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On temperate areas, basal clades and biodiversity conservation

Juan J. Morrone, Liliana Katinas and Jorge V. Crisci

It has been accepted traditionally that biodiversity is concentrated in the tropics. However, threatened temperate areas in southern South America, South Africa, New Caledonia, Australia and the Holarctic possess a significant number of unique taxa. Phylogenetic information encoded in cladograms can be used to develop indices for measuring biodiversity. Application of these indices to Asteraceae (Angiosperms) and Curculionoidea (Coleoptera) indicates the relevance of the temperate areas to biodiversity conservation: they are rich in phylogenetically valuable species and are environmentally threatened.

All animals are equal, but some animals are more equal than others.
George Orwell (1946), *Animal Farm.*

In times when human activities are destroying the natural world at an accelerated rate, biodiversity conservation is perhaps the most important challenge that is currently faced by biologists (Wilson, 1988). Economic resources for conservation are limited and it would be desirable to find means to quantify and maximize the contribution of managed areas to biodiversity conservation (Vane-Wright *et al.*, 1991).

It has been accepted traditionally that the greatest amount of biological diversity is concentrated in tropical forests (Myers, 1988; Wilson, 1988, 1992), where several hotspots have been identified (Myers, 1988; Wilson, 1992). Platnick (1991, 1992), however, considered that the concept that biodiversity is concentrated in the tropics was merely an assumption rather than a demonstrated fact, and postulated that threatened temperate areas in southern South America, South Africa, New Caledonia, Australia and New Zealand, as well as some in the Holarctic, may possess a significant number of unique taxa and thus deserved attention.

Cladistic methods are now used throughout almost all biological disciplines, and they are increasingly playing a major role for setting priorities in biodiversity conservation (Forey *et al.*, 1994). For example, several indices have been proposed to evaluate taxa according to their phylogenetic value instead of considering that all species have the same value (Vane-Wright *et al.*, 1991; Forey *at al.*, 1994).

We intend to show that temperate areas are as important as tropical ones for biodiversity conservation, by applying a cladistic approach to two groups of taxa: Asteraceae (Angiosperms) and Curculionoidea (Coleoptera). Asteraceae comprises 20,000 described species and is the most diverse family of flowering plants. Curculionoidea, with 57,000 described species in 6000 genera, constitutes the largest and one of the most diverse animal groups. For these reasons, we consider that they are taxonomically significant, demanding attention from a conservation viewpoint, and that they could be considered representative groups for evaluating areas for biodiversity conservation.

The critical areas

Ackery and Vane-Wright (1984) and Myers (1988) developed an approach to critical areas by identifying hotspots, i.e. areas of major taxonomic diversity, which are both rich in endemic species and environmentally threatened. Myers (1988) identified 12 hotspots: Hawaii, Colombian Chocó, western Ecuador,

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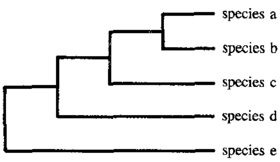

	W	P
species a	1	6.25
species b	1	6.25
species c	2	12.50
species d	4	25.00
species e	8	50.00
	16	100.00

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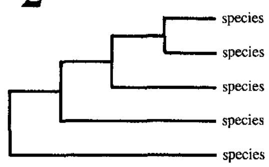

	I	Q	W	P
species a	4	3.50	1.00	10.7
species b	4	3.50	1.00	10.7
species c	3	4.66	1.33	14.3
species d	2	7.00	2.00	21.4
species e	1	14.00	4.00	42.9
	14	32.66	9.33	100.00

Figures 1 and 2. Cladistic measures for biodiversity conservation. **1.** Equal weighting of sister groups. **2.** Topology and weighting of sister groups, according to taxonomic information. I, number of groups to which each taxon belongs; Q, quotient of the total information for the whole group; W, weight for each taxon; P, percentage (after Vane-Wright *et al.*, 1991).

uplands of western Amazonia, Atlantic Forest of eastern Brazil, eastern Madagascar, eastern Himalayas, Philippines, Peninsular Malaysia, northern Borneo, Queensland and New Caledonia. These hotspots total 3.5 per cent of remaining primary forest and contain at least 27 per cent of the higher plant species found in the tropics. Wilson (1992) added a further eight hotspots: California floristic province, central Chile, Ivory Coast, Cape Province, Tanzania, Western Ghats, Sri Lanka and south-western Australia. Because of the vast potential of the species inhabiting these hotspots for expanding agricultural production, as well as providing new and effective cures for diseases, numerous agencies and institutions (e.g. World Wildlife Fund–US, World Wild Fund for Nature–International, the Nature Conservancy) manage important resources for conservation (Myers, 1988).

