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Mistletoes of the Annapurna Conservation Area, Central Nepal Himalayas

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An inventory of the diversity, distribution and host trees of mistletoes of the Annapurna Conservation Area, Central Nepal Himalayas yielded a total of twelve mistletoe species, eight belonging to five genera in the family Loranthaceae and four belonging to one genus in the family Viscaceae. Ninety-five tree species belonging to 74 genera in 45 unrelated angiosperm families were identified as hosts in the Annapurna Conservation Area. Three new, formerly unrecorded mistletoe species could be added to the checklist for Nepal. Previous suggestions that mistletoes of the family Loranthaceae usually have a wide host range and are frequently generalist, whereas Viscaceous mistletoes have a narrow host range and are highly host specific were approved, as were the observations that the irregular and patchy distribution of mistletoes is governed by three major factors, namely forest structure, site mesoclimate and zoochoric dispersal, the latter being the dominant factor in most cases were approved. Degraded marginal forests, sunny warm slopes and ridges below 3000 m appear to be particularly suitable habitats for mistletoes. *Dicaeum ignipectus* (Fire-breasted flower pecker) was identified as the most important disperser of mistletoes in the Annapurna Conservation Area.

Key words: Distribution, Himalayas, host trees, Loranthaceae, Viscaceae.

Mistletoes are found in a wide range of ecosystems, including boreal forests, tropical rainforests and arid woodlands (Norton and Carpenter 1998). Nepal is in the transition zone of the mistletoe species rich Indian and Malesian region to the species poor Western Himalayas, SW Asia and Europe. Mistletoes of both the Loranthaceae (worldwide 75 genera and about 900 species) and Viscaceae (worldwide seven genera and about 350 species), the two commonest mistletoe families (Nickrent 2002), are present in Nepal. The mistletoes of the Nepal Himalayas have never been studied exclusively in the past, but mistletoes are included in the lists of many botanical explorations. The most extensive and reliable work by Hara et al. (1982), reports eight genera and fifteen species of mistletoes for Nepal. This paper is the first report of specific research on the mistletoes of the Annapurna Conservation Area (ACA) of Central Nepal.

Many mistletoe species are found on a wide range of hosts due to their ability to parasitize diverse, not closely related woody plants, (Reid and Lange 1988, de Lange et al. 1997), whereas others exhibit a high degree of host specificity (Reid et al. 1995, de Lange et al. 1997). The greatest diversity of mistletoes is found in forests and woodlands (Kuijt 1969, Calder 1983, Hawksworth 1983). An extensive compilation of host lists

of *Viscum album* by Barney et al. (1998) showed that this mistletoe parasitized 452 species of hosts among 96 genera of 44 families. For *Dendrophthoe falcata,* in the Loranthaceae, the host number reported by Hawksworth et al. (1993) is 401 species among 227 genera and 77 plant families. On the other hand specialist mistletoes use a single host, but may occasionally parasitize a number of other hosts at very low frequencies (Norton and Carpenter 1998).

The distribution of mistletoes in natural plant communities is never uniform. Temperature and sunlight are considered to be major factors affecting mistletoe distribution, as a result mistletoes occur more abundantly along roadsides, on the edges of forests, on mountain ridges, and generally on sunny and warm slopes (Hawksworth 1959, Ganguly and Kumar 1976, Zakaullah 1977, Zakaullah and Khan 1982, Xiao and Pu 1988, Lopez et al. 2002). Kuijt (1964) reports that the occurrence of mistletoes in open forests is not only favored by increased available light but also by the preferences of many seed disseminating birds in such habitats. Devkota and Acharya (1996) suggested two major possibilities affecting mistletoe distribution in the Kathmandu valley in Nepal — distribution of host trees and ecology of avian pollinators and dispersers.

