1 INTRODUCTION

Out of 260, 000 species of vascular plants, the majority of them, (around 248,000) are angiosperms, Judd *et al.* (1999). Angiosperms are a huge and diverse group of plants; not only providing dominant vegetation on the earth surface, but also playing crucial roles in ecosystems, and is also of the highest value to mankind. Among the angiosperms, in the group of Commelinids under the group Monocots, is placed the Order Zingiberales. The group Zingiberales comprises of about 63 genera and up to 978 species APG II (2003). The family Zingiberaceae falls in this Order along with seven other families, viz. Musaceae, Heliconiaceae, Strelitziaceae, Lowiaceae, Cannaceae, Marantaceae and Costaceae.

1.1 The Family

Zingiberaceae is a tropical to temperate herbaceous family, 'comprising over 1000 species in some 40-50 genera (over a third of these with very few species), typical of floors of lowland forests' (Rogers, 1984). Takhtajan (1986) traces the family's distribution in South, East and South-east Asia, Malaysia, and New Guinea, with a few species in northeastern Australia. It is characterized vegetatively as mostly terrestrial, sometimes epiphytic, rhizomatous, sometimes large herbs with aromatic oils in specialized cells and with ligulate leaf sheaths. Inflorescence a compact spike or open raceme, or the flowers solitary, each flower or cluster of flowers subtended by a conspicuous bract and sometimes bracteoles. The common floral structure in the entire family is flower bisexual, irregular, trimerous; calyx tubular and splitting along one edge; corolla and androecium form a tube, from which arise three petals, often two petal like lateral staminodes, one fertile stamen bearing a complete anther and a usually large labellum formed by the fusion of at least two staminodes. The thin style characteristically lies in a groove in the filament and passess between the locules of the anther.

Though the fossils of the Zingiberaceae are rare; ‘leaves of Zingiberaceae were described from the Late Cretaceous to Early Eocene of North America (Hickey and Peterson, 1978)’ Herendeen *et al.* (1995). Also, Cronquist (1988) mentioned fruits considered to represent the Zingiberaceae date from Eocene.

One striking feature of the gingers is that they tend to have a rich diversity in the soil rich in limestone. The genus *Hedychium* is a prime example of it.

Bentham *et al*. (1883) have described Zingiberaceae as a part of Order Scitamineae. From Lawrence (1951) we find that ‘Loesener in 1930 divided the family into two subfamilies (Zingiberoideae and Costoideae)’. The first subdivided into 3 tribes (Hedychieae, Globbeae, and Zingibereae) and the latter with no tribes and only 4 genera.

Hutchinson (1959) rejected the subfamilies and treated the same taxa as tribes. Hence, Tribe 1: Costeae, Tribe 2: Hedychieae, Tribe 3: Globbeae and Tribe 4: Zingibereae. The tribes were delimited on the basis of arrangement of leaves, lateral staminodes and ovary characters.

However these days the Order *Scitamineae* have been divided into families *Zingiberaceae*, *Cannaceae*, *Marantaceae* and *Musaceae* respectively. Engler (1924) classified the Family Zingiberaceae under *Scitamineae*. Modern day Plant taxonomists like Cronquist (1988) placed the family under the Order *Zingiberales* of the Subclass *Zingiberidae* within Class *Liliopsida*. Takhtajan (1997) classified it under Class Liliopsida, but under Subclass Commelinidae, Superorder Zingiberanae, and Order *Zingiberales*.

Cronquist (1988) placed the family along with eight other families under the Order Zingiberales of the Sub-Class Zingiberidae of the Class Liliopsida.

Burtt *et al*. (1992) divided the family into two subfamilies, Costoideae and Zingiberoideae, with four tribes of the latter: Hedychieae, Zingibereae, Alpineae

and Globbeae. The delimitation has been done on the basis of phyllotaxy, presence or absence of lateral staminodes and epigynous glands, placentation, plane of distichy of leaves whether parallel or transverse to the rhizome, character of lateral staminodes among others.

Kress *et al.* in 2002 (The Phylogeny and a New Classification of the Gingers (Zingiberaceae): Evidence from Molecular Data) recognized four sub-families and four tribes: Siphonochiloideae (Siphonochileae), Tamijioideae (Tamijeae), Alpinioideae (Alpineae, Riedelieae), and Zingiberoideae (Zingibereae, Globbeae).

Ngamriabsakul *et al.* (2004), has divided the Tribe Zingibereae into further two clades, the *Curcuma* clade and the *Hedychium* clade.

Angiosperm Phylogeny Group (APG II, 2003) has recognized four sub-families in the family Zingiberaceae, namely, (i) Siphonochiloideae W. J. Kress, (ii) Tamijioideae W. J. Kress, (iii) Alpinioideae Link and (iv) Zingiberoideae Hasskar. The genus *Hedychium* is placed in the group Zingiberoideae Hasskar.

The group in focus, *Hedychieae* contains about 21 genera.The key character of *Hedychieae* being the plane of leaf distichy parallel to the rhizome, lateral staminodes petaloid and free from the lip except in *Siphonochilus* and *Curcumorpha*. In the entire Family Zingiberaceae, plants have a single pollen-bearing stamen and four petaloid staminodes that are united in various ways in the different tribes. In *Hedychieae* there are a large compound labellum (lip), two petaloid staminodes owing to zygomorphy (Ronse *et al.* 1995), and a stamen giving the impression of the absence of the sixth androecial member. Kirchoff (1997, 1988) explains, in *Hedychium* two inner and one outer androecial members are initiated on the anterior side of the flower. However as the outer androecial member aborts soon after initiation the total androecial members only count up to five in a fully developed flower, the lip being formed by joining two androecial members. Furthermore, the interpretation of lip of the members of Zingiberales has been controversial as in Zingiberaceae only two lateral inner

staminodes form the lip, while in the sister family Costaceae all five staminodes contribute to the lip, (Endress, 1995).

In Nepal 12 genera with altogether 43 species belonging to the family are reported so far, Press *et al.* (2000).

1.2 The Genus

When Koenig (1783) described the genus for the first time, it was with a single species *Hedychium coronarium*. The taxonomy of the genus *Hedychium* has always been controversial and recent works like Larsen *et al*. (1995), Wood (2000), Stearn (1978), also opine the same. Natural hybridization is also a potential source of taxonomic confusion in the genus (Wood, 2000).

At least 115 names have been published under the genus; about 65 of these are biologically valid species (Wood *et al.*, 2000). Rogers (1984) and Wood *et al*. (2000) have given some taxonomic history of the genus.

The following discussion is based on Rogers (1984) and Wood *et al*. (2000):
Lestiboudios (1829) argued that 'as both *Hedychium* and *Canna* (i) have a six part calyx in two tiers (as in most monocotyledons) (ii) the petaloids inside the calyx represents five staminodes. Also, the elements on top of the ovary of *Hedychium* cannot be regarded as sterile stamens' and hence both the genera should be placed under the same family. He further argued that the family Cannaceae to be put under the family Musaceae, therefore ultimately placing the genus *Hedychium* in the Musaceae family.

Wallich in 1853 (Initiary attempt to define the species of *Hedychium*, and settle their synonymy, *Hooker's Journal of Botany* V: 321-329, 367-377.) recognized the four subgroups of the genus *Hedychium* without assigning the ranks, *Coronariae* (more or less tightly imbricate spikes), *Spicatae* (elongated spikes with distant, spreading bracts), *Siphonum* (one species, *H. scaposa*, slightly crested anther and a stemless habit similar to *Kaempferia*), and *Brachylium* (*H.*

horsefieldii, a cleistogamous plant almost lacking a labellum with the lateral staminodes). Altogether 23 species were circumscribed.

Horaninow in 1862 (*Prodromus Monographiae Scitaminearum*, St Petersburg: Typis Academiae Caesareae Scientiarum) classified the genus *Hedychium* into three groups (without assigning any ranks), *Gandasulium* (stamen shorter than or equal to the length of labellum), *Macrostemium* (stamen much longer than labellum), and *Brachylium* (one species lacking a significant labellum).

Schumann in 1904 (Zingiberaceae. In ENGLER, A. (ed.) Das Pflanzenreich 20. Leipzig: W. Engelmann) classified the genus into two subgeneric divisions, *Gandasulium* Horan. and *Euosmianthus* K. Schum. . He redefined the *Gandasulium* Horan. to include taxa with a dense short and wide, ellipsoid, ovoid, rarely long cylindrical inflorescence; with bracts flat, densely imbricate, rarely arched; and with rachis always hidden. The other subgenus *Euosmianthus* included species with less dense, longer than wide inflorescence; bracts never densely imbricate, commonly patent, or divergent or distant from each other, clasping the flowers; and with a rachis not hidden. Schummann also maintained a separate genus for Brachylium (?) comprising *H. horsefieldii*. He used the characters of inflorescence and bracts.

Lourteig in 1972 (Lourteig, A. Le genre Hedychium à Madagasar (Zingibéracéés). Adansonia, II. 12: 121-127) changed the name of subgenus *Gandasulium* Horan. into subgenus *Hedychium* and adopted for *Euosmianthus* K. Schum the name *Macrostemium* Horan. with *H. gardnerianum* as lectotype.

Naik and Panigrahi in 1961 (Genus *Hedychium* in eastern India. Bull. Bot. Surv. India **3:** 67-73) gave generic descriptions, key to species, taxonomic history of *H. coronarium* complex, discussion of problems connected with other species and enumerated altogether 17 species.