The emphasis on critical tropical areas, however, could lead to insufficient attention being given to temperate areas. We believe that this situation is caused primarily by the fact that areas to be conserved are usually evaluated according to the number of species inhabiting them, especially endemic ones. In contrast, when considering certain taxa, the temperate areas – even when possibly appearing to have less diverse biotas – can harbour a significant number of taxa that are important from a phylogenetic viewpoint.

Cladistic measures

Conservation biologists have traditionally measured biodiversity in terms of species richness, for example the total number of species known for a particular place. We question if it is appropriate to treat all species as equal. Should the ginkgo, or maidenhair tree, a relict species from eastern China be given the same conservation priority as any other species of gymnosperm and the panda the same conservation attention as any other species of bear? Atkinson (1989) considered that, 'given two threatened taxa, one a species not closely related to other living species and the other a subspecies of an otherwise widespread and common species, it seems reasonable to give priority to the taxonomically distinct form'. In order to measure this 'distinctness', measures based on cladograms can be used. A cladogram is a branching diagram that represents the natural order of the taxa, which results from their evolutionary history (phylogeny). In the cladogram the temporal sequence in which the taxa evolved can be recognized, with the basal branches or clades representing the most 'primitive' taxa of the study group. These basal clades are essential for understanding fully the evolutionary history of the taxa in the rest of the cladogram.

There are several cladistic measures that allow us to estimate the value of each species in terms of its phylogenetic information. Using these measures the species inhabiting a particular area – be they part of the same or

Table 1. Genera of Barnadesioideae

Genus	No. species	Distribution
Arnaldoa	3	Andes
Barnadesia	23	South America, mainly Andes
Chuquiraga	20	Andes and Patagonia
Dasyphyllum	40	Andes and Brazil
Doniophyton	2	Andes and Patagonia
Duseniella	1	Patagonia
Fulcaldea	1	Andes
Huarpea	1	Andes
Schechtendahlia	1	Brazil, Uruguay, north-eastern Argentina

different higher taxa – can be given scores and the sum of the scores used to attribute a value to that area. One of the simplest ways to score the different species in a cladogram was introduced by Vane-Wright *et al.* (1991). Figure 1 shows the cladistic relationships between five species in the same genus. If we give species 'a' and 'b' each a weight of 1, and then give their sister species, 'c', an equal aggregate score (1 + 1 = 2), and so on, the most basal species of the cladogram, 'e', has the highest score, 8 (column W).

In order to avoid overweighting basal taxa, Vane-Wright *et al.* (1991) proposed another index. In the cladogram in Figure 2, four taxonomic statements can be made about the species 'a' or 'b' (because they belong to groups ab, abc, abcd and abcde), three for species 'c' (groups abc, abcd and abcde), two for species 'd' (groups abcd and abcde), and

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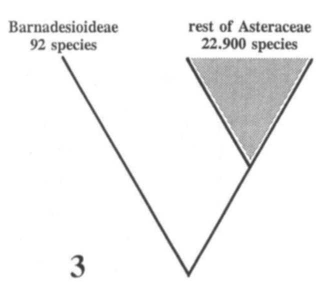

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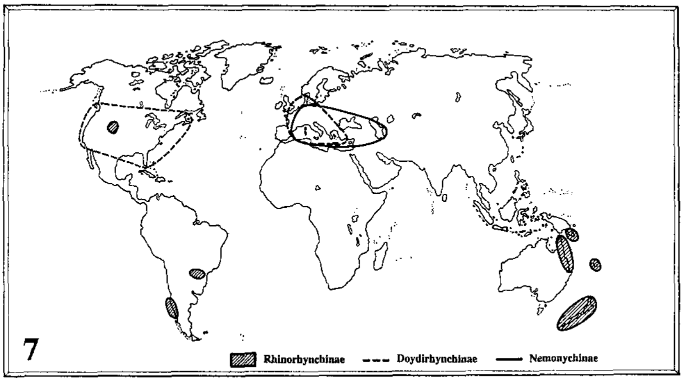
Figures 3–5. Subfamily Barnadesioideae (Asteraceae). **3.** Basal position and number of species. **4.** Geographical distribution. **5.** *Barnadesia odorata* Griseb., habit.



