Global hotspots in the Arabian Peninsula

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Abstract. The Hotspot concept was formulated to highlight areas of the world that contain concentrations of endemic species. The effectiveness of this approach applied to the two sectors of global hotspots located in the Arabian Peninsula is examined in the context of overall strategies to conserve the biodiversity of the region. Rates of vertebrate endemism in the region range from 6%-75%. Over 58% of Arabian Peninsula endemic vertebrates have distributions restricted to The Arabian Hotspot Area, compared to a global figure of 42%, and over 77% of these endemics species occur there. These figures highlight the importance of the Arabian Hotspot Area for this aspect of biodiversity conservation, but it excludes large areas of the Arabian Peninsula containing characteristic habitats and species, including Arabian Oryx and Houbara Bustard. Additional approaches are needed to provide a fully representative and comprehensive conservation strategy.

Key words. Hotspot, Arabian Peninsula, vertebrate endemism, conservation strategy.

Introduction

The 'hotspot' concept was first developed by MYERS (1988) who identified 10 tropical forests containing exceptionally high levels of species diversity. The hotspot approach was later adopted by Conservation International (CI) as its central strategy. Its aim was to identify areas containing concentrations of endemism and that were under threat, and that would allow conservation efforts to be targeted at areas where a disproportionate amount of global biodiversity was concentrated.

A hotspot was defined as an area containing at least 1500 endemic species of vascular plants (i.e. >0.5% of the global total) and that had also lost 70% or more of its original cover (MITTERMEIER et al. 1999). An initial analysis identified 25 global Hotspots, subsequently revised and the total increased to 34 (MITTERMEIER et al. 1999, 2004; MYERS et al. 2000). These 34 global hotspots include within them 50% of the world's plant species and 42% of vertebrates yet cover only 15.7% of the global land surface. When the intact areas alone are considered, the total area amounts to only 2.3%, representing a remarkably high concentration of life forms (MITTERMEIER et al. 2004).

Individual hotspots vary widely in size: three exceed 2 million km^2 while the smallest covers only 18,972 km^2. The original analysis, though based on plant diversity and habitat loss, was supported by an analysis of vertebrate groups (mammals, birds, reptiles, amphibians and fish), though these groups were not used to define hotpots. Invertebrates were not included in the analysis because of the lack of adequate global datasets at that time.

Two of the 34 global hotspots, the Horn of Africa and the Eastern Afromontane include parts of the Arabian Peninsula. The Horn of Africa Hotspot covers the arid and semi-arid zones of Ethiopia, Eritrea, Somalia, Djibouti, north-eastern Kenya, south-east Sudan, and south-west Arabia. The Arabian sector comprises the lower mountains and coasts of Saudi

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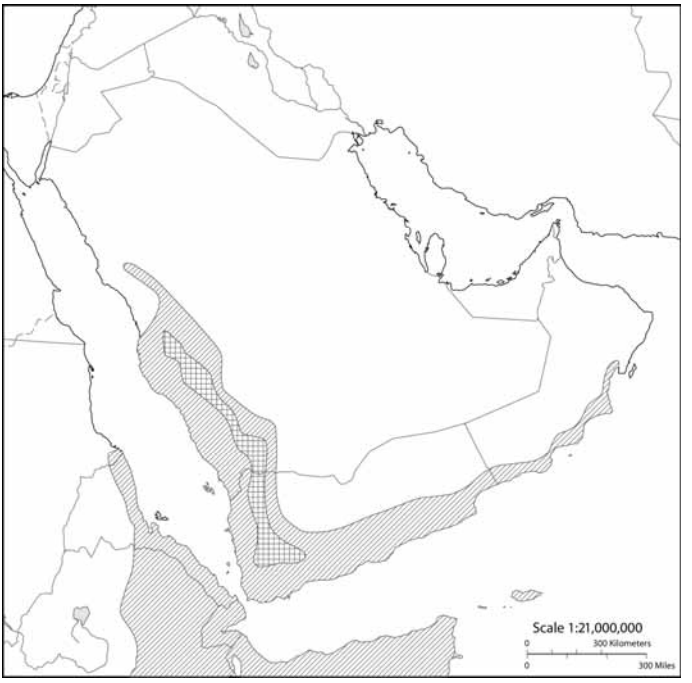

Fig. 1. The Arabian Hotspot Area (AHA). Pale grey - Horn of Africa Hotspot; hatched - Eastern Afromontane Hotspot.

Arabia, Yemen (including Socotra) and Oman. The Eastern Afromontane Hotspot comprises the isolated mountains of the Afrotropical region extending from Zimbabwe, Tanzania, Kenya, and Uganda to Ethiopia and the high elevation zone of the south-west Arabian mountains in Saudi Arabia and Yemen. The Arabian sectors of these two hotspots are contiguous and together they encompass the mountains and coastal areas of the southwestern and southern rim of the Arabian Peninsula. The combined area is referred to here as the Arabian Hotspot Area (AHA; Fig. 1).