The habitats of species of *Hedychium* range from tropical to temperate, at altitudes approaching 3000m or higher, in usually (but not always) open, typically

wet places; often shores, moist slopes and edges of forests. The genus *Hedychium* is distributed along the Himalayan range that encompasses northeastern India, Bangladesh, the upper Ganges River, and Nepal. Continuing to the south and east with a diminished number of species the probable natural range of *Hedychium*, outlined by southern China, Vietnam, the Philippines, Java, and Sulawesi, crosses Wallace's line but does not reach New Guinea or Australia. At the western extreme *Hedychium peregrinum* N.E. Br. is endemic to Madagascar. The natural distribution of *Hedychium coccineum* doubtfully includes Sri Lanka (Rogers, 1984). However, given the diversity of gingers and *Hedychium* particularly in Southeast Asia, the argument expressed by Good (1964) that it is associated with the Continental South-East Asiatic Region and reaching up to India or Malaysia appears strong. Also some of the species of the genus have gone on to become invasive plants in New Zealand, Jamaica, several parts of South Africa and Hawaiian islands (Williams P. A. *et al*. 2003) and some are nowadays also cultivated as ornamental plants.

Few species of *Hedychium* are also found to be epiphytic. In Nepal *Hedychium spicatum* is generally found to be epiphytic however, sometimes *H. thyrsiforme* are also observed to be so. It is important to mention that both the aforementioned species are also found in terrestrial habitat. Similarly *Hedychium densiflorum* in Khasi Hills (India) is occasionally found as epiphytic. However from Nepal, only the terrestrial ones have been recorded so far.

1.3 Literature Review

Sound taxonomic literature about the genus *Hedychium* in Nepal is scant. It is indeed imperative to review the literatures that describe the genus reported in Nepal. Also it is equally important to review the literatures that describe the genus reported in the neighbouring regions and throughout Himalaya. Here, while reviewing the literature, emphasis has been laid upon those publications which mention/describe the species that are or could be common to Nepal.

The reviews are classified in following categories:

1.3.1 *Hedychium* in Neighbouring Regions
1.3.2 *Hedychium* in Nepal

1.3.1 Hedychium in Neighbouring Regions

Baker (1892) described a total of 24 species of *Hedychium* from British India. Out of which, 11 species are common to Nepal. The most comprehensive work of its kind in its time, the Flora of British India has descriptions from other literature and those personally observed by Baker himself. He proposed two Sections for the genus. Three species [*H. coronarium* (with five varieties, of which three have become synonyms), H. *spicatum (*with three varieties) and *H*. *densiflorum*] fall under the Section Gandasulium (Stamen never much longer than the lip). The rest eight species (*H*. *ellipticum*, *H*. *villosum*, *H*. *gracile*, *H*. *thyrsiforme*, *H*. *gardnerianum*, *H*. *coccineum*, *H*. *aurantiacum* and *H*. *elatum*) are placed in the Section Macrostemium (stamen much longer than the lip). FBI however has not used the characters of ligules, bracteoles. It has also described the calyx of the genus as three-dented, which is not a consistent observation. The publication has not given any keys to the species.

Pottinger and Prain (1902) mentioned three species of *Hedychium* (*H.coccineum*, *H. coronarium* and *H.luteum* under Scitamineae from the Eastern Himalaya. Save *H.luteum*, the remaining two species are common to Central and Eastern Nepal. The literature bolsters the evidence of the two common taxa being eastern element.

Smith (1913) reported two species of *Hedychium* (*H.spicatum* and *H. coccineum*) under Scitamineae from South-East Sikkim. Since the aforementioned species are also reported in Nepal, they give an indication of the distribution of those taxa from Nepal towards the Eastern Himalaya. Press *et.al*. (2000) have reported *Hedychium coccineum* from Central and Eastern Nepal and Smith (1913) from Sikkim Himalayas.

Hara (1966) enumerated seven *Hedychium* species from Eastern Himalaya. All the species are common to Nepal.

Polunin & Stainton (1984) and Stainton (1988) described altogether 6 species of *Hedychium* from the Himalayas, namely, *H. aurantiacum* (*H. coccineum*), *H. densiflorum*, *H. ellipticum*, *H. gardnerianum*, *H. spicatum* and *H. thyrsiforme*, all are reported from Nepal. The pioneering work of its kind on the himalayan plants, they described the plants laying much emphasis upon the flower colour, bract, stamen, and staminode characters. Though the key to species are not given, the plates of all six species are a great help in identification.

Smith (1994) described 13 species of *Hedychium* from Bhutan. Among them 10 species are common to Nepal. Using the bracketed keys, the characters of bract, relative length of stamen and lip, shape of lip and the color of flowers are used to distinguish different species. In the introduction of the genus, the character 'bracteole' is reported as 'tubular' throughout the taxon. This is slightly contradictory to other literature viz. Walters (1984) the bracteoles are said to be 'usually tubular'. Brief illustrations of two species, *Hedychium coronarium* and *H. spicatum* are given.

Shu (2000) described 28 species of *Hedychium* from China. Among them, eight species are common to Nepal. Indented Keys are used for identification. Apart from the comprehensive descriptions, the remarkable aspect of the literature is the use of the 'ligule' character (unlike any other flora) in the keys to delimit the taxa. In this treatment, along with the qualitative characters, characters based on measurements, like the length of bracts, lips, anthers, have also been used. However, these have been applied in tandem with the qualitative ones.

1.3.2 *Hedychium* in Nepal

Landon (1928) published *Hedychium spicatum*, *H. densiflorum*, *H. villosum*, *H. gardnerianum*, and *H. aurantiacum* under the group Scitamineae in a checklist titled 'Flora of Nepal'. The list of Nepalese plants was compiled under the authority of the Director of the Royal Gardens, Kew and took references from books like D. Don's 'Prodromus Florae Nepalensis', Wallich's 'Tentamen Florae Nepalensis', Burkill's 'Notes from a Journey to Nepal', among others.

Malla *et al.* (eds.) (1976) catalogued four species of *Hedychium* (*H.coccineum*, *H.densiflorum*, *H.ellipticum* and *H.spicatum*) of the family Zingiberaceae from Nepal. This is a very preliminary work and based upon the collection of the KATH Herbaria since 1960. This is the first official document of the flowering plants of Nepal.

Hara *et al*. (1978) enumerated 12 species of *Hedychium namely, Hedychium aurantiacum*, *H. coccineum*, *H. coronarium*, *H*. *denslflorum*, *H. elatum*, *H.ellipticum*, *H. flavescens*, *H. gardnerianum*, *H. glaucum*, *H. spicatum*, *H*.*spicatum* var. *spicatum*, *H*. *spicatum* var. *acuminatum*, *H. spicatum* var. *trilobum*, *H. thyrsiforme* and *H. villosum* from Nepal. This is the first and the most comprehensive work of its kind about the Nepalese Flora. The literature incorporates the mention of original literatures, common synonymies, their distribution in the overall Himalaya and other significant citations.

Press *et al.* (2000) annotated 12 species of *Hedychium*, namely, *Hedychium aurantiacum*, *H. coccineum*, *H. coronarium*, *H. densiflorum*, *H. elatum*, *H.ellipticum*, *H. flavescens*, *H. gardnerianum*, *H. glaucum*, *H. spicatum*, *H.spicatum* var. *spicatum*, *H*. *spicatum* var. *acuminatum*, *H*. *spicatum* var. *trilobum*, *H*. *thyrsiforme* and *H. villosum* from Nepal. Being somewhat spruced up than Hara *et al.* (1978), this book is efficient in providing information about the original literature, plant form and distribution, at a glance. The synonyms and

basionyms are separately given in the index of synonyms at the back, which is another convenience of this literature.

Singh *et al*. (2001) also listed 12 species of *Hedychium*, the same as that of Press *et al* (2000), the only difference being that, here all the taxa are given in alphabetic order irrespective of their family groupings.

Hedychium in Central Nepal

From Central Nepal, the genus *Hedychium* has been described in several of the local floras of Kathmandu Valley. Malla *et al*. (1969) described two species, *Hedychium ellipticum* and *H. spicatum* from Phulchoki and Godavari forests. The significance of the literature lies in the fact that this is one of the first attempts on the concept of local flora. Similarly, Malla *et al.* (1973) described two species viz., *Hedychium ellipticum*, and *H. spicatum* under the family Zingiberaceae from the Nagarjun forests. The descriptions of the plants are extremely brief. Baniya *et al.* (1984) described two species of *Hedychium*: *H. spicatum* and *H*. *gardnerianum* from Chandragiri Hill, South West of Kathmandu. The authors have described the taxa and also provided some ecological notes. Finally, Malla *et al.* (1986) described two species, *Hedychium ellipticum* and *H. spicatum* from Kathmandu Valley. The characters of stamens and lips are used to distinguish the species. The descriptions very closely match those of FBI.

Hedychium in East Nepal

Hara (1966) listed seven species of *Hedychium* from Eastern Himalaya, out of which three species were from Eastern Nepal. *Hedychium flavescens* was recorded from Dhankuta-Hilay at 1200-2000m, *H. glaucum* (=*H. gracile*) was recorded from Phusri-Sanguri Bhanjang in between 450-1200m, and *H. thyrsiforme* was recorded from Ilam-Ranga Pani in the range of 1200-400m.