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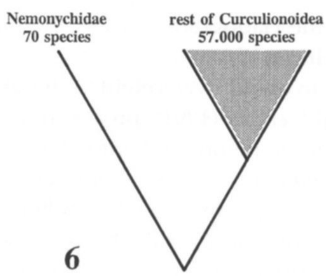

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Figures 6–8. Family Nemonychidae (Coleoptera: Curculionoidea). **6.** Basal position and number of species. **7.** Geographical distribution. **8.** *Mecomacer collaris* (Voss), habit.

Table 2. Subfamilies and genera of Nemonychidae

Subfamily	Genus	No. species	Distribution
Nemonychinae	*Nemonyx*	4	Palaearctic
Doydirhynchinae	*Cimberis*	8	Holarctic
	Pityomacer	3	Nearctic
	Acromacer	1	Nearctic
	Lecontellus	3	Nearctic
	Doydirhynchus	2	Palaearctic
Rhinorhynchinae	*Atopomacer*	3	Nearctic
	Rhinorhynchus	2	New Zealand
	Basiliorhinus	1	Australia
	Basiliogeus	2	Australia, New Guinea
	Pagomacer	1	Australia
	Nannomacer	2	Patagonia
	Mecomacer	4	Patagonia
	Rhynchitomacerinus	1	Patagonia
	Rhynchitomacer	14	Patagonia
	Rhynchitoplesius	1	Eastern Brazil
	Notomacer	8	Australia, New Caledonia
	Aragomacer	5	Australia, New Guinea
	Euctatobius	1	Australia
	Bunyaeus	2	Australia

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one for species 'e' (group abcde). By dividing each terminal score by the total score, the basic weights (Q) are obtained. These can be standardized by dividing each by the lowest value of Q, giving the values W, which can be expressed as percentages (P).

Basal clades in temperate areas: two examples

We present two examples, one of the plant family Asteraceae and another of the weevil superfamily Curculionoidea. Within the Asteraceae, the subfamily Barnadesioideae (Table 1, Figures 3–5) represents phylogenetically the most basal group (Bremer, 1994) and comprises 92 species in nine genera, representing a small entity when compared with the remaining members of the family (Figure 3). These species are exclusively South American, being primarily distributed along the Andean range (Figure 4). Within the Curculionoidea, the family Nemonychidae (Table 2, Figures 6–8) is a small group with a relict distribution in the temperate areas of both hemispheres

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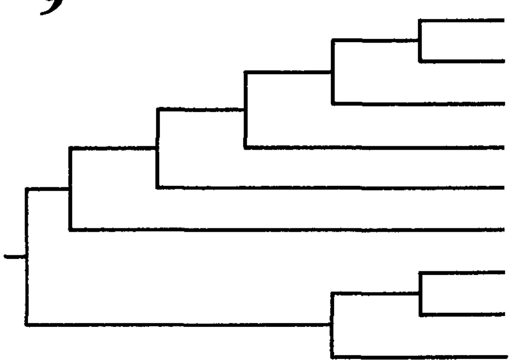

	I	Q	W	P
Huarpea AND	6	5.66	1.00	3.61
Barnadesia BRA - AND	6	5.66	1.00	3.61
Fulcaldea AND	5	6.80	1.20	4.33
Arnaldoa AND	4	8.50	1.50	5.42
Dasyphyllum BRA - AND	3	11.33	5.66	20.45
Chuquiraga AND - PAT	2	17.00	3.00	10.84
Doniophyton AND - PAT	3	11.33	5.66	20.45
Duseniella PAT	3	11.33	5.66	20.45
Schlechtendahlia BRA	2	17.00	3.00	10.84
	34	94.61	27.68	100.00