Materials and Methods

Study area—The study was conducted in the largest protected area of Nepal, the Annapurna Conservation Area (7,629 km^2), located in the Central Himalayan region of Nepal, between 28°15′ to 29°15′ latitude and 83°30′ to 84°30′ longitude, 235 km north west of Nepal's capital Kathmandu. The study covered the altitudinal range between 1000m (Middle Mountains) and 3500 m (High Mountains) and was concentrated in the southern parts of the Annapurna Conservation Area, as this region receives sufficient precipitation for mixed broadleaf forests. The climate varies from tropical monsoon type to Alpine Himalayan type. The southern part of the conservation area receives 3000 mm of annual precipitation because of the massive Annapurna Range, which separates it from the northern part with 400 mm annual precipitation. The monsoon starts about the middle of June and lasts until the middle of September. Summers are hot and humid in lower elevations, temperatures reaching up to 30°C, whereas winters are cold and dry and temperatures drop to 1° to –3° C in southern parts (Biodiversity Conservation Data Project (BCDP). The BCDP (1994) has reported 22 different forest types for the Annapurna Area, ranging from subtropical to alpine types.

Mistletoe field inventory—A total number of 15 field visits were made at the different time of the year from 2000 to 2002 and mistletoe inventories were carried out in selected forest areas in the southern parts of ACA including Ghandruk, Lwang, Siklis and Bhujung regions. Due to the extremely difficult mountain terrain of the study area, only parts of the forest areas could be visited, mainly along trekking routes and trails established by the local population for herding, hunting and collection of forest products. During the inventory, the maximum possible area, representing different forest types at different elevations including plantation forests and orchards, were surveyed. Interviews of the ACA Project Forest Rangers and local villagers regarding the occurrence and distribution of mistletoe in their respective areas, was an important source of information. During the inventory the occurrence of all mistletoe species were recorded with their respective hosts along with the ecological description of the site and habitat, such as altitude, slope direction, availability of light and moisture, forest type and condition. Collected mistletoe and the host specimens were identified in the National Herbarium,

Table 1. Host list of all observed mistletoe species in the Annapurna Conservation Area, Nepal (survey 2000/2003)

Hosts	mistletoe species											
	Spa	Se	Sg	Spu	Tv	Hl	Lo	Mc	Vm	Vl	Va	Vn
Aceraceae												
Acer campbellii Hook. f. & Thoms. ex Hiern		●										
A. sterculiaceum Wall.		●										
A. oblongum Wall. ex DC.									●			
Alangiaceae												
Alangium salviifolium Wangerin	●											
A. chinense (Lour.) Hams	●											
Anacardiaceae												
Rhus wallichii Hook. f.		●										
R. succedanea L.		●										
R. javanica L.		●										
Mangifera indica L.								●				
Dobinea vulgaris Buch.-Ham.	●	●										
Apocynaceae												
Chonemorpha fragrans Alston	●											
Aquifoliaceae												
Ilex dipyrena Wall.		●										
Araliaceae												
Macropanax dispermum Kuntze		●										
Acanthopanax cissifolius Harms	●											
Asclepiadaceae												
Cryptolepis buchanani Roem. & Schult.			●									
Betulaceae												
Alnus nepalensis D. Don		●	●					●			●	
Berberidaceae												
Mahonia nepaulensis DC.		●										
Caprifoliaceae												
Viburnum erubescense Wall.	●	●										
V. mullaha Buch.-Ham. ex D. Don	●											
V. cylindricum Buch.-Ham. ex D. Don	●											
Lonicera glabrata Wall.	●	●										
Coriariaceae												
Coriaria nepalensis Wall.	●	●	●									
Cornaceae												
Swida oblonga (Wall.) Sojak			●			●						
Cucurbitaceae												
Trichosanthes lepiniana Cogn.	●		●									
Elaeagnaceae												
Elaeagnus parvifolia Wall.	●	●	●									
Hippophae salicifolia D. Don	●	●	●									
Ericaceae												
Rhododendron arboreum Sm.	●	●	●			●		●	●			
Pieris formosa D. Don	●	●										
Vaccinium dunalianum Wight		●										
Lyonia ovalifolia Hort.		●										
Euphorbiaceae												
Mallotus tetracoccus Kurz	●		●									●
Macaranga indica Wight							●					
Kirganelia reticulata Baill.	●											
Fabaceae												
Albizia julibrissin Durazz.			●									
Dalbergia sissoo Roxb.		●										
Puereria sp.				●								
Bauhinia purpurea L.				●								
Fagaceae												
Quercus leucotrichophora A. Camus		●			●			●	●			
Q. lamellosa Sm.	●	●					●					●
Q. semecarpifolia Sm.					●				●			
Castanopsis indica Drake			●		●		●		●			
Flacourtiaceae												
Xylosma controversum Clos						●						
Grossulariaceae												
Ribes takare D. Don		●										
Hippocastanaceae												
Aesculus indica Coleb. ex Wall.		●										
Hydrangeaceae												
Dichroa febrifuga Lour.	●											
Hypericaceae												
Hypericum choisianum Wall. ex N. Robson	●											
Juglandaceae												
Juglans regia L.		●										
Lamiaceae												
Leucosceptrum canum Sm.	●	●										