Miyamoto (2000) listed two species of *Hedychium* from Hinku and Hunku Valleys, East Nepal. The two species are *Hedychium aurantiacum* and *H. ellipticum*.

2 OBJECTIVES

As mentioned in the Literature Review, there are some taxonomical works on the genus *Hedychium* with reference to Nepal (Malla *et al*. 1969, Malla *et al.* 1973, Polunin & Stainton 1984 and Stainton 1988). However, all of them are mere brief taxonomical descriptions scattered in few local floras.

A detailed taxonomic work on the genus is lacking. Stearn in EFPN (1978) has also mentioned the need of a monograph on *Hedychium*. As detailed taxonomic works like Revision, Monograph are important resources for the writing of Floras, the case for taxonomic work on the genus like *Hedychium* is even much stronger in Nepal , where the Flora has not yet been published.

The general objective of the current work is to revise the genus critically by analyzing the morphological characters, distribution in Nepal, and extrapolate a phylogenetic pattern (of the infra-generic level) based on cladistic analysis.

The **specific objectives** of this study are as follows:

1. To prepare taxonomic treatment of individual species with illustrations, author citations, full synonyms, complete description, and phenology.
2. To prepare the distribution map (horizontal and vertical) for all species based on herbarium specimens and literatures.
3. To construct identification keys (bracketed) on the basis of reliable morphological characters.
4. To identify and solve potential nomenclatural problems.
5. To perform the cladistic analysis of Nepalese *Hedychium* based on morphological characters.

3 METHODOLOGY

3.1 Selection of Characters

As a taxon belonging to ginger group, the morphology of *Hedychium* without doubt is very complicated. The important characters in the group are floral characters. The selection of characters was done based on earlier works on the family and the genus. However, the problems are compounded when doing work from the herbarium materials. Working only with pressed specimens is always prone to error in observations. Hence, fresh specimens were studied as far as possible.

3.2 Collection of Fresh Plant Specimens

As it is extremely difficult and at times unreliable to work only from the herbarium specimens, the collection of fresh plant specimens give some respite. Fresh specimens were collected from various areas around Kathmandu valley (altogether seven species). Photographs were taken, the characters noted preliminarily and illustrations were drawn from the fresh specimens as far as possible. The flowers along with the bracts were preserved in 30% spirit for further study purpose. Then the rest of the plant specimens were pressed, dried, and mounted on herbarium sheets.

3.3 Study of the Fresh Plants

After the initial study of plants in the field, the preserved materials were studied thoroughly with the help of 5x hand lens, flowers dissected under the ACCUMAX 15*3X stereo microscope. The vegetative as well as the reproductive parts were illustrated and described.

3.4 Study of Herbarium Specimens

Herbarium specimens were studied from KATH, TUCH, BM and E (digital images). 56 specimens were on loan from BM out of which four were Type

specimens; 28 specimens were studied at KATH; 15 specimens were from TUCH which also included the author's own collection of seven species of Hedychium. The descriptions on the taxonomic treatment are based on Anonymous (2007).

3.5 Construction of Identification keys

The keys prepared in this study are in 'bracketed format'. In the genus *Hedychium* reproductive characters are of greater importance, hence they are profusely used accordingly. The characters deemed reliable for easy identification morphologically are that of bracts, shapes of labellum, leaves and ligules as well as flower colours.

3.6 Cladistic Analysis

The Cladistic Analysis of the genus Hedychium was done based on its morphological characters. The character selection and coding was done based upon Kitching *et al.*(1998) and Elredge and Cracraft (1980). For the Out-Group the genus Canna (Cannaceae) was chosen based upon Kress *et al.* (2002), Kress (1995) and Stevenson *et al*. (1995).

The characters and character-states were chosen based upon their consistency traced in the description and other literatures.

4 LIMITATIONS OF STUDY

Hedychium belonging to the family Zingiberaceae is extremely difficult to observe from herbarium specimens alone. When gingers are described only based upon the herbarium specimens the possibilities for error multiply. So I tried my best to study the living specimens as much as possible. As most of the genus flowers in the peak of monsoon, field trips were rather difficult. Not to mention the problems in preserving the succulent inflorescences of *Hedychium* in the humid season. Due to the aforementioned reasons, during this work I could not study all the species in living state and had to content my self with only the herbarium specimens in case of two species, namely, *Hedychium densiflorum* and *H. gracile*.

Hedychium villosum erstwhile reported in Press *et al.* (2000), could not be traced, either in living state or in the herbaria enquired (TUCH, KATH, BM, E and K). For *Hedychium elatum*, only the digital image of the herbarium specimen from E could be studied.

While making identification keys, three species, *Hedychium elatum*, *H. forrestii* and *H. villosum,* on which this author could not work on first-hand, had to be omitted. Regarding *Hedychium elatum,* only a digital image was available; *H. villosum* was found absent, and regarding *H. forrestii* a possible new species, the plant material available in the herbarium sheet was incomplete and insufficient to obtain a detailed description.

5 RESULTS

5.1 Morphological Treatment

5.1.1 Vegetative structures

The genus *Hedychium* is either terrestrial or epiphytic. Most of the species of this genus found in the South-East Asia are epiphytic. However of the Nepalese species, two species (*Hedychium spicatum*, *H. thyrsiforme*) are both epiphytic and terrestrial, whereas the rest are only terrestrial. No entirely epiphytic species have been recorded in Nepal so far. The genus is an erect herb with tuberous rhizomes that are parallel to the plane of distichy of leaves. Taxonomic delimitations in *Hedychium* have been based mostly on reproductive characters, as there are not much variations observed in the vegetative ones.

5.1.1.1 Life forms

All the species under the genus are herbaceous. The species (*Hedychium coccineum*, *H. speciosum*, *H. thyrsiforme*, *H. ellipticum*) are limestone lovers. Field study revealed that the genus is typically found flourishing in the disturbed forest patches alongside undershrubs. They also love shady areas where there is enough moisture but the water does not hold. Hence they are seen flowering in shady gullies and on the edge of slopes during the peak of monsoon.

5.1.1.2 Pseudostems

The Pseudostems (after Shu, 2000) do not have significant variation save for their height. *Hedychium speciosum* is found to be the most robust one and grows tallest (up to two meters), whereas *H. gracile* is the shortest one (less than one meter).

5.1.1.3 Leaves

Leaves are borne on the unbranched pseudostems (leafy aerial shoots) that die out after flowering. The venation in all the species is 'striate', Takhtajan (1991). Leaf blades are inserted immediately above the sheathing base or sometimes have petioles (*Hedychium densiflorum*, *H. ellipticum*, *H. gracile*, *H. thyrsiforme*). Petioles are longest in *Hedychium speciosum* (up to 6 cm) and are shortest in *H. gracile* (up to 2 cm). The leaf shape range from lanceolate, ovate, obovate, elliptic and their intermediates (Fig. 1 & Fig. 1a); color green-dark green on the abaxial surface and light green on the adaxial surface, the ventral surface are sometimes glaucous (*Hedychium speciosum*, *H. coccineum*, *H. thyrsiforme*). Surface of leaves sometimes appear wavy due to raised veins on the leaf surface (*Hedychium thyrsiforme*, *H. ellipticum*), texture sometimes coriaceous (*H. speciosum*). Leaf margin is entire, occasionally membranous (*Hedychium speciosum*). The leaves of *Hedychium speciosum* and *H. coccineum* are completely glabrous; *H. ellipticum*, *H. densiflorum* is sparsely hairy on both surfaces, the rest have sparsely to more pubescent adaxial surfaces. Since the leaves do not have remarkable variations, they are not much help for taxonomic purposes.

5.1.1.4 Ligules

Ligules are conspicuous in the genus. Most are membranous, sometimes slightly coriaceous (*Hedychium speciosum*), pink-red in colour (*H. ellipticum*, *H. gracile*). Four species, *Hedychium coccineum*, *H. ellipticum*, *H. gracile*, *H. speciosum* had glabrous ligules. Both hairy and glabrous ligules were present in *Hedychium coronarium*. The remaining four species (*Hedychium densiflorum*, *H. flavescens*, *H. spicatum* and *H. thyrsiforme*) had pubescent ligules either at base or apex or on the dorsal surface. Longest ligule was observed in *Hedychium speciosum* (4cm) and the shortest in *H. gracile* (0.3 cm). The apex of ligule (fig. 2) acute (*Hedychium coronarium*, *H. densiflorum*, *H. flavescens*, *H. thyrsiforme*), obtuse

(*Hedychium coccineum*, *H. ellipticum*, *H. spicatum*), truncate (*Hedychium speciosum*, *H. spicatum*), emarginate (*H. gracile*) and 2-cleft (*H. coccineum*). *nota bene*: apex shapes are variable in case of *Hedychium spicatum* (obtuse or truncate), *H. coccineum* (obtuse or 2-cleft) and *H. ellipticum* (acute to vaguely 2-cleft).

5.1.2 Reproductive Structures

Much of the taxonomic delimitations in the genus are done on the basis of the morphology of reproductive structures. Structures and lengths of bracts, bracteoles, calyces, labellums, lateral staminodes and stamens show considerable variation and are also conventionally used in morphological treatments for differentiating the taxa.

