PATTERNS OF DISTRIBUTION AND ENDEMISM IN IRAN

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ABSTRACT. Some frequently occurring patterns of phanerogamic distribution in Iran are indicated. They are discussed within the three phytochoria of the country—Euro-Siberian, Irano-Turanian and Saharo-Sindian. Endemism in the three regions is considered; the highest levels, up to c. 80% in some genera, are in the Irano-Turanian region; an appendix gives a tentative list of endemic genera—c. 33 in all.

It may seem somewhat premature to discuss significant plant distributions in Iran when our knowledge of its flora is still very far from complete. Scarcely half of the country's modern standard Flora (Rechinger 1963–) has been published and there is much basic collecting still to be done, particularly in the less accessible parts. Nevertheless, the numerous patterns of distribution that are now known amongst Iranian plants, both within the country and without, warrant definition and some preliminary discussion. The final picture will not be clear until all the country's species have been accurately classified, but this is certainly many years ahead.

Any selection of distributional patterns is inevitably a subjective one, based to a considerable degree on one's own knowledge and interests. We have, however, tried to cast our net fairly wide in the examples that we cite. There is a selection of more than 120 families in *Flora Iranica* to choose from, one of us (P.W.) has travelled widely in Iran during a two year spell there, and both of us have considerable experience of the floras of adjacent regions of southwest Asia.

Iran (fig. 1) is a vast country with a total land mass of more than 1·5 million square kilometres, not much less than the combined areas of France, Germany, Spain and Italy. Altitudinally, it ranges from below sea-level on the shores of the Caspian to the 5770 m of Mt Damavand; most of the land is over 1200 m. Climatically, there is the contrast between the humid, almost jungle-like forests of the south Caspian and the arid, in places lifeless, deserts of the Dasht-e-Lut; a temperature range from a winter low of c. −35°C in the north-west to a summer high of c. 50°C on the Persian Gulf. With these extremes of altitude, humidity and temperature, together with considerable variations of rainfall and edaphic conditions throughout the country, there is naturally great diversity and richness in the plant life. Estimating the exact total of phanerogams in Iran is still rather a shot in the dark, but probably it is around the 6000 mark. This compares with an estimated c. 1800 for Iraq, and at least 8000 for Turkey.

For the purposes of this paper, which is based on chorology, we have found it most convenient to consider the distribution patterns separately within the three basic phytogeographical regions of Iran: Euro-Siberian,

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FIG. 1. Map of Iran showing some of the localities more commonly cited in this paper; land over 2000 m is indicated by stippling.

Irano-Turanian and Saharo-Sindian. These three regions, however, should not be thought of as precise entities but rather as a useful framework for discussion. That they have a reality anyone who has travelled in Iran will know, but scarcely surprisingly when one remembers the huge size of the country they defy precise circumscription.

In considering endemism, which after all is merely a restricted distribution of a taxon, we have taken a liberal view of the area reviewed. That is, political frontiers are not regarded as absolute criteria. In addition to the numerous endemic taxa confined to natural areas in Iran, there are many others which have their main distribution within its borders but extend into such adjacent countries as Afghanistan, Pakistan, U.S.S.R., Turkey or Iraq. In such cases, it would be misleading not to designate them as endemics.

Several earlier authors have considered aspects of plant distribution and phytogeography in Iran such as Rechinger (1951), Bobek (1951), Wendelbo (1971) and Zohary (1973). Zohary's *Geobotanical foundations of the Middle East*, in particular, contains a great deal of basic information about plant life in southwest Asia, including Iran, and is a major source of references. What we have tried to do in this paper is to take a more exact look at certain distributions than previous authors were able to do. At an early stage in the work, during the mapping of a considerable number of species, it became quite clear that much more is known about Iranian plant ranges than even ten years ago, largely as a result of the collecting activities of both Persian and European botanists. Equally, however, as this work continues, it will be possible in a decade from now to present considerably more accurate maps and information than given here.

Euro-Siberian

This region of Iran is the most readily defined, both with regard to extent and content, of the three phytochoria in the country. It is also quite clear as far as terminology is concerned, belonging to the Hyrcano-Euxine (or Euxino-Hyrcanian) province of the Euro-Siberian region—even though Zohary (1973, p. 82, map 6) included it in the Pontic province, which is rather a broad concept. Many of its constituent species are of particular interest, not so much for their local Iranian distribution as for their overall ranges and the indications that they give of links with distant areas, both past and present.

Occupying a very small area of the country, it stretches from the Talysh (politically in the U.S.S.R.) in the west to Gorgan in the east; from c. 48° E to c. 56° E. It is an area intimately connected with the climate, particularly to rainfall which ranges from c. 2000 mm in the west to c. 700 mm in the east (Bobek 1952); it should, however, be noted that the rainfall rises much with increasing altitude. There is great uniformity in the overall facies of the vegetation and the constituent species throughout the area, and no subdivisions can usefully be distinguished within it. A general account is given by Gauba (1954/55).

Essentially a Caucasian-Central European broad-leaved deciduous forest, some of the characteristic and common boreal tree genera are *Acer*, *Alnus*, *Carpinus*, *Fagus*, *Quercus*, *Tilia* and *Ulmus*. In general appearance, the Iranian forests are very similar to those of the Black Sea coast of Turkey and adjacent parts of the U.S.S.R.—the other sector of the Hyrcano-Euxine province (Davis 1971). All the woody genera cited above are represented and in many cases the species are the same. In addition, there are numerous other woody and herbaceous species in common. There are, however, some surprising differences. Surprising because there is relatively little distance separating the two areas and many of the species common to both forests are present in an almost complete connecting band across southern Transcaucasia. *Abies*, *Picea* and *Pinus*—important and often dominant trees in the Turkish forests—are totally absent in the Caspian. Absent too from Iran are the rhododendrons that are so characteristic of the wetter eastern end of

N Turkey. Some other Colchic species absent from Iran are: *Daphne glomerata*, *Epigaea gaultherioides*, *Hedera colchica*, *Helleborus orientalis*, several species of *Quercus*, *Salvia forskahlei*, *Staphylea colchica* and *S. pinnata*.

Patterns of distribution and endemism. The most distinctive endemic genus of the area is *Parrotia* (Hamamelidaceae). It is widespread from sea level to c. 1400 m, forms trees up to at least 20 m, and is a frequent and important constituent of the forest vegetation (fig. 9). The genus is closely related to the E Afghanistan, NW Himalayan *Parrotiopsis*. Both are monotypic with no connection to the east and south Asiatic genera of the family. Instead, they are clearly related to the E North American *Fothergilla* with four closely allied species; the three genera forming the tribe *Fothergilleae*. There are many interesting disjunct distributions in the family, some of which are hard to explain, but in this instance the present-day pattern can readily be explained by the contraction of a once widespread pan-temperate distributional area (*Cercis* and *Styrax* have similar world ranges though both are in E Asia).

At present it is not possible to give any accurate figures for specific endemism, although it is certainly very much lower than in the other regions of Iran. There are nevertheless some striking examples of endemics. *Gleditsia caspica*, a frequent species in the forests, has its relatives in China and N America and in this respect shows a certain similarity to *Parrotia*.

Other examples of endemics that are common in the forests are *Quercus castaneifolia* (with a distribution identical to that of *Parrotia*), *Ilex spinigera* (close to the European *I. aquifolium*) and *Buxus hyrcana* (related to the W/C European *B. sempervirens*). It is of interest to note that among the herbs of the lowland and montane forests it is rather difficult to cite good examples of distinctive specific endemics, although *Scrophularia megalantha* may be one, and *Crocus caspica* another. However, the number of endemics is clearly much higher in the upper parts of the *Fagus orientalis*/*Quercus macranthera* forest, and above it. *Alyssopsis* is an example of an endemic monotypic genus; endemic species are *Crocus gilanicus*, *Fritillaria kotschyana*,

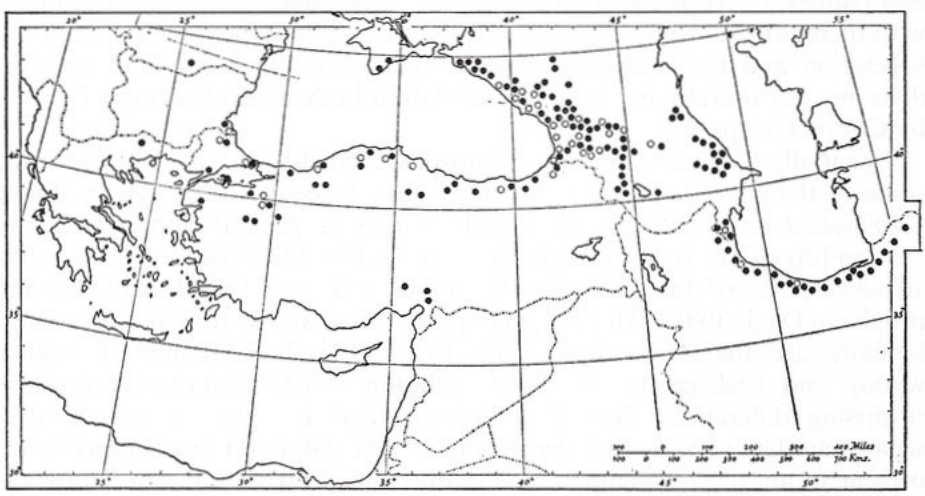

FIG. 2. Total distributions of ○ *Vaccinium arctostaphylos* and ● *Fagus orientalis*; the north-western limits of the *Fagus* are approximate and areas of introgression with *F. sylvatica* are not shown.