Table 1. Continued

Hosts	mistletoe species											
	Spa	Se	Sg	Spu	Tv	Hl	Lo	Mc	Vm	Vl	Va	Vn
Lardizabalaceae												
Holboellia latifolia Wall.	●											
Lauraceae												
Cinnamomum camphora T. Nees & Eberm.		●										
Dodecadenia grandiflora Nees		●										
Lindera pulcherrima (Nees) Benth. ex Hook. f.	●	●										
L. neesiana Kurz	●											
Persea duthiei (King ex Hook. f.) Kosterm.						●						
P. gamblei (King ex Hook. f.) Kosterm.						●						
P. odoratissima (Ness) Kosterm.	●	●				●		●				
Loranthaceae												
Scurrula elata Danser			●							●		
S. pulverulenta G. Don	●		●									
Magnoliaceae												
Michelia kisopa Buch.- Ham. ex DC.		●										
Melastomaceae												
Melastoma normale D. Don	●											
Meliaceae												
Melia azedarach L.						●						
Toona ciliata M. Roem.				●								
Moraceae												
Ficus neriifolia A. Rich.								●				
F. religiosa L.				●								
F. hispida L. f.				●								
Myricaceae												
Myrica esculenta Buch.-Ham. ex D. Don		●										
Myrsinaceae												
Maesa chisia D. Don	●	●	●			●						
Myrsine semiserrata Wall.						●						
Myrtaceae												
Psidium guajava L.				●								
Oleaceae												
Fraxinus floribunda Wall.	●	●										
Rhamnaceae												
Rhamnus virgata Roxb.	●	●										
Rosaceae												
Cotoneaster frigida Wall.		●										
Neillia rubiflora D. Don		●										
Prunus cerasoides D. Don		●	●									
P. persica (L.) Batsch	●	●	●									
P. napaulensis C. Koch		●										
Pyracantha crenulata M. Roem.	●	●	●									
Pyrus communis Linn.				●		●						
Rosa brunonii Lindl.	●	●										
Sorbus cuspidata Hedl.		●										
S. microphylla Wenzig		●										
Rubiaceae												
Leptodermis lanceolata Wall.	●											
Musandea roxburghii Hook. f.	●					●						
Rutaceae												
Citrus limon (L.) Burm. f.	●			●								
C. reticulata Blanco				●								
Zanthoxylum armatum DC.	●	●	●			●						
Z. oxyphyllum Edgew.	●	●										
Salicaceae												
Salix babylonica L.	●	●										
Saurauiaceae												
Saurauia napaulensis DC.	●					●						
Symplocaceae												
Symplocos ramosissima Wall.	●					●						
Theaceae												
Camellia kissi Wall.		●				●						
Eurya acuminata DC.	●					●						
E. cerasifolia (D. Don) Kobuski						●						
Schima wallichii Choisy								●				
Tiliaceae												
Grewia subinaequalis DC.				●								

Spa: *Scurrula parasitica*; Se: *Scurrula elata*; Sg: *Scurrula gracilifolia*; Spu: *Scurrula pulverulenta*; Tv: *Taxillus vestitus*; Hl: *Helixanthera ligustrina*; Lo: *Loranthus odoratus*; Mc: *Macrosolen cochinchinensis*; Vm: *Viscum multinerve*; Vl: *Viscum loranthi*; Va: *Viscum album*; Vn: *Viscum nepalense:*

Kathmandu (KATH); Central National Herbarium, Botanical Survey of India, Calcutta and Dehradun, and the herbaria of the Forest Research Institute, Dehradun, India and at the Royal Botanic Garden, Kew, with reference to Hara et al. (1978–1982), Malla et al. (1976), Koba et al. (1994) and Press et al. (2000) and deposited in KATH and TUCH.