The effectiveness of AHA is assessed here in the context of regional strategies to conserve the biodiversity of the Arabian Peninsula. Socotra is excluded, in part because its biota are so distinct from those of the rest of the Arabian Peninsula and are biogeographically closer to NE Africa, and in part because they were not included in the regional assessments carried out at the annual Sharjah conservation workshops (AL MIFDA et al. 2011).

The assessment is based as far as possible on the same groups of vertebrates used in the global hotspot data assessment. For each group, the following information was compiled: the number of species occurring in the Arabian Peninsula; number of endemic species; number of endemics occurring exclusively in AHA; and number of endemics occurring partially within AHA and elsewhere in the Arabian Peninsula. Baseline information data was taken from standard published sources: mammals (except marine) - HARRISON & BATES (1991); breeding birds - PORTER et al. (1996), with some updated information from BirdLife International. Freshwater fish (ENVIRONMENT AND PROTECTED AREAS AUTHORITY 2002, 2003);

Table 2. Global and regional Red List status of large and medium-sized carnivores in the Arabian Peninsula. Global status according to IUCN (2008).

Species		Global status	Regional status[1]
Grey Wolf	*Canis lupus*	Least Concern	Endangered
Golden Jackal	*Canis aureus*	Least Concern	Vulnerable
Blanford's Fox	*Vulpes cana*	Least Concern	Vulnerable
Rüppell's Fox	*Vulpes rueppellii*	Least Concern	Endangered
Red Fox	*Vulpes vulpes*	Least Concern	Least Concern
Striped Hyaena	*Hyaena hyaena*	Near Threatened	Endangered
Cheetah	*Acinonyx jubatus*	Vulnerable	Regionally Extinct
Common Leopard	*Panthera pardus*	Near Threatened	Critically Endangered[2]
Caracal	*Caracal caracal*	Least Concern	Vulnerable
Sand Cat	*Felis margarita*	Near Threatened	Endangered
Wild Cat	*Felis silvestris*	Least Concern	Endangered

[1] CBSG (2000, 2001); EPAA (2002, 203, 2004, 2005); [2] Global assessment for *P. pardus nimr* (IUCN 2008)

amphibians (ENVIRONMENT AND PROTECTED AREAS AUTHORITY 2003); snakes ENVIRONMENT AND PROTECTED AREAS AUTHORITY (2007) and EGAN (2008). Lizards - SINDACO & JEREMČENKO (2008). Regional assessments were taken from the reports of the Sharjah meetings 2000-2009 (see references). The species inventories reflect those in the works cited. It is possible that additional species have been recorded subsequently, either through field studies, genetic research or taxonomic revision.

Results

In the vertebrate groups assessed, 476 species have been recorded in the Arabian Peninsula, of which 103 (21.6%) are endemic. Sixty (58.3%) of the endemics have their distributions exclusively within the AHA. A further 20 have distributions overlapping AHA to a greater or lesser extent. Thus in total 77.6% of all Arabian Peninsula endemics occur within AHA (Table 1).

Rates of endemism vary among groups from 6.1% for birds and 8.9% for mammals to 66.7% for amphibians and 75% for fish. The low level of endemism in breeding birds is perhaps unsurprising, given their generally greater mobility. Eleven of the 12 endemic species have distributions that are restricted to AHA while the other one occurs both there and in the southeast of the Arabian Peninsula. Eight of the endemics are highly range-restricted, occurring only in the narrow band of wooded mountains of south-west Saudi Arabia and Yemen: these mountains are recognized as an Endemic Bird Area (EBA 118 South-west Arabian Mountains; BIRDLIFE INTERNATIONAL 2003). Mammal endemism is also low, at only 8.9%; three of the 10 endemic species are restricted to AHA and two more occur partly there.

According to EGAN (2008), 42 terrestrial species of snake occur in the Arabian Peninsula. This figure includes some species recorded from one location and others known only from a single specimen. Ten species (23.8%) are endemic, with seven of these restricted to AHA and two more whose distribution overlaps it. Thus, 90% of all endemic snake species occur within AHA. Furthermore, 36 of all AP snake species (85.7%) occur within the AHA, an impressive example of species richness.