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	P	Acc. P
(1) AND	41.02	41.02
(2) PAT	36.09	77.11
(3) BRA	22.86	100.00

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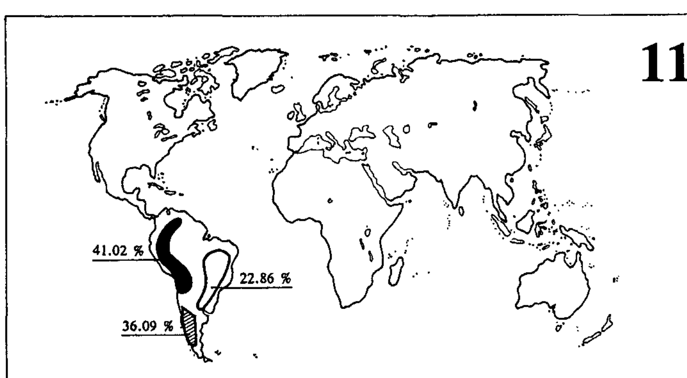

Figures 9–11. Priority area analysis for the Barnadesioideae (Asteraceae). **9.** Cladogram of the genera. **10.** Priority area sequence. **11.** Map showing priority areas.

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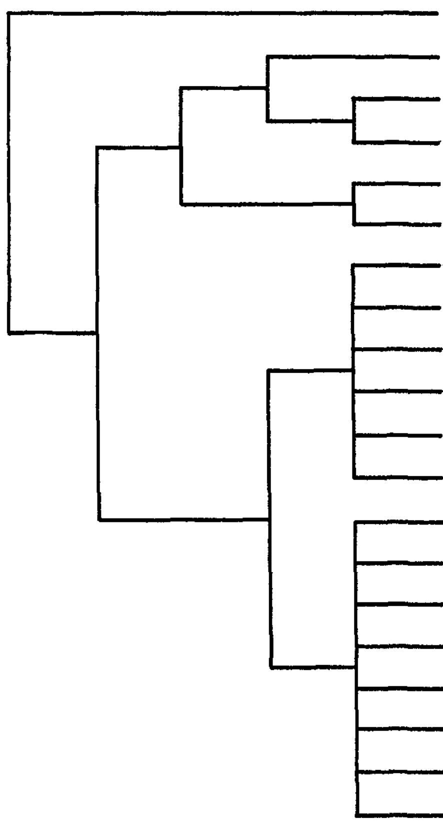

Taxon	I	Q	W	P
Nemonyx PAL	1	79.00	5.00	17.69
Cimberis PAL - NEA	4	19.75	1.25	4.38
Pityomacer NEA	5	15.80	1.00	3.53
Acromacer NEA	5	15.80	1.00	3.53
Lecontellus NEA	4	19.75	1.25	4.38
Doydirhynchus PAL	4	19.75	1.25	4.38
Atopomacer NEA	4	19.75	1.25	4.38
Rhynorhyncus NZ	4	19.75	1.25	4.38
Basiliorhinus AUS	4	19.75	1.25	4.38
Basiliogeus AUS - NG	4	19.75	1.25	4.38
Pagomacer AUS	4	19.75	1.25	4.38
Nannomacer PAT	4	19.75	1.25	4.38
Mecomacer PAT	4	19.75	1.25	4.38
Rhynchitomacerhinus PAT	4	19.75	1.25	4.38
Rhynchitomacer PAT	4	19.75	1.25	4.38
Rhynchitoplesius BRA	4	19.75	1.25	4.38
Notomacer AUS - NC	4	19.75	1.25	4.38
Aragomacer AUS - NG	4	19.75	1.25	4.38
Eutactobius AUS	4	19.75	1.25	4.38
Bunyaeus AUS	4	19.75	1.25	4.38
	79	446.35	28.25	100.00

13

	P	Acc. P
(1) PAL	24.26	24.26
(2) AUS	24.09	48.35
(3) NEA	18.01	66.36
(4) PAT	17.52	83.88
(5) BRA	4.38	88.26
(6) NZ	4.38	92.64
(7) NG	4.38	97.02
(8) NC	2.19	100.00