Bird species visiting mistletoe flowers and fruits were observed with the help of a pair of binoculars and the activities were recorded. Bird species were identified with the help of field books by Fleming et al. (1979), Ali (1996) and Grimmett et al. (2000) and also identification was confirmed against specimens available in the Natural History Museum, Kathmandu, Nepal.

Results and Discussion

Mistletoe diversity and host range—A total of twelve mistletoe species, eight belonging to five genera in the family Loranthaceae and four species of mistletoes belonging to one genus in the family Viscaceae (Table 1) were recorded in the Annapurna Conservation Area, parasitizing 95 host species belonging to 74 genera in 45 unrelated families.

It was found that one species in the family Loranthaceae *Scurrula gracilifolia* (Schult.) Danser and two species in the family Viscaceae *Viscum loranthi* Elmer and *V. multinerve* Hayata are new records for the flora of Nepal. *Scurrula gracilifolia* has been reported from the Eastern Himalayas of Bhutan (Grierson and Long 1983) and Bangladesh (Alam 1985), similarly *V. loranthi* has been reported from the Doon Valley and the Garhwal region of Western Indian Himalayas (Pundir 1989, 1994). On the basis of this study *V. multinerve* is reported for the first time from the Himalayas of this region.

Most of the Loranthaceae mistletoes have a much wider host range than the Viscaceae mistletoes as shown in Table 2. The genus *Scurrula* (Loranthaceae) with four species is more successful in parasitizing a large number of host plants of taxonomically unrelated angiosperm families than other genera. *Taxillus* and *Loranthus* had the narrowest host range among the Loranthaceae. *Scurrula gracilifolia* and *S. parasitica* were also recorded as hyperparasites on *S. elata* and *S. pulverulenta*. *Viscum loranthi* (Viscaceae) was recorded as an obligate hyperparasite only on *S. elata*.

Distribution patterns—In the visited areas of Ghandruk, Lwang, Siklis and Bhujung regions mistletoes showed irregular and patchy

Table 2. Mistletoe species of the Annapurna Conservation Area and their host range (survey 2000/2002)

Mistletoe species	host species	host genus	host family
Scurrula parasitica L.	42	37	28
S. elata Danser	48	40	26
S. pulverulenta G. Don	10	8	7
S. gracilifolia (Schult.) Danser	18	16	14
Taxillus vestitus Danser	3	2	1
Helixanthera ligustrina Danser	18	15	13
Loranthus odoratus Wall.	2	2	1
Macrosolen cochinchinensis (Lour.) Van Tiegh.	7	7	7
Viscum multinerve Hayata	5	4	3
Viscum loranthi Elmer	1	1	1
V. album L.	1	1	1
V. nepalense Spreng.	2	2	2

distribution. Most of the mistletoes in Loranthaceae had wider altitudinal range than the mistletoes of Viscaceae family as shown in Figure 1. Mistletoes were usually absent in dense, moist and undisturbed forests, however, some individuals were found around kharkas, which are small areas cleared for grazing and herding within a closed forest. Mistletoes were most abundant around 2000 m elevation, in disturbed forests, warm and exposed southeast facing sunny slopes, ridges, and along the trekking routes. Marginal forests, on warm sunny slopes affected by human activities create small open areas and provide better opportunities for mistletoe habitat. We found such areas supporting large population of mistletoe as they are mainly made up of non-fodder tree species on which mistletoes get better opportunities to establish and grow than on fodder trees with annual harvesting of new shoots. In general, the human settlements around 2000 m elevation show that human activities tend to create favourable conditions for mistletoe establishment. Fragmented marginal forests, usually with remaining non-fodder tree species, may provide light exposure sufficient for the establishment and growth of mistletoes as observed by Kuijt (1964), Calvin and Wilson (1998), and Lopez et al. (2002). Invasion of many shrubby species such as *Berberis aristata*, *Rubus ellipticus*, *R. paniculata*, *Viburnum mullah* and *V. erubescens* in fragmented marginal forests appears to increase the suitability of the habitat for the mistletoe birds by providing additional sources of food for the frugivorous birds.