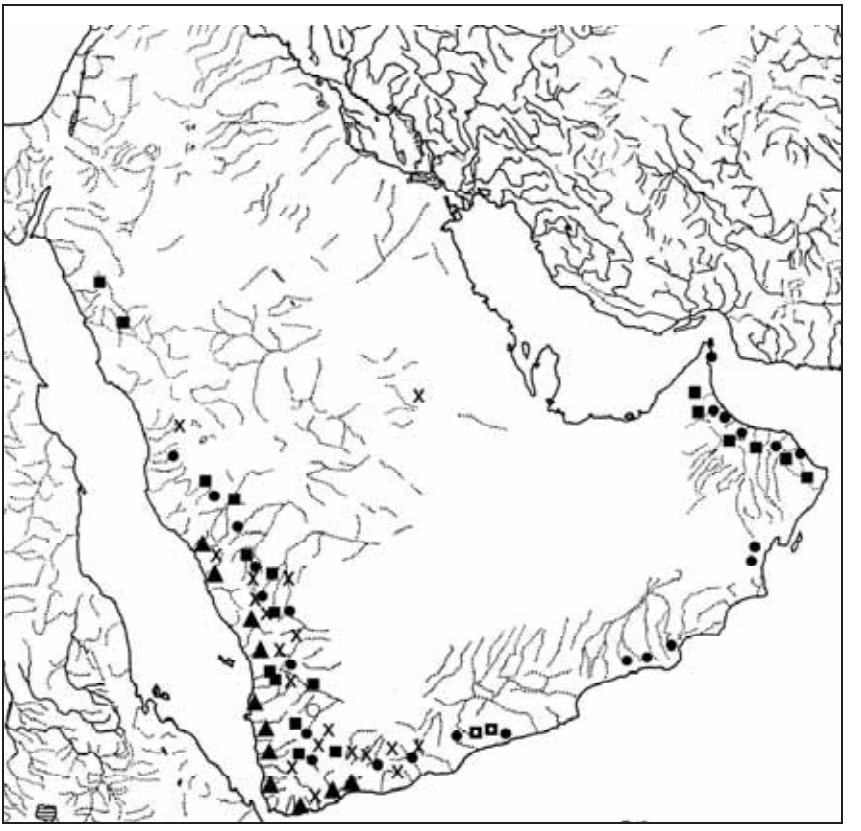

Fig. 2. Approximate distribution of endemic amphibians in the Arabian Peninsula (based on data in ENVIRONMENT AND PROTECTED AREAS AUTHORITY 2003) ■ = *Bufo arabicus*, ● = *B. dhufarensis*, ▲= *B. tihamicus*, ◘ = *B. hadramutinus*, ○ = *B. scortecci*; x = *Euphlyctus ehrenbergii*.

SINDACO & JEREMČENKO (2008) show that 50 (51.5%) out of 97 lizard species occurring in the Arabian Peninsula are endemic, with 25 (50%) of these confined to AHA and a further 12 (24%) whose ranges overlap. ARNOLD (1987) identified five areas of high endemism for reptiles in the Arabian Peninsula, three of which lie in AHA and one partially within it.

Only eight species of amphibians have been recorded in the Arabian Peninsula. Six are endemic and four (three toads and one frog) are confined to AHA. Two of these have extremely restricted ranges: *Bufo hadramutinus* is known from two sites in central southern Yemen and *B. scorteccii* is recorded from a single site, Wadi al Khalili in western Yemen (IUCN 2008). There is thus a close match between AHA and the distribution of endemic amphibians in the Arabian Peninsula (Fig. 2). The two non-endemic species are widely distributed in the Arabian Peninsula, including AHA. Fish also show a low level of species diversity with only 20 species recorded (ENVIRONMENT AND PROTECTED AREAS AUTHORITY 2002, 2003). The rate of endemism, however, is high, (75%); 10 of the 15 endemic species (66.66%) are restricted to AHA and one occurs there and elsewhere.

Table 1. Rates of vertebrate endemism in the Arabian Peninsula (AP) and Arabian Hotspot Area (AH).

	No. of species	No. (%) of endemic species	No. (%) of AP endemics restricted to AHA	No. (%) of AP endemics in AHA and elsewhere	Total no. of AP endemics occurring in AHA
Mammals (excl. marine)	112	10 (8.9%)	3 (30%)	2 (20%)	5 (50%)
Birds (breeding)	196	12 (6.1%)	11 (91.6%)	1 (8.4%)	12 (100%)
Snakes (excl. marine)	42	10 (23.8%)	7 (70%)	2 (20%)	9 (90%)
Lizards	97	50 (51.5%)	25 (50%)	12 (24%)	37 (74%)
Amphibians	9	6 (66.6%)	4 (66%)	2 (33.3%)	6 (100%)
Fish (freshwater)	20	15 (75%)	10 (66.6%)	1 (6.6%)	11 (73.3%)
TOTAL	476	103 (21.6%)	60 (58.2%)	20 (19.4%)	80 (77.7%)

The low species diversity and relatively high rates of endemism in fish and amphibians are unsurprising given the very limited extent of the freshwater resource in the Arabian Peninsula, and its fragmented and isolated character that facilitates development of distinctive forms.