5.1.2.1 Inflorescence

Inflorescence of the genus is categorized as 'terminal spike' (Shu, 2000), 'terminal many flowered' (Smith, 1994), 'spicate' (Rogers, 1984), or 'thyrse' Kirchoff, (1997). Spikes often appear quadrangular owing to the spiral arrangement of flowers around it. The length of spikes varies from 34cm, longest (*Hedychium speciosum*) to shorter ones *H. ellipticum* (7-9 cm) and *H. thyrsiforme* (8-10 cm). *Hedychium coccineum* was found to have slightly pubescent spike, and that of all the remaining species were glabrous. The spikes of *Hedychium speciosum* when observed in living condition were found to be glaucous.

5.1.2.2 Bracts

The bracts are green, coriaceous, and margin membranous, sometimes glaucous (*Hedychium speciosum*). Variations were observed in bract shapes (fig. 3), *Hedychium coronarium* (elliptic), *H. coccineum* (oblong-obovate), *H. densiflorum* (oblong), *H. elliptic* (elliptic-lanceolate), *H. flavescens* (elliptic-obovate), *H. gracile* (ovate), *H. speciosum* (elliptic-oblong), *H. spicatum* (elliptic), *H. thyrsiforme* (elliptic-lanceolate).

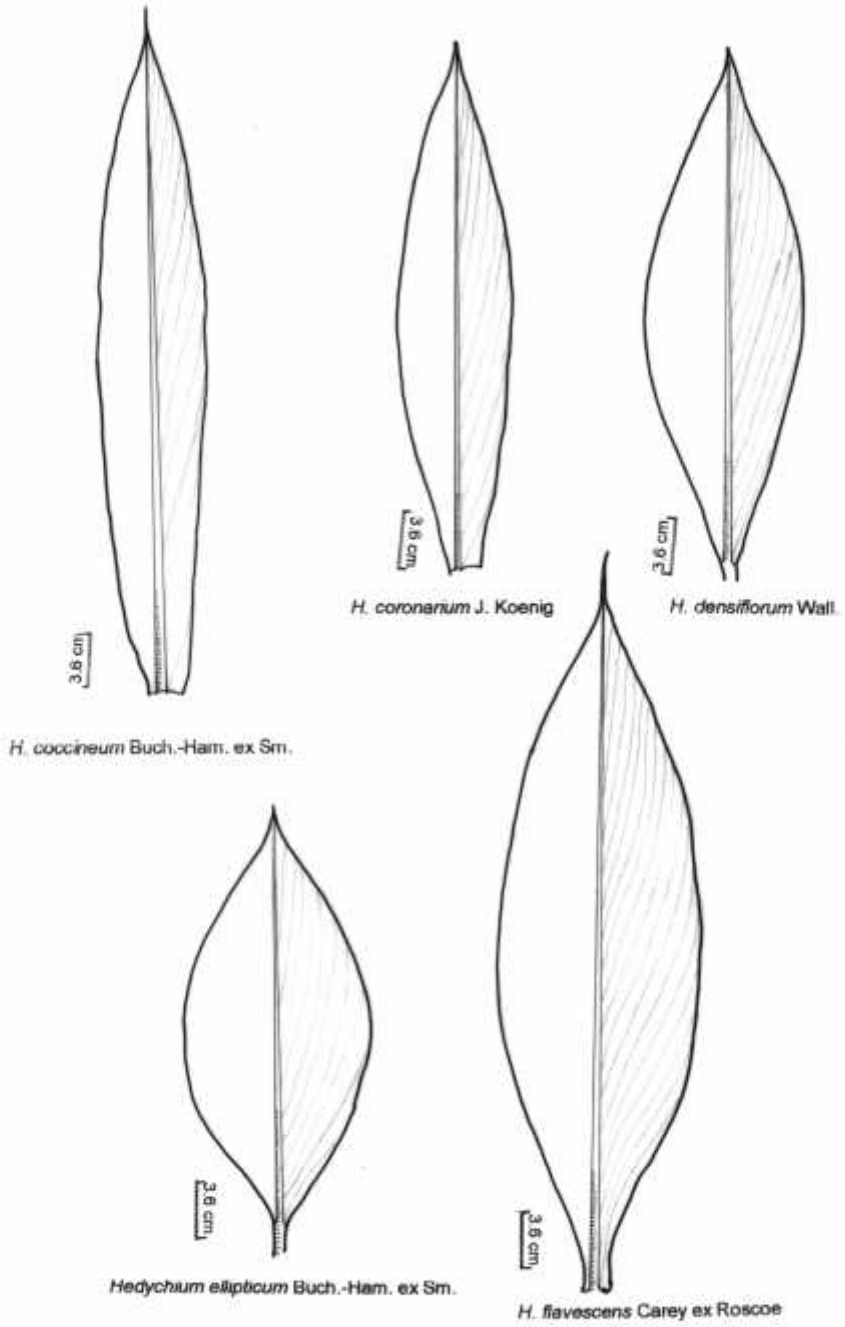


Figure 1. Leaves of *Hedychium*

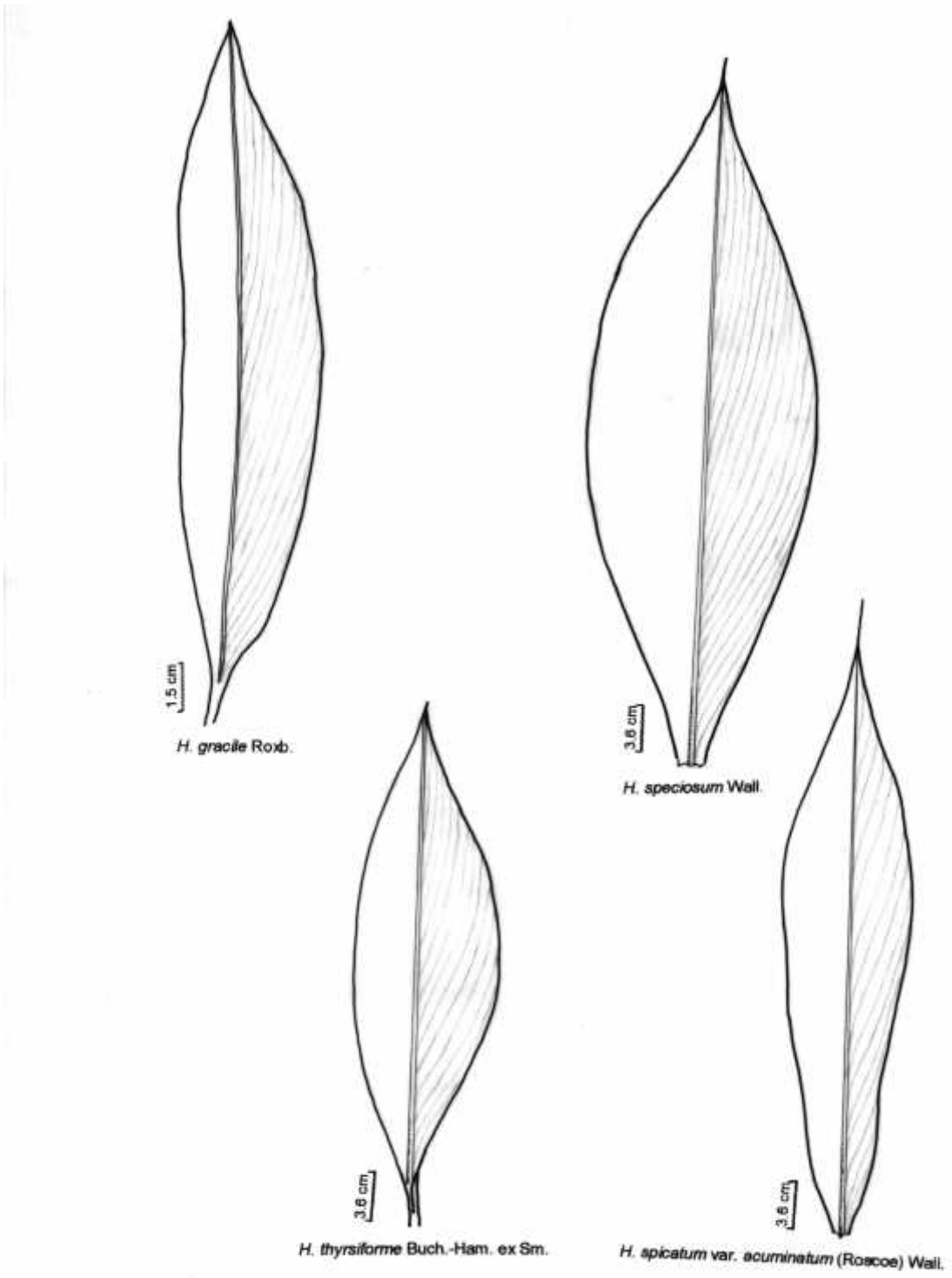


Figure 1 Leaves of *Hedychium*

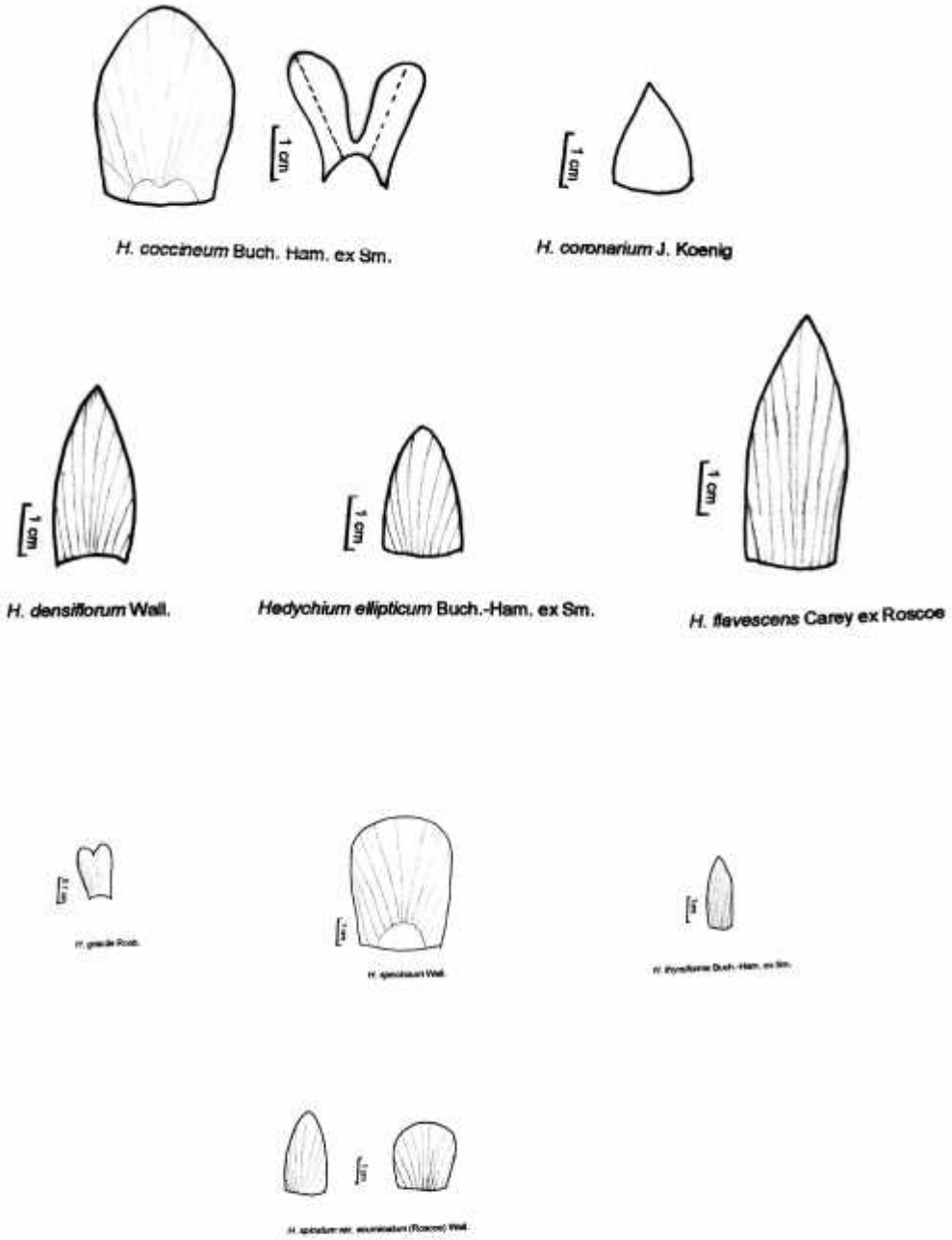


Figure 2. Ligules of *Hedychium*

Five species, *Hedychium coccineum*, *H. coronarium*, *H. flavescens*, *H. spicatum* and *H. thyrsiforme* had hairs, sparsely or densely at the tips of the bracts. *Hedychium flavescens* also had hair sparsely distributed throughout the body of the bracts. The remaining had glabrous bracts. Two species (*Hedychium densiflorum*, *H. flavescens*) had obtuse apex and two species (*H. ellipticum*, *H. gracile*) had acuminate apex. The rest had acute apex.

All bracts in the genus are theoretically imbricate. However some bracts are imbricating and conceal the main axis of the spike, whereas some are imbricating yet do not conceal the main axis of the spike, giving it the appearance of being 'tubular'. In recent literatures they are termed as 'bracts imbricate or lax' Shu (2000), Smith (1994) defines it as 'bracts imbricating or remote/convolute' for the former and the latter respectively. Here it will be mentioned as 'bracts imbricate or convolute' henceforth. Three species (*Hedychium coronarium*, *H. ellipticum* and *H. flavescens*) had 'bracts imbricating' and remaining six species (*Hedychium coccineum*, *H. densiflorum*, *H. gracile*, *H. speciosum*, *H. spicatum*, and *H. thyrsiforme*) had 'bracts convolute'.