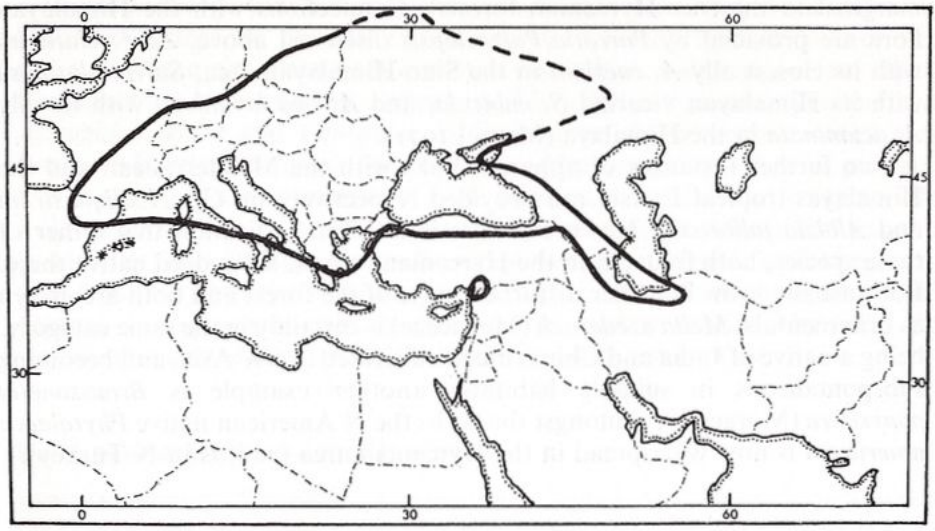

FIG. 3. Total range of *Salvia glutinosa*.

Lilium ledebourii, *Ornithogalum bungei*, *Saponaria bodeana* and the very isolated *Solanum kieseritzkii*.

A number of the cited examples of specific endemics by earlier authors are either of doubtful taxonomic status or are more widespread than previously believed. For example, *Teucrium hyrcanum* is now known from gatherings in the north-east of Turkey; and *Origanum hyrcanum* is not different from the widespread *O. vulgare* subsp. *viride*.

The endemics cited above indicate the individuality of the area but there are many other characteristic distributions amongst more widespread species. Indeed the main impression of the forests is that they show very clear links with the Caucasian/north Turkish, or Colchic territory. Specific examples are provided by *Pterocarya fraxinifolia*, *Acer cappadocicum*, *Zelkova carpinifolia*, *Vaccinium arctostaphylos* (fig. 2) *Paeonia wittmanniana*, *Daphne pontica* (recently discovered in Iran), *Epimedium pinnatum* (subsp. *pinnatum* in the Hyrcanian forests and subsp. *colchicum* in the NE Turkey area), *Andrachne colchica* and *Euphorbia macroceras* (though absent from Turkey). Comparable examples but with a wider range are: *Fagus orientalis*, extending into SE Europe and, disjunct from its main area, in the Amanus and Ala Dagh of southern Turkey (fig. 2); *Prunus laurocerasus* (*Laurocerasus officinalis*) and *Acer hyrcanum* have a similar range extending to the Balkans. With still wider but characteristically Euro-Siberian distributions are: *Salvia glutinosa* (fig. 3), *Calamintha grandiflora*, *Carpinus betulus*, *Acer platanoides*, *Mespilus germanica*, *Daphne mezereum* (and the closely related, if not identical, *D. rechingeri*), *Euphorbia amygdaloides* and *Lathraea squamaria*.

In addition to the examples given above, there are Hyrcanian forest species which extend far outwith the Euro-Siberian region, or whose relatives are far beyond it. Those with sub-Mediterranean links are *Castanea sativa* (not included in the *Flora Iranica* account of the family—see Assadi & Wendelbo, 1977—and *Cupressus sempervirens*, although where this species grows is

marginal to the true Hyrcanian forests). Connections with the Himalayan flora are provided by *Parrotia/Parrotiopsis* discussed above, *Acer velutinum* with its closest ally *A. caesium* in the Sino-Himalayan area, *Salvia glutinosa* with its Himalayan vicariad *S. nubicola*, and *Atropa belladona* with its ally *A. acuminata* in the Himalaya (Meusel 1971).

Two further instances of apparent links with the Mediterranean and the Himalayas-tropical E Asia are provided respectively by *Cercis siliquastrum* and *Albizia julibrissin*. However, there is no clear indication that either of these species, both frequent in the Hyrcanian forests, are indeed native there. Both usually grow in rather disturbed parts of the forest and both are grown as ornamentals. *Melia azedarach* (Meliaceae) is certainly in the same category, being a native of India and China, much cultivated in SW Asia, and becoming subspontaneous in suitable habitats; another example is *Broussonetia papyrifera* (Moraceae). Amongst the herbs the N American native *Phytolacca americana* is now widespread in the Hyrcanian area (as it is in N Turkey).

Irano-Turanian

This region covers about 9/10ths of Iran and contains by far the greatest number of genera and species. It is an extremely diverse area of high plateau with plains, deserts and low mountains surrounded in part by high massifs. The characteristic Irano-Turanian genera *Astragalus*, *Acantholimon*, and *Cousinia* are represented here by huge numbers of species of which, in the two latter genera up to c. 80% are endemic (Table 1). *Acanthophyllum*, *Allium*, *Eremurus*, *Dionysia*, *Ferula*, *Nepeta*, *Stachys* and *Tulipa* are other genera typical of the region with high levels of specific endemism. The present authors (1970) and P.W. (1971) have given some isoflor maps for some of these genera whose overall ranges closely correspond to the Irano-Turanian region. We stressed in these papers the extreme importance of the C Asiatic area as a centre of speciation and maximum morphological diversity. In general as one moves away westwards from this matrix area, levels of diversity and endemism in numerous genera progressively decrease.

TABLE 1

Some typical Irano-Turanian genera with species totals and endemism figures for the political areas of Iran and Turkey. Note how few species are common to the two countries.

	Species in		no. in	% endemism	
	Iran	Turkey	common	Iran	Turkey
Acantholimon	84	26	7	80	54
Allium	77	—	22	23	—
Cousinia	192	38	6	83	68
Dionysia	24	2	1	88	50
Ferula	23	17	3	43	48
Gypsophila	28	49	8	44	56
Nepeta (annuals)	20	1	1	65	0
Scorzonera	51	39	12	41	44
Tragopogon	29	18	4	55	33

In Iran, the distribution patterns are largely regulated, in addition to historical factors, by climatic and edaphic conditions. Special soils or bed rocks, for example, often have isolated, distinctive, endemics—a fact which Rechinger has stressed in several papers. The gypsum soils near Semnan have *Astragalus fridae* and *Centaurea lachnopus*; on the serpentine rocks near Torbat-e-Heydariyeh grow *Diaphanoptera khorasanica* and *Jurinea pungens*.

It is very difficult to satisfactorily fit all the known distribution-types into a clear-cut and limited number of groups. What we have done in this paper is to consider them under two main headings, based on altitude, montane/alpine and desert; within them we recognise further intergrading sub-groups. In general, we have restricted our examples to herbaceous/shrubby taxa; the woody plants were reviewed by Bobek (1951) and Zohary (1963).

Patterns of distribution and endemism

MONTANE/ALPINE. There are c. 24 genera endemic to the montane/alpine part of Iran; it should, however, be stressed that this is a provisional total since some of the genera are of questionable status and the real total will probably turn out to be rather less. The 12 endemic genera of Cruciferae are of special interest for their distributional patterns. The Cruciferae are better known and better represented in collections than most families (Hedge & Rechinger 1968; Esfandiari 1976) and their characteristic ranges frequently occur in many other families. For these reasons we have paid special attention to them.

We recognise five primary integrading patterns of distribution/endemism within the montane/alpine area of the Irano-Turanian region.