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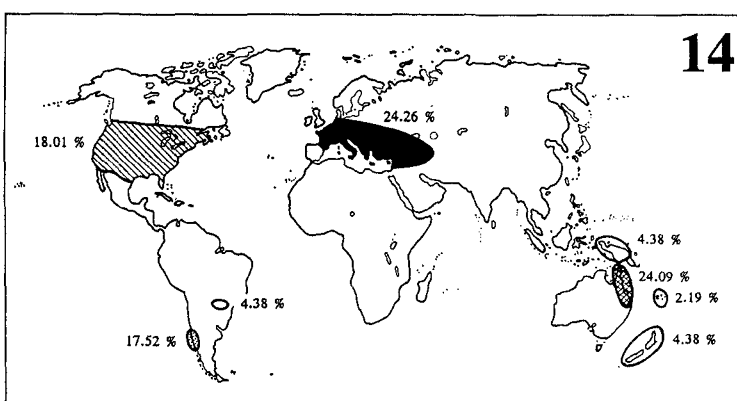

Figures 12–14. Priority area analysis for the Nemonychidae (Coleoptera: Curculionoidea). **12.** Cladogram of the genera. **13.** Priority area sequence. **14.** Map showing priority areas.

(Kuschel, 1989, 1994). It is the most basal family of Curculionoidea (Figure 6) and consists of three subfamilies: Nemonychinae (Palearctic), Doydirhynchinae (Holarctic) and Rhinorhynchinae (Australia, South America and Nearctic) (Figure 7).

Figure 9 shows the cladogram of the genera of Barnadesioideae, the geographical distribution and cladistic values calculated according to the method described above. By summing values for all the genera inhabiting the same area, the overall value for that particular area is obtained, and different areas can be ranked by comparing their overall values. In the Barnadesioideae, the most important areas for conservation are the southern areas of the Andes (AND) and Patagonia (PAT) rather than tropical eastern Brazil (BRA). The areas can be ranked for priority using the calculated values: (1) Andes (AND) with 41.02 per cent of biodiversity; (2) Patagonia (PAT) with 36.09 per cent; and (3) eastern Brazil with 22.86 per cent (Figures 10 and 11). The accumulated percentage of Andes plus Patagonia is 77.11 per cent, while adding Brazil would achieve 100 per cent representation of biodiversity.

The cladogram of the genera of Nemonychidae published by Kuschel (1989) provides values of different areas (Figure 12). The areas can be ranked in order of conservation priority: (1) Palearctic (PAL) with 24.26 per cent of biodiversity; (2) Australia (AUS) with 24.09 per cent; (3) Nearctic (NEA) with 18.01 per cent; (4) Patagonia (PAT) with 17.52 per cent; (5) Brazil (BRA), New Zealand (NZ) and New Guinea (NG) each with 4.38 per cent; and (6) New Caledonia (NC) with 2.19 per cent (Figures 13 and 14).

Establishing priorities

There are several reasons why tropical areas have been considered to be critical for biodiversity conservation. The most important is perhaps their species richness (Myers, 1988; Wilson, 1992). Platnick (1991, 1992), however, considered the idea that biodiversity is higher in the tropics than elsewhere (symmetrically egg-shaped) was an assumption rather than a demonstrated fact. He argued that global patterns of biological diversity may be more pear-shaped, with greatest biological richness and endemism in southern temperate areas than in northern temperate areas (see also Barnard, 1991; Eggleton, 1994; Reid, 1994). In our analysis, Asteraceae and Curculionoidea show the relevance of the temperate areas for biodiversity conservation, not only in the austral region, but also in the Holarctic. Similar studies on other plant and animal taxa are still needed to identify and delimit further hotspots in temperate areas.

Currently it appears that the fundamental question in conservation is: what to protect – the hotspots of tropical areas or the hotspots of temperate areas? It is difficult to answer this question because, as we have tried to show, critical areas for conservation can be found in both tropical and temperate areas. Reasonably, the answer should be that we have to protect critical areas in both tropical and temperate areas.

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