Each bract subtends single to multiple flowers depending upon the species and is useful for classification purposes. Four species had bracts subtending only one flower, *Hedychium densiflorum*, *H. ellipticum*, *H. gracile* and *H. spicatum*. The remaining species had bracts subtending flowers more than one, from a range of two to four; *Hedychium coccineum* (no. of flowers subtending 3-4), *H. coronarium* (no. of flowers subtending 3-4), *H. speciosum* (no. of flowers subtending 2-3), *H. flavescens* (no. of flowers subtending 2-4), *H. thyrsiforme* (1or2).

5.1.2.3 Bracteoles and Inner bracteoles

The bracteoles in *Hedychium* are tubular with cleft on one side, with or without hairs (Fig 4). Occasionally they also subtend inner bracteoles which are similar

to the bracteoles in every respect, save they are slightly smaller in size. The bracteoles of *Hedychium flavescens* were observed to be 2-lobed, those that of *H. coccineum* were found to be minutely 3-lobed or 1-lobed; whereas the bracteoles of *H. coronarium*, *H. ellipticum*, *H. gracile*, *H. speciosum*, *H. spicatum* and *H. thyrsiforme* were found to be 1-lobed. The bracteole of *Hedychium densiflorum* could not be studied. The bracteole texture of *Hedychium ellipticum* was observed to be coriaceous and those that of the remaining species were found to be membranous. Four species (*Hedychium coccineum*, *H. flavescens*, *H. gracile* and *H. spicatum*) had tuft of hairs on their bracteole lobes with *H flavescens* being sparsely pubescent throughout.

5.1.2.4 Calyx

Calyces are tubular, split on one side, membranous, the apex 1, 2 or 3 toothed, with or without hairs on the lobe/s (Fig. 5). Shu (2000) has mentioned the apex of the calyx to be either truncate or 3-lobed. Whereas the current study showed six species (*Hedychium coronarium*, *H. densiflorum*, *H. ellipticum*, *H. gracile*, *H. spicatum* and *H. thyrsiforme*) with 2-lobed calyces; two species (*Hedychium coccineum* and *H. speciosum*) with 3-lobed calyces and only one species, *H. flavescens* was observed with 1-lobed calyx.

The calyx lobes of three species (*Hedychium coronarium*, *H. gracile* and *H. thyrsiforme*) had tufts of hairs on their apices. In *Hedychium coccineum* hairs were either present or absent. Remaining five species (*Hedychium ellipticum*, *H. flavescens*, *H. speciosum* and *H. spicatum*) had glabrous calyx lobe apices.

The apices of the calyx lobes were, acute (*Hedychium gracile*), acuminate (*H. coronarium*, *H. coccineum*, *H. ellipticum*, *H. flavescens*, *H. speciosum*, *H. spicatum*, *H. thyrsiforme*) and obtuse (*H.densiflorum*). *H. coccineum* had both acute and obtuse apices.