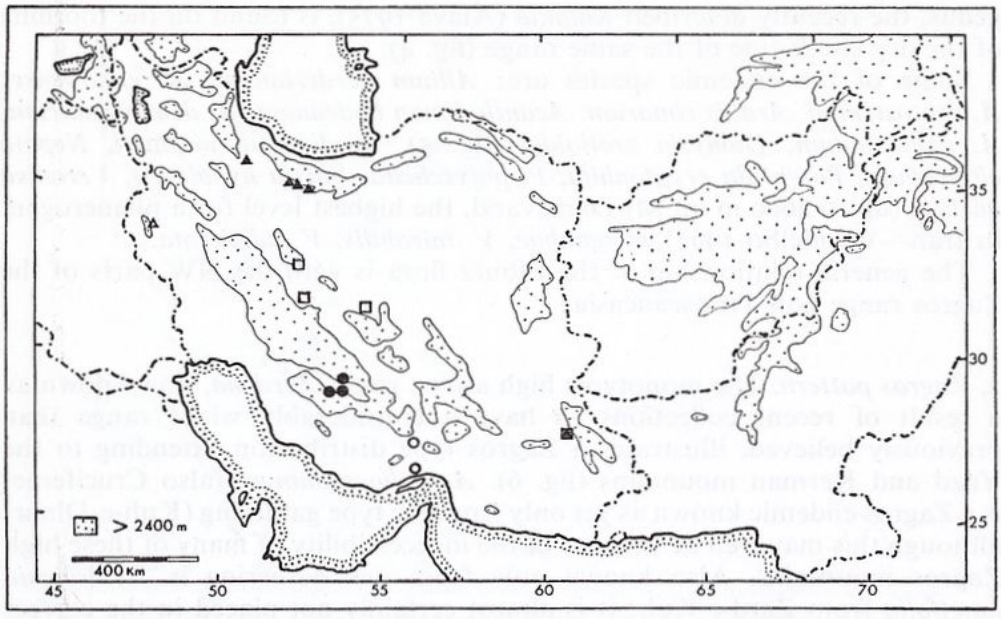

FIG. 4. The distribution of some endemic, monotypic, Iranian genera: □*Heliocarya* (Boraginaceae); ●*Hypericopsis* (Frankeniaceae); ▲*Kalakia* (Umbelliferae); ■*Karvandarina* (Compositae); △*Zeugandra* (Campanulaceae); ○*Zhumeria* (Labiatae).

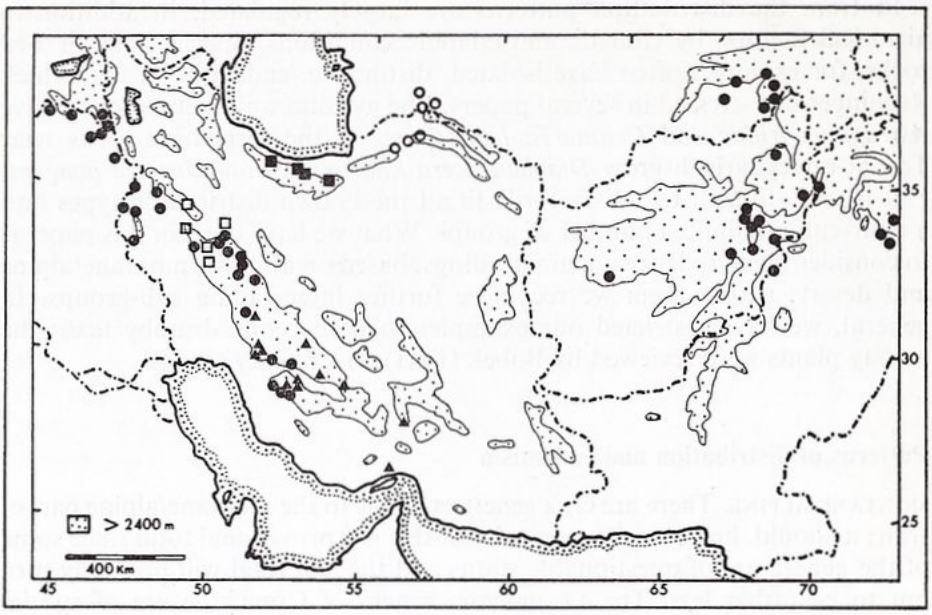

FIG. 5. Total distribution of three related species of *Dionysia*: ■ *D. aretioides*; □ *D. leucotricha*; ▲ *D. revoluta*. Distribution of ● *Fritillaria imperialis* (the total range in C Asia is not shown) and ○ *F. raddeana*.

1. *Elburz pattern.* The monotypic *Elburzia* (Hedge 1969) has a limited distribution in the central Elburz from c. 1800–3000 m. Another monotypic genus, the recently described *Kalakia* (Alava 1975), is found on the foothills of the dry south side of the same range (fig. 4).

Some of the endemic species are: *Allium derderianum*, *A. elburzense*, *A. scotostemon*, *Arabis rimarum*. *Acantholimon bodeanum*, *A. demawendicum*, *A. ophiocladum*, *Dionysia aretioides* (fig. 5), *Erodium dimorphum*, *Nepeta elbursensis*, *Potentilla cryptophila*, *P. polyschista*, *Salvia hypoleuca*, *Veronica aucheri* (up to 4600 m on Mt Damavand, the highest level for a phanerogam in Iran—Wendelbo 1962), *V. gaubae*, *V. mirabilis*, *V. paederota*.

The general relationship of the Elburz flora is with the NW parts of the Zagros range and Transcaucasia.

2. *Zagros pattern.* The monotypic high alpine genus *Zerdana*, now known as a result of recent collections to have a considerably wider range than previously believed, illustrates a Zagros type distribution extending to the Yazd and Kerman mountains (fig. 6). *Acanthocardamum* (also Cruciferae) is a Zagros endemic known as yet only from the type gathering (Kuh-e-Dinar) although this may well be because of the inaccessibility of many of these high Zagros mountains. Also known only from one gathering is *Heldreichia longifolia* from Zard-e-Kuh; it is almost certainly not placed in the correct genus, the other species being in west and south Turkey, and probably represents another monotypic genus. *Brossardia* grows at lower altitudes in the Zagros from near Shiraz in the south to Azerbaijan and Iraqi Kurdistan.

Two other Crucifer genera with limited ranges are *Pseudofortuynia* and *Straussiella*.

Some examples of species endemics are:

Acantholimon melananthum
,, *scabrellum*
,, *schirazianum*
Allium hirtifolium
,, *kirindicum*
,, *longivaginatum*
Bellevalia tristis
Cousinia sect. *Albidae*
,, *araneosa*
Daphne stapfii
Dionysia bryoides
,, *caespitosa*
,, *leucotricha* (fig. 5)
,, *revoluta* (fig. 5)
Fritillaria reuteri
Nectaroscordum koelzii
Nepeta chionophila
Potentilla elvendensis
Rosularia elymaitica
,, *globulariifolia*
Stachys benthamiana
Tragopogon bakhtiaricus

Detailed mapping would certainly show great differences in the distribution of these taxa: some are widely scattered, some restricted to the east or west, and others restricted to particular mountains such as Oshtaran Kuh, Kuh-e-Dinar and Zard-e-Kuh (see above). The monotypic *Pseudofortuynia esfandiarii* is distributed marginally on the inner drier ranges of the Zagros (fig. 6); *Heliocarya monandra*, also monotypic (Boraginaceae), is restricted to the low dry mountains of the Esfahan area (fig. 4) and is not a true Zagros plant.

The mountains of Yazd and Kerman are geographically isolated but may be considered as extensions of the Zagros range. *Zerdana*, mentioned above, extends to these mountains and there are many other examples showing this connection. However, their isolated position is shown by the following endemics:

Yazd: *Acantholimon nigricans*, *Dionysia curviflora*, *D. janthina*.

