Oriental. In China, Xizang (Tibet Autonomous Region) is Palearctic, but the altitudinal upper limit of the Oriental region, at c. 2,400 m, locally reaches into southernmost Xizang (Gyirong, Nyalam, part of upper Arun Valley, Yadong area in Chumbi Valley, Dihang/ Yarlung Valley near Bomi, Zayü Valley, parts of Nu Jiang/Salween and Lancang Jiang/Mekong rivers). In Yunnan Province, the Palearctic extends south to the Dali area, and east to c. 103°E between northern Yunnan and central Sichuan provinces. Farther east the border becomes highly capricious, reaching north in the lowland plains to 32°N near the Yangtze River estuary, and still farther north into the upper Han Shui River basin in northern Hubei Province. In Sichuan Province, the low-lying Red Basin is undoubtedly Oriental (as in fig. 4), but the surrounding mountains have a predominantly Palearctic passerine fauna (above c. 2,300–2,400 m).

A Palearctic list

In this analysis, species are assigned to a certain faunal region according to their breeding distribution; for example, one with the larger part of its range in the Orient is defined as Oriental, even though a smaller part may extend well into the Palearctic (as defined here). Compare this with the concept of a national list,

where every species which has occurred within that nation's borders is counted. The same approach could be applied to a list of Palearctic birds, which then would include species having only a tiny foothold in the Palearctic as a breeding bird (or even species which occur as a migrant or vagrant), even though the species is mainly Afrotropical or Oriental in distribution (or in some cases Nearctic: Grey-cheeked Thrush *Catharus minimus* and Savannah Sparrow *Passerculus sandwichensis* breed regularly in extreme north-eastern Siberia). Those species which have recognisable taxa in the Palearctic have a strong case for inclusion on the Palearctic list; for example, the Afrotropical Black-crowned Tchagra, of which there is a distinct race resident in northwest Africa, or the Oriental Common Babbler, which has distinct taxa in the Middle East. Species like these, with recognisable taxa in different faunal regions, are probably the first that should be examined in terms of potential taxonomic splits, not only those with distributions shared between the Palearctic and Afrotropical or Oriental regions, but also those with ranges which extend into both southern regions, like Graceful Prinia *Prinia gracilis* (and indeed Oriental Skylark, Red-rumped Swallow, Long-billed Pipit, Zitting Cisticola, Clamorous Reed Warbler, Large-billed Crow, and House Sparrow mentioned already), which are not included here because of the difficulty in assigning them to a particular region.

Phil Gregory

347. Lidth's Jay *Garrulus lidthi*, Amami-Oshima, Japan, February 2006. The islands of the Nansei-shoto (Ryukyu Islands) form the southeastern boundary of the Palearctic and are home to 18 passerine species, most of which are shared with the main islands of Japan, while others are endemic to the islands. Lidth's Jay is found only on Amami-Oshima, but is morphologically close to Lanceolated Jay *G. lanceolatus* of the western Himalaya.

In this zoogeographical analysis, 563 passerine bird species are considered to be Palearctic. All these are also listed as Palearctic by Beaman (1994), apart from some species recently discovered or split (including some *Seicercus* and *Phylloscopus* warblers, and Sichuan Treecreeper *Certhia tianquanensis*). Beaman listed a further 43 species as Palearctic which here are considered to have Afrotropical affinities (mainly in Arabia, where opinions on the Palearctic boundary differ widely), and 92 species here considered to belong to the Oriental region (though some do extend into the Palearctic, some quite extensively). Nonetheless, Beaman's Palearctic list represents a valuable overview of species occurring in the Palearctic, provided that those restricted to the south-western and southern Arabian Peninsula are excluded.

Would the southern boundary of the Palearctic change if non-passerines were included?

Although the available maps for Palearctic non-passerines are more crude than those for passerines, many non-passerines show range sizes and distributions comparable with those of passerines, especially birds of forests, shrub, and open plains, such as pheasants and quails (Phasianidae), raptors (Accipitridae), sandgrouse (Pteroclididae), pigeons and doves (Columbidae), cuckoos (Cuculidae), owls (Strigidae), nightjars (Caprimulgidae) and woodpeckers (Picidae). Some non-passerine landbirds are far more widespread than any songbird (e.g. Peregrine

Falcon *Falco peregrinus*, Osprey *Pandion haliaetus* and Barn Owl *Tyto alba*), but these are relatively few and their number would have little effect on the boundaries established here. Note that the zoogeographical regions as defined by Sclater (1858) are based on landbirds; seabirds such as petrels (Procellariidae), gannets (Sulidae) and auks (Alcidae) simply do not fit this essentially land-based concept.

On the other hand, the passerines include very few waterbirds (just two dippers) or tundra dwellers (mainly a few pipits, finches, and buntings), while these are numerous among non-passerine species – e.g. waterfowl (Anatidae), divers (Gaviidae), grebes (Podicipedidae), herons (Ardeidae) and, particularly on the tundra, many waders (Charadriidae and Scolopacidae). The breeding ranges of many of these are extensive and/or extend to other continents, and including them in an analysis such as this may affect the outcome, although their inclusion is more likely to affect the northwestern and/or northeastern boundary than the southern one.

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