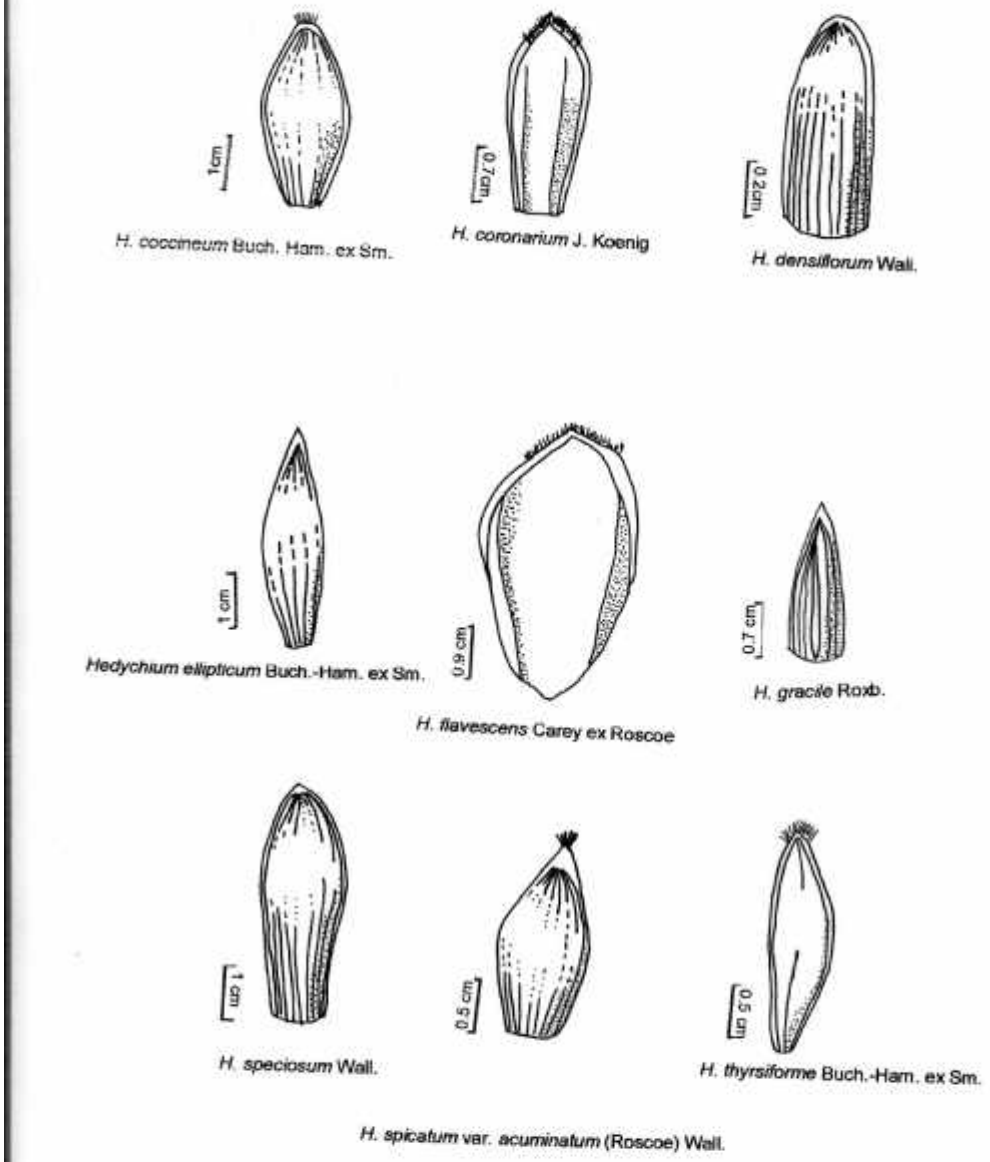


Figure 3. Bracts of *Hedychium*

In two species (*Hedychium spicatum* and *H. thyrsiforme*) calyces were found to be longer than bracts. Four species (*Hedychium coronarium H. coccineum*, *H. ellipticum*, *H. flavescens* and *H. speciosum*) had calyces shorter than bracts. In *Hedychium coronarium* the calyces were occasionally also observed to be longer than bracts. In two species (*Hedychium gracile* and *H. densiflorum*) calyces were found to be more or less equal to the length of bract.

5.1.2.5 Corolla

The corolla consists of long tube that projects beyond or shorter than bracts, and three linear lobes with margins in-rolled; reflexed; sometimes the two margins touching each other (*Hedychium flavescens*, *H. spicatum* var. *acuminatum*), Fig. 6.

Five species (*Hedychium coronarium*, *H. ellipticum*, *H. flavescens*, *H. spicatum* and *H. thyrsiforme*) had corolla tubes longer than their respective bracts. Two species (*Hedychium gracile* and *H. speciosum*) had the corolla tubes equal to or longer than their subtending bracts. Only one species, *Hedychium coccineum* had corolla tube shorter than its bract.

The tip of the corolla lobes showed some variation. As the morphological variations traced of the tips of the corolla lobe could not be found elsewhere, it is probably the first time it has been attempted. This can be only observed clearly through the help of a dissecting microscope or a stereo-microscope nevertheless can be useful in identification of the species using simple morphological observations. The ends of the corolla lobes are ovate, save in *Hedychium densiflorum* (oblong). The corolla-tips were found to be acuminate (*Hedychium speciosum*, *H. coronarium*, *H. gracile*, *H. spicatum*), acute (*H. coccineum*), acute-acuminate *(H*. *thyrsiforme*), obtuse (*H. densiflorum* and *H. ellipticum*), aristate (*H. flavescens*).

5.1.2.6 Stamen and Staminodes

As aforementioned elsewhere in the text (Introduction 1.1), *Hedychium* has six androecial members out of which only one is a fertile stamen; two staminodes are fused to form a labellum, there are two separate staminodes and one staminodial member in between the lips of the labellum degenerate soon after initiation. Stamens and staminodes show interesting variations in shapes, sizes and lengths, hence are important characters for taxonomic purposes.

5.1.2.6.1 Lateral Staminodes

Two lateral staminodes are present in the flower of *Hedychium*. The lateral staminodes are petaloid, showy, broader than the corolla lobes and narrow than the labellum (Fig. 6). The shapes of lateral staminodes in the genus *Hedychium* are linear, elliptic-obovate and clawed. In two species (*Hedychium ellipticum* and *H. thyrsiforme*) lateral staminodes were linear. In *Hedychium thyrsiforme* the lateral staminodes were found coiled upwards when observed in living specimens. Two other species (*Hedychium coronarium* and *H. flavescens*) had elliptic-obovate lateral staminodes. Those on the five species viz., *Hedychium coccineum* (oblanceolate), *H. densiflorum* (oblanceolate), *H. gracile* (lorate-clawed), *H. speciosum* and *H. spicatum* were clawed.

Two species (*Hedychium coccineum* and *H. speciosum*) had a small tuft of hair at the bottom of the claw. This character was observed when studying living specimens and was found to be consistent. This is a new character that can be used for the taxonomy of *Hedychium*.

The lateral staminodes show some variations, however it is difficult to distinguish a species entirely on the basis of it. The lateral staminodes can only be used as an accessory character and are not useful when used independently.