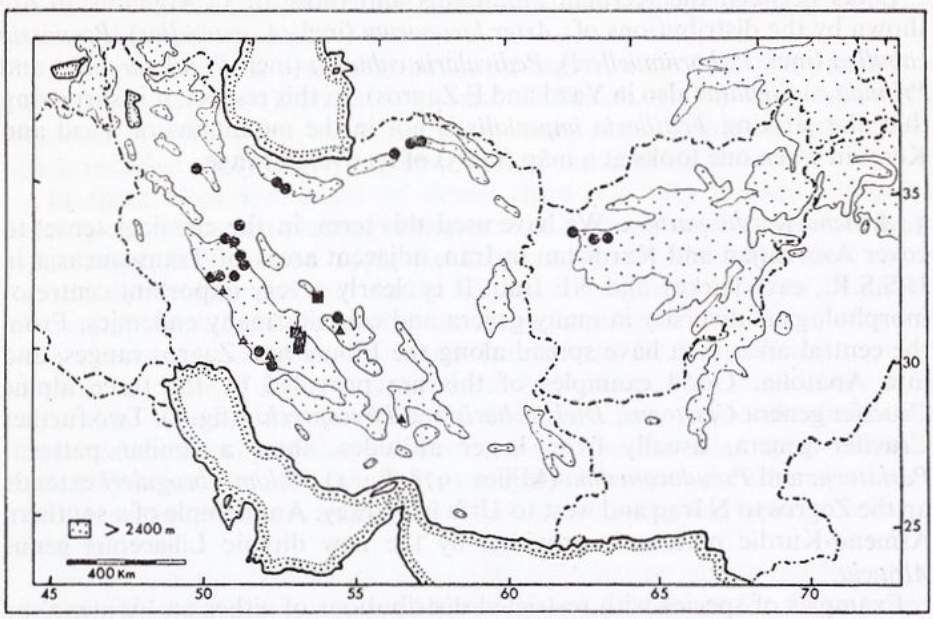

FIG. 6. Total distribution of three Cruciferae genera: ● *Chalcanthus* (the stations in Syr-Darya and the Zeravschan area of the USSR are not indicated); ■ *Pseudofortuynia*; ▲ *Zerdana*.

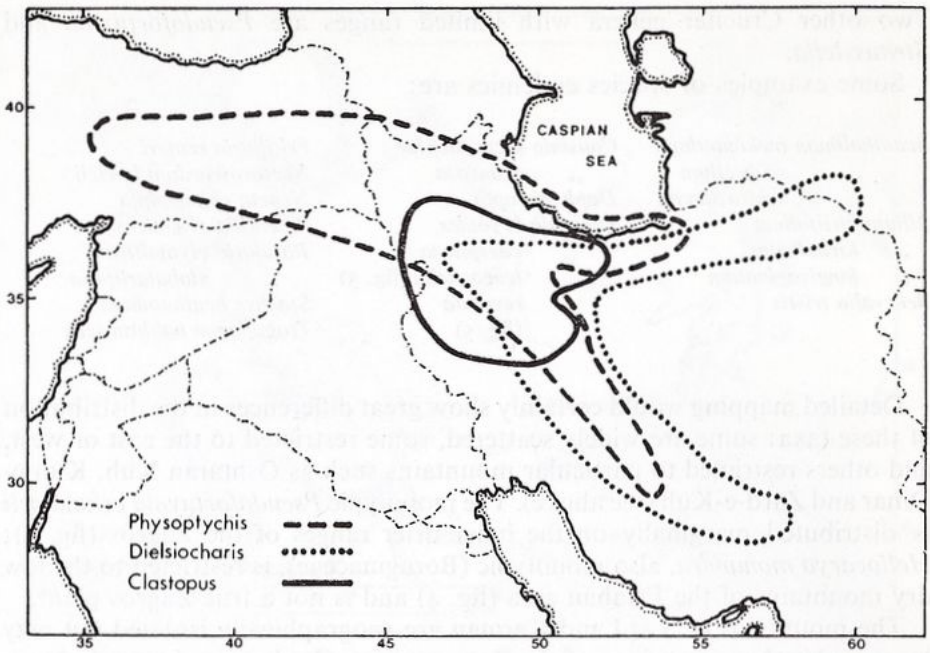

FIG. 7. Total ranges of three alpine Cruciferae genera: *Dielsiocharis*; *Clastopus*; *Physoptychis*.

Kerman: *Acantholimon cupreo-olivascens*, *A. modestum*, *Allium lalesarensis*, *Cousinia fragilis*, *Dionysia oreodoxa*, *D. rhaptodes*, *Nepeta assurgens*, *Rosularia modesta*, *Salvia lalesarica* (very close to the C Afghan *S. rhytidea*).

Links between the Kerman mountains and those of C Afghanistan are shown by the distributions of: *Aster lacunarum* (incl. *A. asterellus*), *Parnassia cabulica* (incl. *P. bornmuelleri*), *Pedicularis cabulica* (incl. *P. lalesarensis*) and *Primula capitellata* (also in Yazd and E Zagros). In this respect, it is surprising that the striking *Fritillaria imperialis* is not in the mountains of Yazd and Kerman when one looks at a map (fig. 5) of its overall range.

3. *Armeno-Kurdic pattern*. We have used this term, in the classical sense, to cover Azerbaijan and Kurdistan in Iran, adjacent areas of Transcaucasia in U.S.S.R., east Turkey and NE Iraq. It is clearly a very important centre of morphological diversity in many genera and contains many endemics. From the central area, taxa have spread along the Elburz and Zagros ranges, and into Anatolia. Good examples of this are provided by the three alpine Crucifer genera *Clastopus*, *Dielsiocharis* and *Physoptychis* (fig. 7). Two further Crucifer genera, usually from lower altitudes, show a similar pattern: *Parlatoria* and *Pseudocamelina* (Miller 1978, fig. 1). *Phlomis bruguieri* extends up the Zagros to N Iraq and west to Urfa in Turkey. An example of a southern Armeno-Kurdic pattern is provided by the new ditypic Liliaceous genus *Alrawia*.

Examples of species with restricted distributions of either an 'Armeno' or 'Kurdic' type are: *Allium cardiostemon*, *Bellevalia tabrizana*, *Hyoscyamus leptocalyx*, the remarkable relict *Salvia aristata*, *S. sahendica*, *Scilla persica* and *Viola pachyrrhiza*. At the other extreme, the following are taxa which

clearly have an Armeno-Kurdic centre and spread out widely from it: *Iris* subsect. *Oncocyclus*, *Bellevalia pycnantha*, *Corydalis verticillaris* s.l. and *Ornithogalum arcuatum*.

Numerous other examples could be cited within this sub-heading.

4. *Khorassan pattern*. This area, including Kopet Dagh, is clearly an important meeting point for C Asiatic and Elburz plants. Many species have their western and eastern limits respectively in these mountains. The relationships of the endemics also reflect these dual links. A selection of endemic species is:–

Acantholimon khorassanicum	*Cousinia* sect. *Platyacanthae*	*Hyacinthus litwinowii*
,, *raddeanum*	,, *euchlora*	*Iris fosterana*
Allium cristophii	*Dionysia kossinskyi*	*Salvia chorassanica*
,, *kopetdagense*	*Fritillaria raddeana*	*Tulipa micheliana*
Corydalis chionophila	(fig. 5)	

5. *Pan-mountain pattern*. The last of the categories we recognise within the montane/alpine part of the Irano-Turanian region is that of species which are widespread in all the high mountains of Iran. A good example is provided by the endemic *Allium scabriscapum* (Wendelbo 1971, fig. 7). Similarly, *Chalcanthus renifolius* (fig. 6) and *Matthiola alyssifolia* are quite widely distributed in the same mountains; in both instances the species are also in Afghanistan and C Asia, where indeed the relatives of the endemic *Allium* grow.

With our present knowledge this does not seem to be one of the commoner distribution patterns.

DESERT. That there is rather a clear distinction between the montane/alpine division discussed above and the desert one is indicated by the poor representation in the latter of the giant Irano-Turanian genera *Acantholimon*, *Astragalus* and *Cousinia*.

It is only in recent years that botanical exploration of the great deserts or subdeserts of Iran (Dasht-e-Kavir and Dasht-e-Lut) has risen above the haphazard level. These new collections, many made within the last decade, have revealed many interesting new facts of distribution.

In these often vast tracts of desert there is a very marked difference, ecologically, between plants growing on sand, gravel/stone or salt substrates (Rechinger & Wendelbo 1976; Rechinger 1977). Floristically, most of the species are widespread and clearly fall into two types: those of C Asiatic, Turanian, origin; and those of Saharo-Sindian origin. The Turanian species either reach their southern limits in N Iran, N or NW Afghanistan, or extend all the way from C Asia through Iran to NW Africa. The importance of the Turanian elements in the flora of Iran has not previously been fully appreciated. Details of the northern limits of the Turanian desert flora are given by Musayev (1968) who uses examples largely in the Chenopodiaceae and *Artemisia* (taxa not considered by us) in analysing the representatives of this province.

Because of the absence of up-to-date information about the halophytes (mostly belonging to the Chenopodiaceae, not yet revised for *Flora Iranica*) and also because of special ecological problems connected with them, we have restricted our review of the desert plants to those from sand and gravel habitats.