Discussion

The figure for endemic vertebrate species from the selected groups confined to AHA is 58.3%, which compares favourably with the global figure of 42% (MITTERMEIER et al. 2004). When all endemic species with overlapping distributions are included, the figure for AHA rises to 77.7%.

Two broad caveats are necessary concerning the species data. First, two important taxonomic groups, plants and invertebrates, were not incorporated into the original hotspot analysis and these may display differing patterns of endemism compared to what is shown so far. However it seems reasonable to suppose that there is some overlap, given that the western mountains harbour biogeographic refugia and several endemic trees (HALL & MILLER 2011). Second, an analysis based predominantly on species may not take into account the full range of intraspecific genetic diversity present and therefore risks understating the real level of regional distinctiveness.

AHA clearly succeeds on its own terms in highlighting concentrations of endemic species. This raises the issue of the 23 species of endemic vertebrates (22.3%) and, e.g., 50% of endemic mammals, that do not occur within the boundaries of AHA. A review of the data used here shows a smaller concentration of endemic species in the Hajar mountain range of Oman and the United Arab Emirates. Among these are the Arabian Tahr *Hemitragus jayakari*, endemic to south-eastern Arabia, three species of fish, several lizards (SINDACO & JEREMČENKO 2008) and one snake (EGAN 2008). The Hajar range was recognized as one of five centres of endemism for Arabian reptiles by ARNOLD (1987).

In theory, the Horn of Africa hotspot could be extended eastwards to include the Hajar range. The area would then correspond very closely to the WWF Global 200 Ecoregion, Arabian Highlands Woodlands and Shrublands, which includes the Hajar range (OLSON & DINERSTEIN 1998). Another option would be to recognize a second tier of 'regional hotspots' with appropriate criteria and scaled down thresholds. An extended AHA would encompass a higher proportion of the region's endemic species, but still cover only the mountainous rim of the west and south. This comprises a relatively small proportion of the Arabian Peninsula and omits the central and northern deserts of the interior. Deserts – like other biomes such as polar tundra - are inherently unlikely to qualify as global hotspots because their low primary productivity precludes them from reaching the required species thresholds. These so-called 'cold-spots' nonetheless support endemic species and unique communities. This is certainly the case in Arabia, where arid and hyper-arid deserts cover much of the Arabian Peninsula and characteristic regional habitats such as sand dunes and *sabkha* are under-represented or unrepresented in AHA along with their associated biodiversity. The deserts support endemic species and communities, including the iconic Arabian Oryx *Oryx leucoryx* and other species and subspecies with high regional significance such as Houbara Bustard *Chlamydotis mcqueenii* and Arabian Sand Gazelle *Gazella subgutturosa marica.*

The hotspot approach fails to capture some other salient features of regional biodiversity. For example, it focuses on terrestrial biota so marine habitats and species are not included. The Arabian Peninsula also lies on important flyways and has many stopovers for migrating

and wintering birds, among them critical sites for highly threatened species such as Sociable Plover *Chettusia gregaria* and Bald Ibis *Geronticus eremita* (PORTER et al. 2009).

Another issue concerns widely distributed species that are declining within the region. A good example is provided by the 11 species of carnivores in the families Canidae, Felidae and Hyaenidae. The Cheetah *Acinonyx jubatus* is already Regionally Extinct and all except one of the other species is assessed regionally as 2-3 categories more highly threatened than globally (Table 2). The Red Fox *Vulpes vulpes* is the only exception, apparently increasing its range along with expanding human population and listed regionally and globally as Least Concern. This raises again the issue of loss of local distinctiveness, since several forms occurring in the Arabian Peninsula have been named as subspecies e.g. Caracal *Caracal caracal schmitzi*, Striped Hyaena *Hyaena hyaena sultana*, and Grey Wolf *Canis lupus arabs*. While the validity of most of these forms remains unclear, pending confirmation by molecular genetic analysis, research is increasingly demonstrating that locally occurring forms display distinctive characters (e.g. White-tailed Mongoose *Ichneumon albicauda*; FERNANDES 2011). Of course, the widespread loss of large and medium-sized predators has additional and wider implications for biodiversity, not least the threat to fully functioning ecosystems.

The Arabian Hotspot Area identifies a high biodiversity value in the south-west and south of the Arabian Peninsula and its limits can be revised, once syntheses of plant and invertebrate data become available, in order to reflect patterns of endemism across a wider range of taxa. It is not fully representative of the overall biodiversity of the region – but nor does it set out to be. It highlights one important aspect of biodiversity, concentrations of endemic species, and forms an important component, alongside other approaches in developing an integrated regional conservation assessment as outlined by HOLNESS et al. (2011).

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