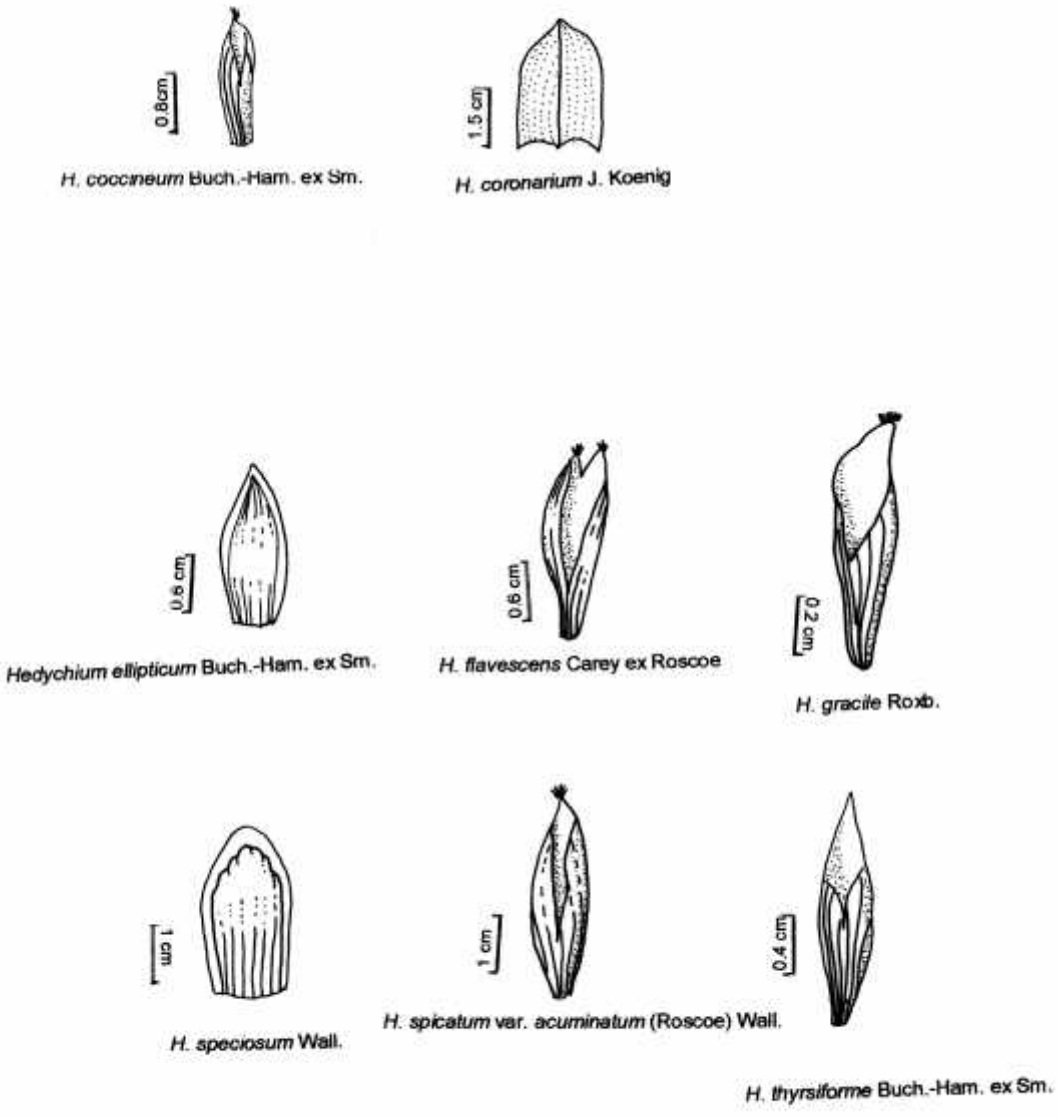


Figure 4. Bracteoles of *Hedychium*

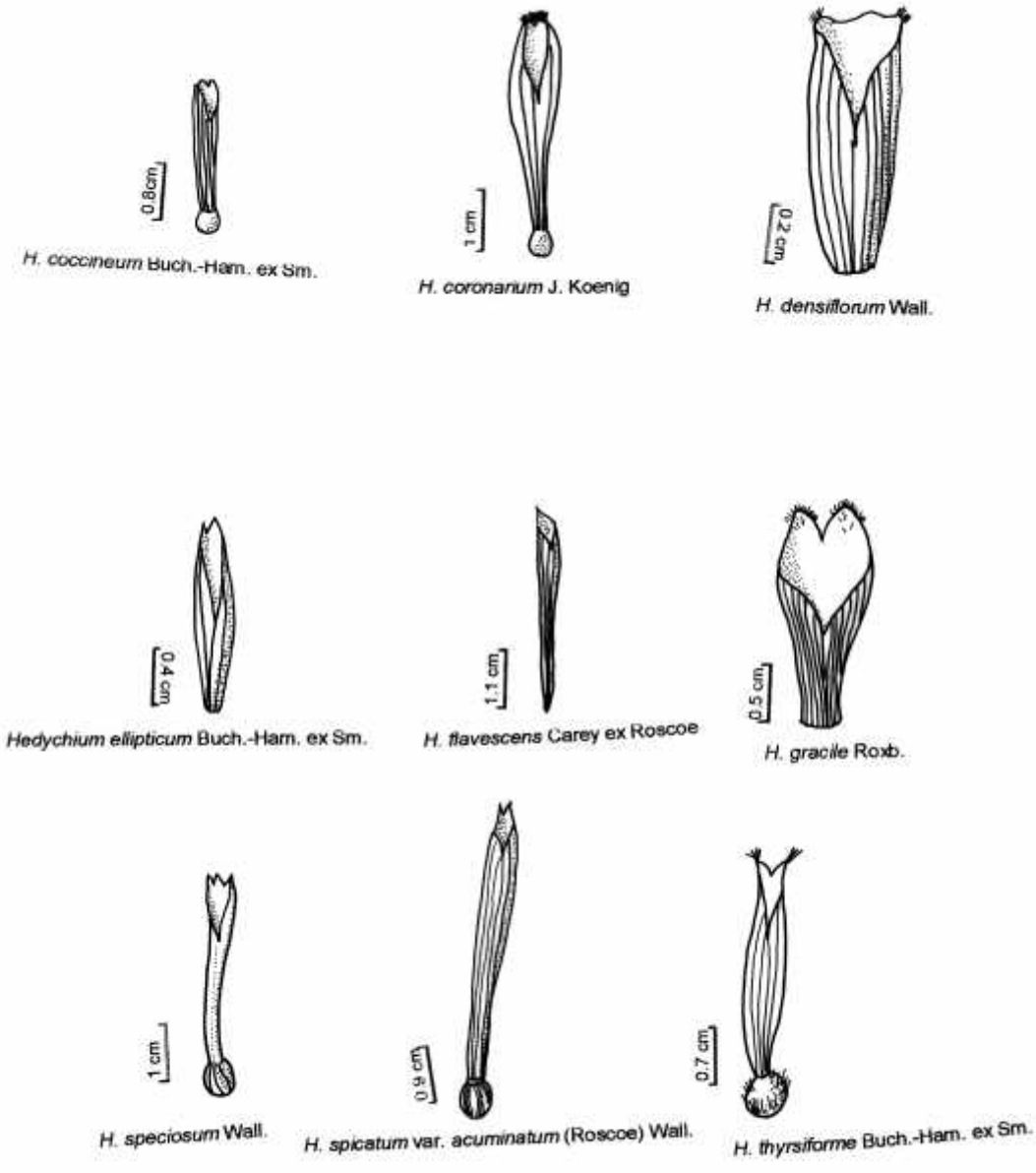


Figure 5. Calyces of *Hedychium*

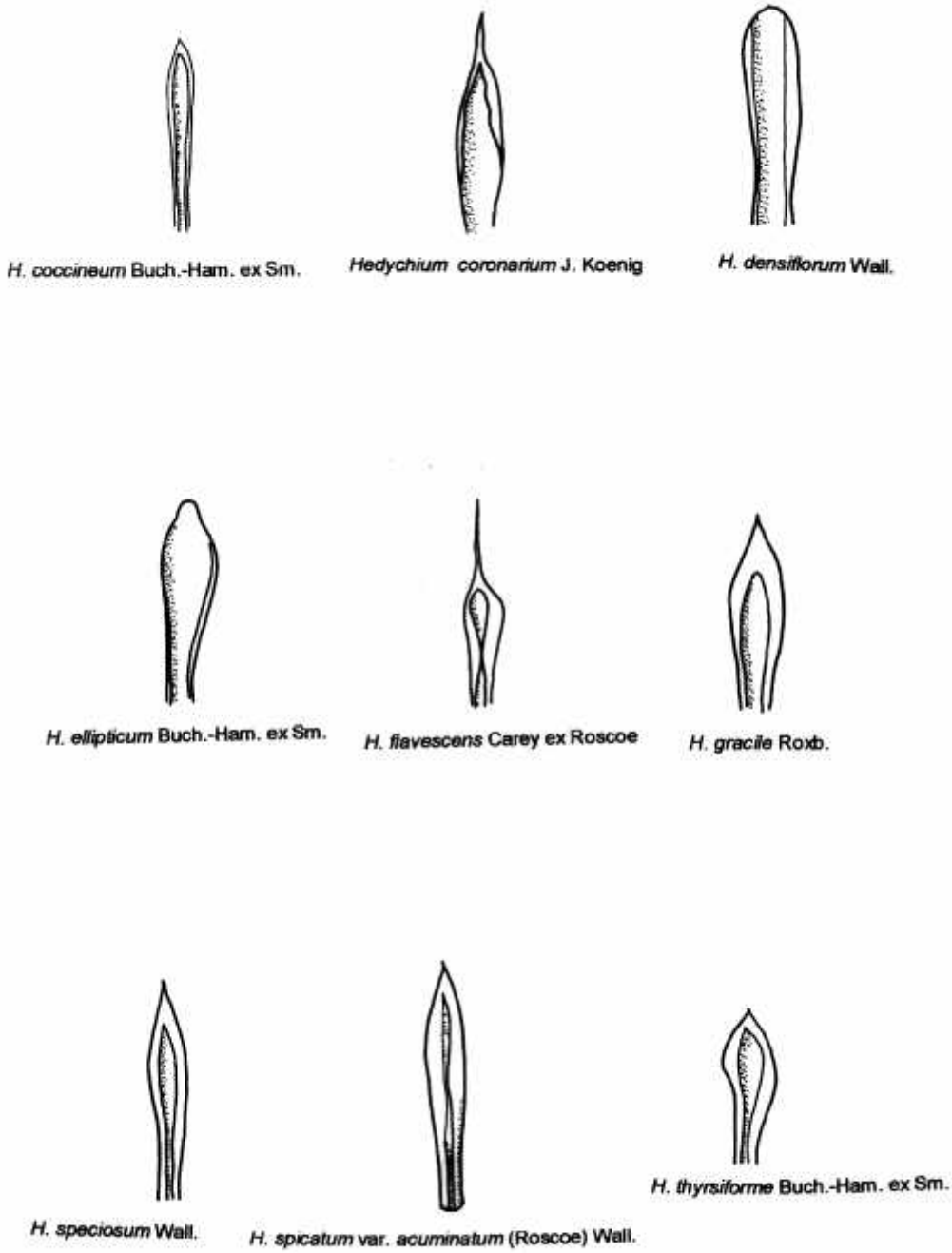


Figure 6. Corolla tips of *Hedychium*

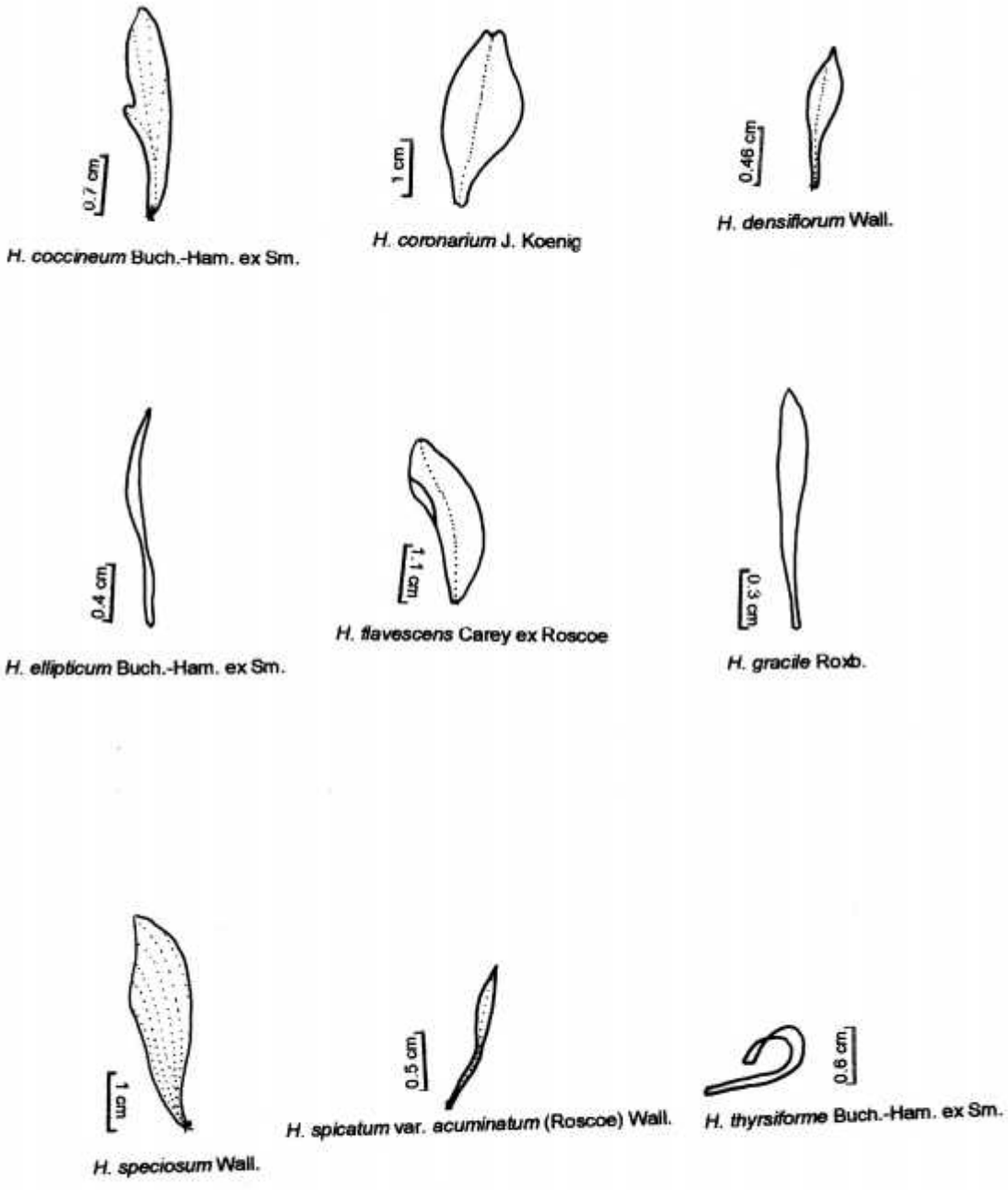


Figure 8. Lateral staminodes of *Hedychium*

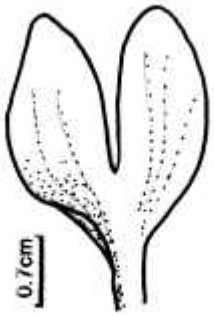
5.1.2.6.2 Labellum

In the genus *Hedychium* labellum (lip) is the showiest part of the genus that is made up of the fusion of two staminodes, resulting in the labellum appearing two-lobed, except in *H. bordelonianum* where it is three-lobed (Williams, K. J. *et al.* 2003). All the Nepalese species of the genus have lips conspicuously 2-lobed (Fig 7, 7a). The labellum is suborbicular to obcordate in shape and attenuated at the base. The limb (claw) forming a furrow till its insertion in the corolla tube. The shape of the lobes, the length of the cleft and colour show considerable variation. Labellum in *Hedychium gracile* was linear, with each lobe further mildly and unequally cleft.

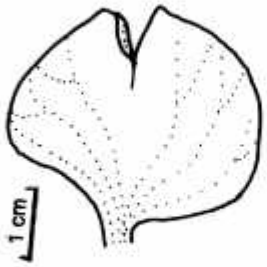
Two species (*Hedychium coronarium* and *H. flavescens*) had obcordate labellums. The difference between the two, apart from the colour (white in *Hedychium coronarium* and yellow in *H. flavescens*) was that *H. flavescens* had the labellum longer than wide and *H. coronarium* had labellum equal to or slightly wider than long.

The elliptic-obovate labellum in *Hedychium speciosum* formed a concave surface in living specimens. *Hedychium thyrsiforme* had apices of the lobes bent backwards making it not visible from the front.
Six species (*Hedychium coronarium*, *H. densiflorum*, *H. ellipticum*, *H. flavescens*, *H. spicatum* var. *acuminatum* and *H*. *thyrsiforme*) had lobes with acute apex. In the remaining three species (*Hedychium coccineum*, *H. gracile* and *H. speciosum*), the apex lobes were obtuse.

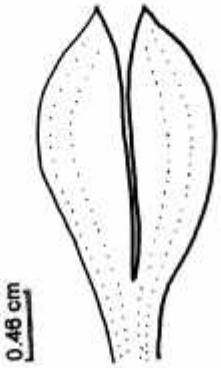
Three species (*Hedychium densiflorum*, *H. gracile*, and *H. thyrsiforme*) had the cleft exceeding more than half the length of labellum. In *Hedychium coccineum* the cleft was equal to or more than half the length of the labellum. In the remaining five species (*Hedychium coronarium*, *H. ellipticum*, *H. flavescens*, *H. speciosum*, and *H*. *spicatum*) the cleft was not more than half the length of the labellum.



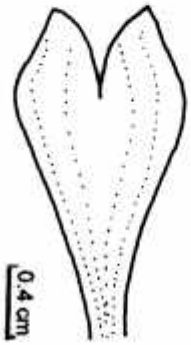
H. coccineum Buch.-Ham. ex Sm.



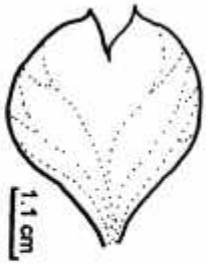
H. coronarium J. Koenig



H. densiflorum Wall.



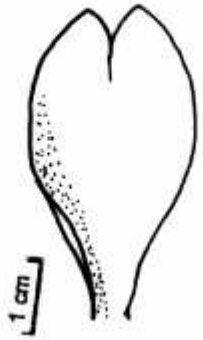
Hedychium ellipticum Buch.-Ham. ex Sm.



H. flavescens Carey ex Roscoe

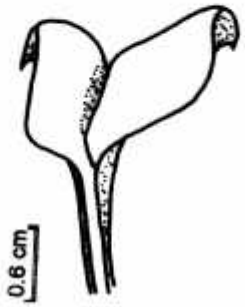
Figure 7. Labellums of *Hedychium*

H. gracile Roxb.



H. speciosum Wall.

H. spicatum var. *acuminatum* (Roscoe) Wall.



H. thyrsiforme Buch.-Ham. ex Sm.

Figure 7 Labellums of *Hedychium*

5.1.2.6.3 Stamens

Stamen of the genus is 'clasping type', which clasps the thin style that passes through the two locules. The filament is long, anther dorsifixed, base divaricate and connective appendage absent with starchy pollens (Zona, 2001). Length of stamens in respect to the length of labellums are explored in the present work. Three species, *Hedychium coronarium*, *H. flavescens* and *H. spicatum* had the filaments that were subequal to the labellums. In the first and second the length of filament were slightly subequal, whereas in the third the length of the filament was less than half of the length of the labellum.