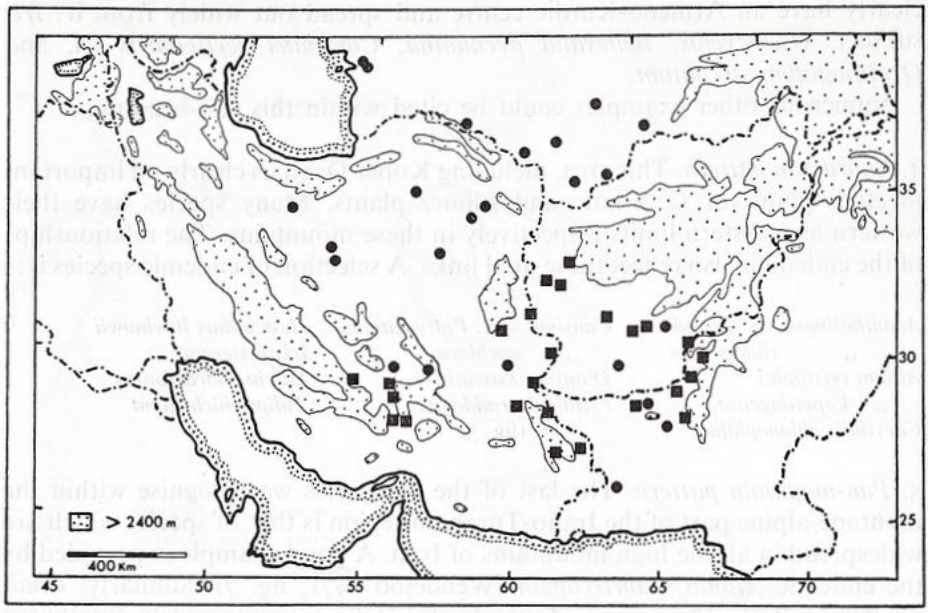

FIG. 8. Total distribution of ■*Stocksia* (Sapindaceae) and range of ●*Spirorrynchus sabulosus* in Iran and adjacent areas.

Psammophytes. Examples of species which in Iran seem to be restricted to sandy areas of the northern margins of the Dasht-e-Kavir are:

Agriophyllum minus	*Corispermum lehmannianum*	*Salsola aperta*
Chrozophora gracilis	*Horaninowia ulicina*	*Smirnovia turkestana*
Convolvulus eremophilus	*Heliotropium acutiflorum*	(Rech. 1977, p. 176).

All except the endemic *Convolvulus* have their main ranges in the vast deserts of the Aralo-Caspian, Kara Kum, Kizyl Kum, etc., in Soviet C Asia.

Four most distinctive Crucifers, *Cithareloma lehmannii* s.l., *Octoceras lehmannianum*, *Spirorrhynchus sabulosus* (fig. 8) and *Streptoloma desertorum*, all widespread in the C Asiatic deserts, are now known to grow around the Dasht-e-Kavir and Dasht-e-Lut thence to SW Afghanistan and Pakistan Baluchistan. The curious annual Labiate *Chamaesphacos ilicifolius* and *Allium borszczowii* have similar distributions.

Examples of wider ranging C Asiatic genera are provided by *Calligonum* and *Haloxylon*. There are species which extend from C Asia through Iran to Iraq, Palestine, Sinai and N Africa. *Calligonum comosum* reaches to the deserts of Libya and Tunisia; *Haloxylon persicum* does not extend beyond Sinai. A paper by Musayev & Soskov (1977) gives an account of the geography, and phylogeny, of *Calligonum* with several detailed maps.

Turning from the Turanian species, which are certainly much more numerous, to a Saharo-Sindian one, a good example is the Crucifer *Schimpera arabica*. It has a wide range all the way from Egypt to Iraq, Arabia and Palestine extending northwards as far as the NW margin of the Kavir, SE of Siah Kuh.

Gravel plants. The term gravel is used here in a wide sense to cover both plants of gravel and rock outcrops of the desert/subdesert areas.

One of the most interesting plants in this category is the semi-shrubby Crucifer *Fortuynia*. This monotypic endemic genus clearly has its origins and allies in the Saharo-Sindian region, but in Iran it extends far outwith that territory into any suitable sub-desertic niche of the Irano-Turanian region (fig. 9). In some localities at the northern limits of the Kavir it is co-dominant with *Artemisia*.

Another species with indisputable Saharo-Sindian allies is the endemic dwarf shrub *Salvia eremophila*; in Iran it grows as far north as Kashan and Ali-Abad. *Moricandia sinaica*, mostly in SW Iran and with clear N African connections, has recently been discovered far to the north in the Kavir; *Gymnarrhena micrantha* (Compositae) provides a similar range penetrating north and northwest to the Kavir—it is also in SW Afghanistan.

In contrast to the above examples of species with Saharo-Sindian links, there are other species which are clearly of Turanian stock and extend in a south or south-easterly direction into Iran. The woolly-fruited Crucifer *Lachnoloma lehmannii* exemplifies this type; although it generally grows on stony or gravelly places in Iran, in C Asia it sometimes occurs as a psammophyte. Other instances of Turanian links are provided by the endemic *Paracaryum salsum*, the sub-endemic *Eremurus luteus* (Wendelbo 1971, fig. 5) stretching down to the north margins of the Dasht-e-Lut, and the endemic *Cousinia piptocephala* (also found on sand) reaching as far south as Kerman.

Of particular interest in this section is the distribution of the monotypic *Stocksia*. It has a restricted endemic range in SE Iran, adjacent parts of Afghanistan and Pakistan Baluchistan (fig. 8). A member of the mainly tropical Sapindaceae, in Iran it is squeezed in between the Dasht-e-Lut and the area of the Saharo-Sindian region.

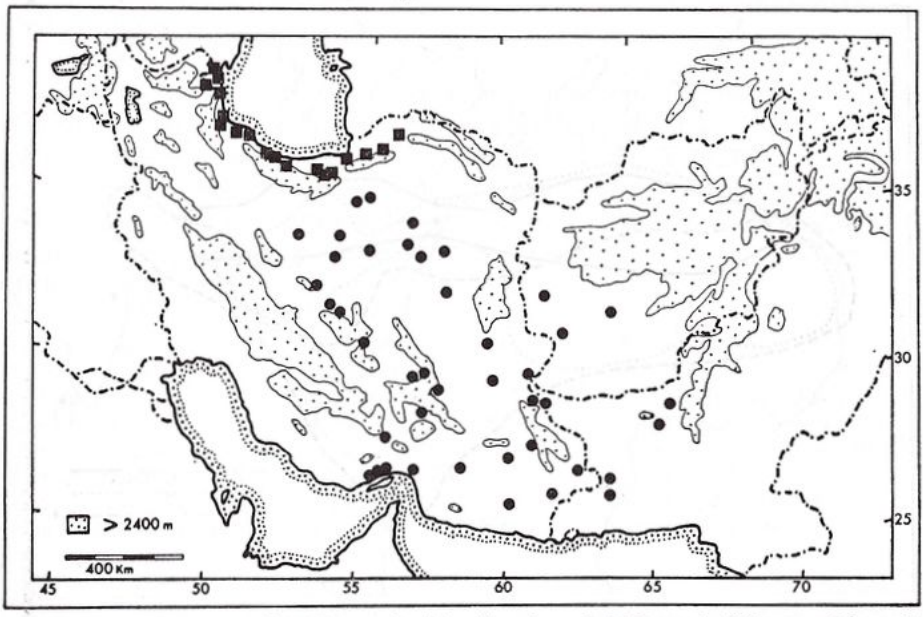

FIG. 9. Overall ranges of ●*Fortuynia* (Cruciferae) and ■*Parrotia* (Hamamelidaceae). The recently discovered locality of the latter in the Caucasus is not mapped. See *Bot. Zhurn.* 62:248–250 (1977).

Saharo-Sindian

The most problematical phytogeographical region in Iran, or at least the one which has suffered most from the vicissitudes of nomenclature, is that of the belt stretching along the southwest of the country near the Persian Gulf. The terms Saharo-Sindian, date-palm zone, Saharo-Arabian, Sudanian, Saharo-Indian, Nubo-Sindian and Sudano-Deccanian have variously been applied to all or part of the area. Zohary with his very wide experience of the vegetation of SW Asia has, in his most recent work (1973), recognised only a Sudanian region in Iran. He also indicated Saharo-Arabian species here but no such territory. This is not the place to discuss in any detail the history and usage of the terms given above (Zohary has already done this), but on the evidence now available there is much to be said for the older Eig term of Saharo-Sindian. Although it is not an ideal term, it does at least indicate that there is in many cases a west to east continuum from NW Africa to the deserts of Sind (see also Monod 1964). Many species or genera extend in a broad belt from Morocco through Arabia and S Iraq to Iran, Pakistan and Sind. Within this broad Saharan floristic belt, which may dip southwards to the Horn of Africa, topographic, edaphic and climatic conditions are relatively similar over large areas.