Mistletoes were absent in cold and moist forests above 3000m elevation (Fig. 1) despite the availability of suitable host species. Very few mistletoe species were recorded from moist riverine forests at lower elevation, despite the abundance of host species. Mistletoes were completely absent in riverine forests at higher elevations probably

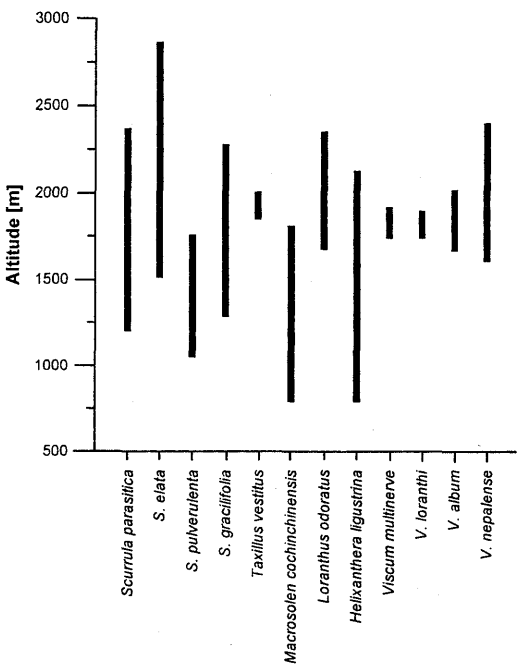

Fig. 1. Altitudinal range of mistletoes in the visited forests in the southern Annapurna area (survey 2000/2002).

not only because of the scarcity of suitable hosts but also very moist and cold conditions. Absence of mistletoes in the dense, cold and cloudy forest above 3000 m elevations and in moist riverine forests where low temperatures and very moist conditions persist throughout the year may indicate the requirement of warmer temperature and light. The occurrence of mistletoes on trees bordering Kharkas (small patch of cleared areas for grazing and herding in the middle of forest) supports this view. It may also indicate unfavourable condition for mistletoe birds. Lichens and cryptogamic epiphytes on the branches might be an additional hindrance for the establishment of occasional mistletoe germinates.

Role of mistletoe birds—Previous studies in South Asia by Ali (1931, 1996), Fleming et al. (1979), Davidar (1978, 1983), Ali and

Riply (1983), Inskipp (1989) and Rahman et al. (1993) show that mistletoe birds are intricately related with the dispersal of mistletoes. We found that mainly two groups of mistletoe birds, namely Sunbirds and Flower Peckers are responsible for pollination and dispersal of mistletoes in the Annapurna Area. These birds are generally considered to be important pollinators and dispersers of mistletoes (Ali 1931a, 1996).

Dicauem ignipectus (Fire-breasted flower pecker), which feeds on the mistletoe fruits, disperse mistletoe seeds by defecating on many host trees. The absence of mistletoes above 3000 m is usually related to the cold and moist forest condition throughout the year in the region, but may be because of absence of mistletoe birds. The understory shrubby species, which may contribute as an alternative source of food for the birds, were absent above 3000 m. Abundance of different mistletoe species exerts positive feedback on mistletoe bird populations because food (mistletoe berries) for the birds is available for extended periods, as the fruiting period of most mistletoe species overlaps. In open and disturbed forests there is usually an additional supply of fruits from shrubby species.

Host specificity—Although host specificity in particular was not a focus of this study, some general patterns became visible. The genera *Scurrula* and *Helixanthera* must be considered generalists, because they infect a large number of hosts of taxonomically unrelated families. Especially *Scurrula* species show low host specificity, a pattern consistent with the findings of Barlow (1991). Even though the genera *Scurrula* and *Helixanthera* must be considered generalists, there are highly preferred host species such as *Rhododendron arboreum, Lyonia ovalifolia, Ulnus nepalensis, Viburnum erubescens, Maesa chisia,* and *Citrus reticulata,* on which they show excellent growth, indicating that there may be possible selection towards a narrower range of host species. Viscaceous mistletoes on the other hand, show a high degree of host specificity as they infest a limited number of hosts in only a few families, in spite of their often high abundance in species rich, diverse forest communities.

Viscum loranthi was found to be an obligate hyperparasite on *Scurrula elata,* maybe due to the fact that the two mistletoe species fruit at the same time and birds tend to wipe off seeds of one on the stem of the other, as suggested by Visser (1982). This is supported by our observation that both *Scurrula elata* and *V. loranthi* have a very lengthy fruiting time, almost throughout the year. The same is true for chance hyperparasites such as *S. gracilifolia* and *S. parasitica,* which also parasitize *S. elata* and *S. pulverulenta* due to their overlapping fruiting period.

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Appendix: Voucher specimens for the new records for Nepal

Scurrula gracilifolia (Schult.) Danser, Kaski District, Annapurna Conservation Area, Ghandruk,

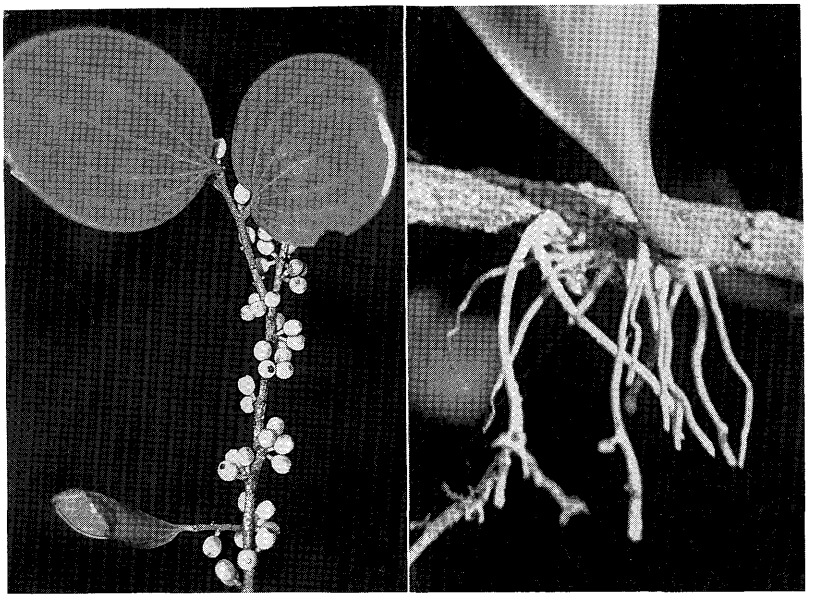

Fig. 2. *Viscum multinerve* Hayata (Nepal, Kaski District, Annapurna Conservation Area, Kande, 1805 m, M. P. Devkota CNO470, 30 June 2001, TUCH).

1650 m, M. P. Devkota CNO268, 28 November 2000 (KATH); Nepal, Kaski District, Central Nepal, Ghandruk, 1650m, M. P. Devkota CNO 269, 28 November 2000 (TUCH).

Viscum multinerve Hayata, Kaski District, Annapurna Conservation Area, Kande, 1805 m, M. P. Devkota CNO475, 30 June 2001 (KATH); Nepal, Kaski District, Annapurna Conservation Area, Kande, 1805 m, M. P. Devkota CNO470, 30 June 2001 (TUCH, Fig. 2).

V. loranthi Elmer, Kaski District, Annapurna Conservation Area, Ghandruk, 2020 m, M. P. Devkota CNO663, 14 September 2001 (KATH).

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M. P. デヴコッタ[a], G. グラッツエル[b]：中部ネパールヒマラヤアンナプルナ自然保護区のヤドリギ類

アンナプルナ自然保護区においてヤドリギ類を調査し，マツグミ科 Loranthaceae 5 属 8 種，ヤドリギ科 Viscaceae 1 属 4 種の12種を見いだした．この中にはネパール新産の次の 3 種 *Scurrula gracilifolia*，*Viscum loranthi*，*V. multinerve* が含まれる．ヤドリギ類12種の宿主は被子植物45科74属95種にわたった．これまでマツグミ科のヤドリギ類は多くの種類の宿主に寄生する一般型であり，一方ヤドリギ科のヤドリギ類は少ない種類の宿主に寄生し，宿主特異性が高いと考えられていた．また，不規則でまだらに分布するヤドリギ類は 3 つの主要要因：森林構造，生育場所の mesoclimate，動物依存の分散 zoochoric dispersal によって形成されており，多くの場合に最後の要因が最優先されると考えられていた．これらの推定が今回の研究で是認された．ヤドリギ類は海抜3000 m 以下の日当たりのよい温暖な斜面や尾根にある森林の周辺林が特に適した生育地であると思われる．アンナプルナ自然保護区ではスズメ目ハナドリの 1 種である *Dicaeum ignipectus* は最も重要な散布者であった．

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