Some of the constituent taxa of this zone are clearly northern temperate in origin, others are equally clearly tropical. For example, many genera of Cruciferae, very characteristic of this region, are temperate, whereas members of such families as the Capparaceae and Zygophyllaceae, equally characteristic, are tropical in their origins and affinities. This intergradation between holarctic and palaeotropic is a feature of this region. No clear line can be drawn between them as far as patterns of distribution are concerned.

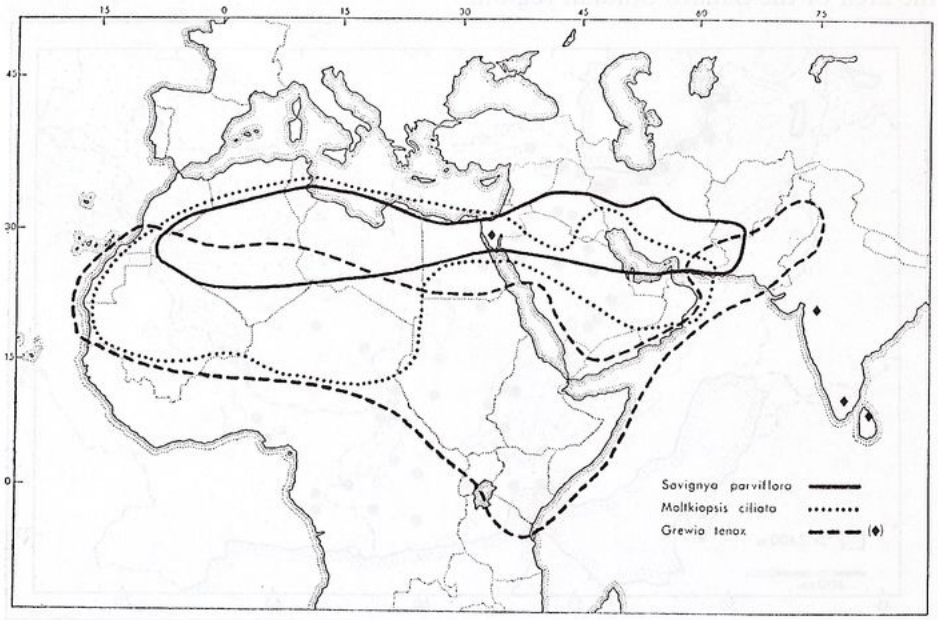

FIG. 10. Total distribution of *Savignya* (Cruciferae); *Moltkiopsis ciliata* (Boraginaceae); *Grewia tenax* (Sapindaceae). Lebrun (1977) gives dot distribution maps of the latter two species.

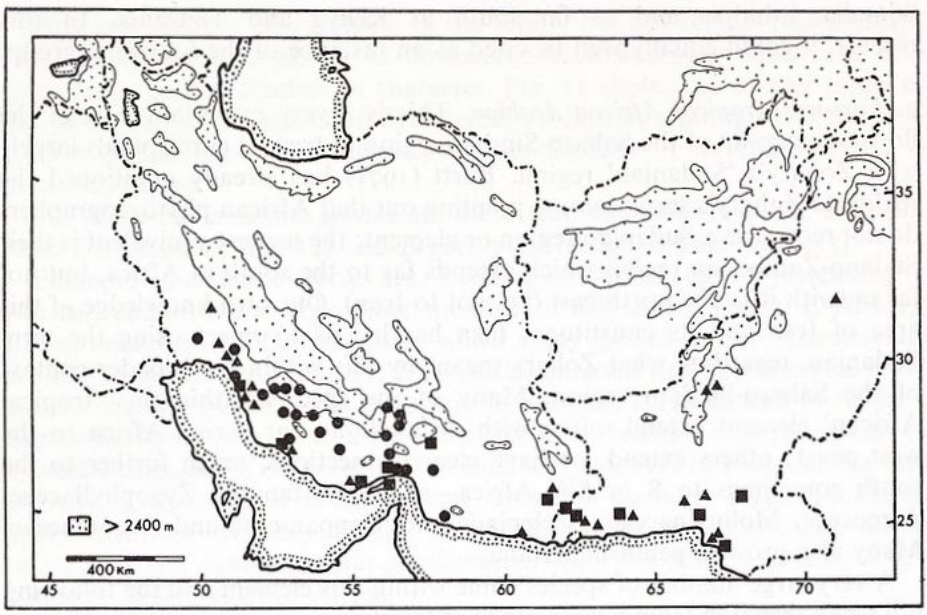

FIG. 11. Total ranges of ● *Dicyclophora* (Umbelliferae) and ▲ *Physorrhynchus* (Cruciferae)—the latter genus is now known from Oman. The Iranian distribution of ▩ *Cometes surattensis* (Illecebraceae) is also shown; its only other stations are in Oman.

In Iran, this region extends at lower altitudes in a belt of varying width all the way along the Persian Gulf from the border of Iraq (Khuzistan) to that of Pakistan Baluchistan. As hinted above, it contains a complex mixture of intergrading elements, of which for ease of discussion we have recognised four: North African/Arabian; East-west-tropical African/Arabian; Endemic; Mediterranean.

1. *North African/Arabian.* There are a large number of herbaceous or semi-shrubby species in this category which extend from Morocco, or occasionally from the Canary Islands, to Pakistan—a distance of up to 8000 km. There are several monotypic genera restricted to this broad zone, many endemic species, and many genera are represented by vicarious species across the belt. Some reach as far south as the mountains of Ahaggar and Tibesti. A selection of these widespread species is:

Anastatica hierochuntica (Hedge 1976, fig. 5)
Anvillea garcinii
Asteriscus pygmaeus
Citrullus colocynthis
Eremobium aegyptiacum
Geranium trilophum
Gymnarrhena micrantha
Gymnocarpus decander
Helianthemum lippii
Launea nudicaulis
Lycium shawii
Moltkiopsis ciliata (fig. 10)
Monsonia nivea
Moricandia sinaica
Neurada procumbens
Pteranthus dichotomus
Rumex vesicarius, cyprius
Salvia aegyptiaca (Davis & Hedge 1971, fig. 2)
Savignya parviflora (fig. 10)
Schimpera arabica (not in NW Africa)
Sclerocephalus arabicus
Senecio desfontainei

An interesting example of a c. 8 species genus with this type of broad distribution, but extending much further south, is *Farsetia* (Hedge 1976, fig. 7). Most of its species are closely related and grow throughout the Sahara to

Somalia, Ethiopia and as far south as Kenya and Tanzania. In this respect, it could equally well be cited as an instance of the following group.

2. *East-west-tropical African/Arabian.* This is a very important part of the floristic make-up of the Saharo-Sindian region in Iran. It corresponds largely with Zohary's 'Sudanian' region. Burtt (1971) has already questioned the reality of Zohary's terminology, pointing out that African phytogeographers do not recognise a Sudanian region or element; the nearest equivalent is their Sudano-Zambesian region which extends far to the south in Africa, but not far outwith it to the north-east (i.e. not to Iran). Our own knowledge of this area of Iran and its constituent taxa has led us to reject using the term Sudanian, regarding what Zohary meant by this within the broader context of the Saharo-Sindian region. Many of the species within this 'tropical African' element extend, often with disjunctions, far across Africa to the west coast; others extend, or have clear connections, much further to the south sometimes to S or SW Africa—as in the families Zygophyllaceae, Aizoaceae, Molluginaceae, Asclepiadaceae, Capparaceae and Acanthaceae. Many also grow in peninsular India.

A very large number of species come within this element and the following is a small selection from a wide range of families:

Blepharis persica
Calotropis procera
Capparis cartilaginea
,, *decidua*
Caralluma edulis
Cocculus pendulus
Commicarpus stenocarpus
Cymbopogon olivieri
Grewia tenax (fig. 10)
Launea massauensis
Lavandula coronopifolia
Leptadenia pyrotechnica
Ochradenus baccatus
Onychium divaricata
Salvadora persica
Sporobolus arabicus
Tavernia glabra
Tephrosia appolinea
Withania somnifera

The species of this element are very widely dispersed with no repetitive clear pattern other than being widely distributed in subtropical and tropical parts of the Old World. In Iran they grow quite intermixed with the species of the previous N African/Arabian element.

One of the most characteristic features of the landscape in the Gulf area of Iran, particularly in the southernmost parts, is the frequent presence of *Acacia* trees. A detailed knowledge of their taxonomy and overall distribution is a major desideratum towards a fuller understanding of this element and the region.

3. *Endemic.* There are only four clearly endemic genera in the region: *Zhumeria*, of restricted range; *Physorrhynchus*, extending well into Pakistan, *Ergocarpon* and *Dicyclophora*, which is quite widespread in SW Iran. A further endemic genus, *Karvandarina*, is not obviously within Saharo-Sindian territory.

Zhumeria (Rechinger & Wendelbo 1967; Bokhari & Hedge 1976) was first discovered as recently as 1966, and provided one of the most remarkable botanical finds in SW Asia in recent years. Known only from a limited number of gatherings in the Bandar Abbas region (fig. 4), it has no affinity with any known Labiate genus and is obviously a most isolated relic. It is also not possible to suggest a floristic region with which it has a phylogenetic connection.

Physorrhynchus is also isolated in the family but has certain relationships with the N African genera of Brassiceae-Moricandiinae which are predominantly Saharo-Sindian in character. Fig. 11 shows the overall range of the genus. A second genus of Cruciferae, *Fortuynia*, although not confined to this region (fig. 9) is certainly Saharo-Sindian in its character; it is discussed above.

The other two endemic genera are those curious members of the Umbelliferae *Dicyclophora* (fig. 11) and *Ergocarpon* (Hedge & Lamond 1973).

Examples of endemic species are: *Cometes surratensis*, fig. 11, (extending to Muscat, and with the only other member of this odd genus in E Africa); *Convolvulus spinosus* (several other allied spiny species of Ser. *Acanthocladi* are also endemic in this region); *Diceratella canescens* and *floccosus* (the other closely similar species in the genus are in Socotra, E Africa and N Africa); *Euphorbia larica* (related to a species in tropical Arabia); *Grantia aucheri* (a typical Composite of the Iranian Gulf area with relatives in Iran, Arabia and N Africa); *Pycnocycla nodiflora* and *Otostegia aucheri*—atypical-looking, spiny members of, respectively, the Umbelliferae and Labiatae; *Salvia mirzayanii* and *Schweinfurthia papilionacea*, with the other 3 species of the genus in Arabia and NE Africa.

4. *Mediterranean.* There are quite clear indications of typically Mediterranean species in the Gulf region of Iran. Whether they, in many cases, are completely indigenous or not is impossible to say, but there is no doubt about their present-day occurrence. Most of them are herbaceous and not a few are annuals; some occur as weeds, others at the edges of fields, but several are in more or less natural vegetation. Closer study of the Mediterranean influence in Iran would probably yield interesting results.

Some examples are:

Anemone coronaria	*Hymenocarpus circinnatus*	*Ranunculus asiaticus*
Asphodelus tenuifolius	*Hippocrepis bicontorta*	*Scorpiurus muricatus*
Biscutella didyma	*Ononis sicula*	*Urginea maritima*

Some of these plants are also found in the adjacent parts of the Irano-Turanian region where a Mediterranean influence is even more obvious.

Other instances of links with Mediterranean flora which do not occur in this region are provided by: *Cercis siliquastrum*, which in Iran is known from the Zagros forests and the Caspian forests (see above); *Cupressus sempervirens* occurring in scattered outposts marginal to the Caspian forests (see above) and, a recent discovery, in the Zagros (Bokhari 1975); *Anagyris foetida* and *Salvia viridis* (*S. horminum*).

Anomalous Distributions and Affinities

In most floras of a complex nature, there occur present-day distributions which, with our poor knowledge of the geological past, are hard to understand. This is certainly true for Iran and a few of these anomalies are now listed without comment.

A typical and often dominant species in the SW of Iran in Irano-Turanian zones bordering Saharo-Sindian territory is *Ebenus stellata*. It is the sole member of sect. *Tragacantha* and endemic to Iran and adjacent Oman.

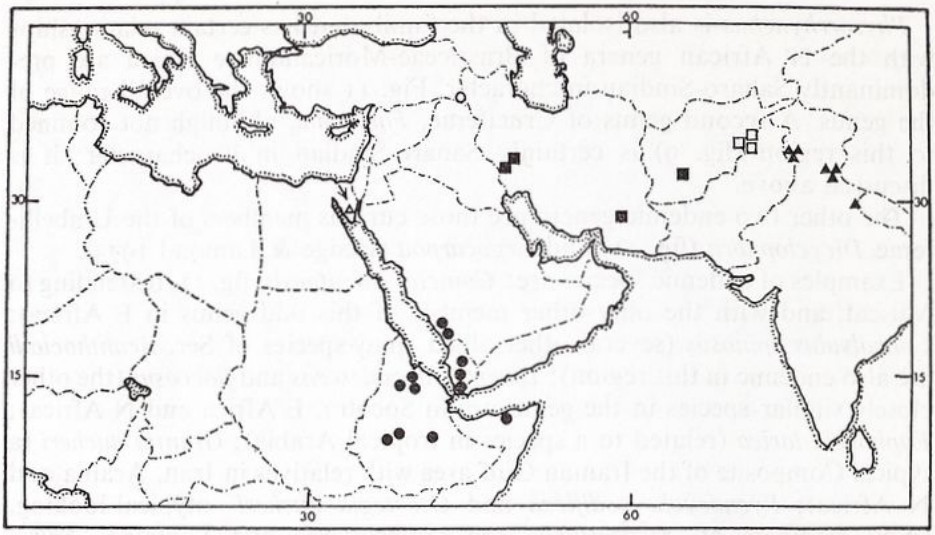

FIG. 12. Total distribution of the species of *Primula* subgen. *Sphondylia*: △*P. boveana*; ○*P. davisii*; □*P. edelbergii*; ▲*P. floribunda*; ■*P. gaubeana*; ●*P. verticillata*.

There are 19 other species in this tightly-knit distinctive genus: 1 other in S Iran (*E. lagopus*, known only from the type); 2 endemic to N Africa; 1 endemic to SE Greece, 1 endemic to Crete and 14 endemic to Turkey in both Mediterranean and Irano-Turanian regions.

The alpine *Dracocephalum kotschyi* from N and NW Iran has a clear affinity with *D. renatii* from the High Atlas of Morocco. Likewise, the high alpine *D. aucheri* from C Elburz is a member of a distinctive species-group, containing several species, which stretches disjunctly from SE Turkey to the Elburz to E Afghanistan to Soviet C Asia and thence to the extreme NE of the U.S.S.R.

The species of *Primula* subg. *Sphondylia* (Wendelbo 1961) show a disjunct distribution (fig. 12) which has some similarities to the southern tropical branch of the Saharo-Sindian region but, as the map shows, extending considerably out of it. The species are confined to higher altitudes and mesophytic habitats.

Notholirion consists of 5 species. Four of these are in the mountains of W China and the Himalayas with *N. thomsonianum* reaching as far west as easternmost Afghanistan. The fifth species, *N. koeiei* grows in Luristan, SW Iran and near Khanaqin in E Iraq. The disjunction gap is more than 2000 km. There are some similarities between this pattern and that of the *Primula* species, but in the former case there are relic stations bridging the gap.

SUMMATION REMARKS

1. In the clearly delimited area of the Hyrcanian forests, the number of endemics in the lowland and lower montane parts is surprisingly low. Two of the most remarkable, and common, endemics—*Parrotia persica* and *Gleditsia caspica*—are very isolated relics. In the upper levels of the forest and above the tree line towards the limits of the region, the number of endemics rises markedly.

Floristic links with the forests of Caucasia, N Turkey and C Europe are very obvious amongst woody and herbaceous species. The absence of *Abies*, *Picea*, *Pinus* and *Rhododendron* in the Iranian forests, and their presence in Turkey, gives some support for recognising a Hyrcanian sub-province of the Euro-Siberian region.

Albizia and *Cercis*, often cited as examples of links with tropical E Asia and the Mediterranean respectively, may well not be indigenous but have spread into the forests from cultivation.

2. The Irano-Turanian region is also comparatively well delimited. It is a major speciation centre with very high numbers of endemics. There is a rather clear difference between the montane/alpine and lowland floras. All types of distributional patterns can be demonstrated from those of taxa covering the whole range of mountains from Kerman through the Zagros and Elburz to the mountains of Khorassan and extending into adjacent countries, to those of taxa with reduced areas in any part of the mountain system.

The flora of the sand-dunes is partly Turanian in character with the typical range of—C Asia, the great deserts of Iran, S Afghanistan, and N Baluchistan in Pakistan. There are also clear links with the Saharo-Sindian region in the desert areas with some species ranging from N Africa eastwards and north to the Iranian Kavir desert.

In many genera which are numerically well-represented in Turkey and Iran, relatively few species are common to both countries (Table 1).

3. In the lowlands of the Persian Gulf area, the floristic situation is complex. African links are strong. The more or less tropical pan-African-S Arabian element is very prominent and possibly the most important one. Another important element is provided by those taxa which stretch all the way from NW Africa through Arabia to S Persia to Pakistan, S and SE Afghanistan. In Iran there is no clear differentiation between these two distributional types; the former palaeotropic, the latter holarctic in origin. We have not accepted Zohary's term Sudanian for this region preferring to use the older, but not completely appropriate, Saharo-Sindian name; the use of supposed climax vegetation to delimit floristic regions cannot be accepted. There is little evidence of a SE Asiatic influence on the flora of the Gulf area but there is a comparatively strong Mediterranean element. This is most obvious in the northwest of the region but is also found in the outer parts of the Zagros mountains in the Irano-Turanian region.

There is also a clear endemic element in the Saharo-Sindian territories of Iran showing autochthonous development within it.

4. The importance of obtaining accurate distributional maps for as many 'good' taxa as possible must be stressed. Too often in the past examples have been used in phytogeographical discussions about Iran without a really clear picture of the taxa involved being available. Detailed maps often give rather unexpected results. In many cases the distributional patterns show complete intergradations between the main types. It becomes very difficult for example, to recognise and delimit such specific *elements* as Armeno-Kurdic, Zagrosian, Elburzian etc., within the Irano-Turanian region.

5. 'Anomalous' distributional areas are not uncommon in Iran. A more detailed knowledge of geological history and climatic changes might help to explain them. The apparently haphazard way in which many of these relics are scattered may be more readily understood when they are mapped together with their nearest relatives; sometimes, however, as in the case of *Zhumeria* there are no relatives.

6. It is dangerous to draw too far-reaching conclusions from our present-day knowledge of plant distribution in Iran. New taxa are found each year and more or less surprising extensions of range come to light with each new collection from lesser known parts of the country.

Acknowledgments

We are grateful to Drs P. H. Davis and J. R. Edmondson for useful comments, and to Rosemary King for preparing the maps.

Appendix—endemic genera

The following is a provisional and tentative list, in family order, of genera which are restricted to Iran or also occur in adjacent parts of surrounding countries. Where possible we have given some indication of the distribution of the genus, its phytogeographical connections and its status or affinities; in some families the tribal position (in brackets) is indicated. Some previously recognised endemic genera now reduced to synonymy (or which should be) are indicated in square brackets.

Boraginaceae

Heliocarya Bge. (Trichodesm.); monotypic; low mountains of the Esfahan area of C Iran—fig. 4; Ir.-Tur.; closely related to *Caccinia*.

Campanulaceae

Zeugandra Davis; monotypic; Kermanshah area—fig. 4; Ir.-Tur.; related to *Symphyandra* and *Campanula*.

Caryophyllaceae

[*Dadjoua* Parsa; monotypic; S Iran ? (Malashour); from its description and drawing this is *Thesium kotschyanum* Boiss.]

Diaphanoptera Rech. f.; monotypic ?; Khorassan; Ir.-Tur.; closely related to *Allochrusa*—two additional species more recently described from Afghanistan are not clearly related to the type species.

Chenopodiaceae

Esfandiaria Charif & Aellen; monotypic; C Iran; Ir.-Tur.; very close to *Anabasis*.

[*Hypocylix* Woloszcz.=*Salsola kerneri* (Woloszcz.) Botsch.]

Compositae

Amblyocarpum Fisch. & Mey. (Inul.); monotypic; Talysh; Eur.-Sib.

Karvandarina Rech. f. (Cynar.); monotypic; Baluchistan—fig. 4; Ir.-Tur.?; allied to *Jurinea*.

Perplexia Iljin (Cynar.); ditypic; 1 species in Elburz, the other in Kopet Dagh/Khorassan; Ir. Tur.; related to *Jurinella* and *Jurinea*.

Cruciferae

Acanthocardamum Thell. (Lepid.); monotypic, known only from the type gathering on Kuh-i-Dinar, Fars; Ir.-Tur.; apparently close to *Lepidium*.

Alyssopsis Boiss. (Arabid.); monotypic; upper forest regions in N Iran; Eur.-Sib.; uncertain affinities.

Brossardia Boiss. (Lepid.); monotypic; Zagros mts to N Iraq; Ir.-Tur.; no clear affinities.

Camelinopsis Miller (Lunar.); monotypic; Elburz/N Iraq; Ir.-Tur.; some affinity with *Peltariopsis*. For description see Miller (1978).

Clastopus Boiss. (Alyss.); ditypic; Elburz, Kurdistan—fig. 7; Ir.-Tur.; some affinity with *Straussiella*.

Dielsiocharis O. E. Schulz (Sisymbr.); monotypic; Elburz, Zagros up to 4000 m—fig. 7; Ir.-Tur.; allied to *Alyssopsis*.

Elburzia Hedge (Drab.); monotypic; Elburz; Ir.-Tur.; related to *Petrocallis* of the Alps and Pyrenees.

Fortuynia Shuttlew. (Brass.); monotypic; C Iran and into Afghanistan and Pakistan—fig. 9; Sah.-Sind. in origin but mostly in Ir.-Tur. region; no clear allies.

Heldreichia longifolia Boiss. (Lepid.); known only from the type gathering on Zard-e-Kuh, C Zagros; Ir.-Tur.; may merit a new independent genus.

Micrantha Dvořak (Hesper.); monotypic; Zagros; Ir.-Tur.; very close to *Hesperis*.

Parlatoria Boiss. (Sisymbr.); ditypic; Zagros extending to N Iraq and Turkey; Ir.-Tur.; no clear allies.

Physorrhynchus Hook. (Brass.); probably monotypic; S Iran extending to Oman, Pakistan and Afghanistan—fig. 11; Sah.-Sind.; no clear allies.

Pseudofortuynia Hedge (Brass.); monotypic; C Iran—fig. 6; Sah.-Sind. in origin but Ir.-Tur. in range; distant links with *Moricandia*.

Pseudocamelina (Boiss.) Busch; 3 species; Zagros and Elburz (Miller 1978, fig. 1); Ir.-Tur.; no clear affinities of tribe or genus.

Straussiellà Hausskn. (Alyss.); monotypic; Zagros; Ir.-Tur.; some affinity with *Clastopus*.

Zerdana Boiss. (Hesper.); monotypic; S Zagros, high alpine—fig. 6; Ir.-Tur.; allied to *Anchonium* and *Sterigmostemum*.

Frankeniaceae

Hypericopsis Boiss.; monotypic; essentially halophytic; Fars and Shiraz areas—fig. 4; Ir.-Tur.; scarcely different from *Frankenia*.

Hamamelidaceae

Parrotia C. A. Meyer; monotypic; forests of N Iran—fig. 9; Eur.-Sib.; clearly allied to *Parrotiopsis* of NW Himalaya.

Labiatae

[*Isinia* Rech. f=*Lavandula coronopifolia*—see Rechinger, 1962]

[*Polakia* Stapf=*Salvia aristata*]

[*Pseudochamaesphacos* Parsa=? For description see Parsa 1946]

Zhumeria Rech. f. & Wendelbo; monotypic; S Iran N of Bandar Abbas—fig. 4; Sah.-Sind.; very isolated in the family.

Liliaceae

Alrawia (Wendelbo) K. Persson & Wendelbo (Scilloideae)—in press; ditypic; W Iran, NE Iraq.

Rubiaceae

Phuopsis Fisch. & Mey.; monotypic; Gilan, Talysh; Eur.-Sib.; closely related to *Crucianella* and *Asperula*.

Sapindaceae

Stocksia Benth.; monotypic; SE Iran, Pakistan, N Baluchistan, S Afghanistan—fig. 8; Ir.-Tur.

Umbelliferae

Alococarpum Riedl & Kuber; monotypic; NW Iran; Ir.-Tur.; closely related to *Prangos*.

[*Buniotrinia* Stapf & Wettst.=*Ferula microcolea*]

Dicyclophora Boiss. (Echinoph.); monotypic; SW Iran—fig. 11; Sah.-Sind.; allied to *Pycnocycla*.

Ergocarpon C. C. Townsend (Echinoph.); monotypic; Zagros/E Iraq; Sah.-Sind.; isolated in the tribe.

[*Haussknechtia* Boiss. ? Apparently not different from *Dorema*]

Kalakia Alava (Tordyl.); monotypic; Elburz—fig. 4; Ir.-Tur.; closely allied to *Ducrosia*. For description see Alava (1975).

[*Opoidea* Lindl.=? *Peucedanum*]

[*Pichleria* Stapf & Wettst. Apparently not different from *Zosima*]

[*Rhopalosciadium* Rech. f. (Scandic.); monotypic; annual, only known from the type gathering in Luristan, Durud; Ir.-Tur.; apparently not different from *Torilis leptophylla*].

Urticaceae

[*Parsana* Parsa & Maleki=? cultivated *Boehmeria nivea*].

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