Six species, *Hedychium coccineum*, *H. ellipticum*, *H. gracile*, *H. speciosum*, and *H. thyrsiforme* had filaments longer than their respective labellums.

Lengthwise, *Hedychium speciosum* had the longest filament ranging from 5.5 to 7.2 cm, followed by *H. gracile* (ca. 6.5 cm). Third came *Hedychium thyrsiforme* (5--5.2 cm), fourth in the range were *H. coccineum* (ca. 4.2 cm) and *H. ellipticum* (4.3--4.5 cm), followed by *H. coronarium* (ca. 3cm) and *H. flavescens* (3.5--4.2 cm). The shortest filament was found in *Hedychium spicatum* (ca. 2cm).

Not much variation was observed in the shape of the anthers except in length. The anther length were, *Hedychium coccineum* (ca. 0.7cm), *H. coronarium* (ca. 1.5 cm), *H. densiflorum* (0.4--0.6 cm), *H. ellipticum* (1.4--1.5 cm), *H. flavescens* (1.2--1.6 cm), *H. gracile* (0.8--0.9 cm), *H. speciosum* (ca. 1cm), *H. spicatum* var. *acuminatum* (ca. 1.5 cm) and *H. thyrsiforme* (ca. 1cm). The anther length was longest in *Hedychium coronarium*, *H. ellipticum*, *H. flavescens* and *H.spicatum* var. *acuminatum;* in all more than 1 cm. While *Hedychium coccineum*, *H. densiflorum*, *H. gracile* had anthers less or not more than 1 cm, with smallest anthers found in *H. densiflorum* (0.4--0.6 cm). When observed in living specimens, the anthers of *Hedychium thyrsiforme* were found to be erect perpendicular to their filaments.

5.1.2.7 Pistils

The pistil of the genus consists of an ovary, a thin style embedded in the clasping filament, and a stigma protruding apically from in between the anthers. The stigma hairs showed some variation.

Stigma hairs in *Hedychium coccineum* were uniquely curled on the apices. In two species (*Hedychium densiflorum* and *H. thyrsiforme*) short straight hairs were observed. In other two species (*Hedychium flavescens* and *H. speciosum*) the stigma hairs were found to be hooked on the apices. In *Hedychium coronarium* the hairs were long and curled, in *H. gracile* they were long, and dense; in *H. ellipticum* short and dense; *H. spicatum* var. *spicatum* had long hairs that were most straight from the rest.

Ovary is 3-locular, with axile placentation, pubescent or glabrous. In the current study, only the pubescence of the ovary has been studied. Out of eight species (ovary of *Hedychium densiflorum* could not be studied), three species had glabrous ovary (*H. coronarium*, *H. speciosum* and *H. spicatum*). The ovary was ridged longitudinally in *Hedychium spicatum*. The remaining five had pubescent ovaries. In *Hedychium coccineum* the hairs were pointed upwards. The pubescence was around the bottom region of ovary in *Hedychium thyrsiforme*. It was pubescent throughout In *Hedychium ellipticum*, *H. flavescens*, and *H. gracile*.

5.1.2.8 Fruit

Fruit is three-locular capsule in the genus. Seeds are variably shaped, numerous and aril lacerate on maturation. Since almost all of the herbarium (save one or two) had flowering specimens only, the characters of fruits could not be studied during this research.

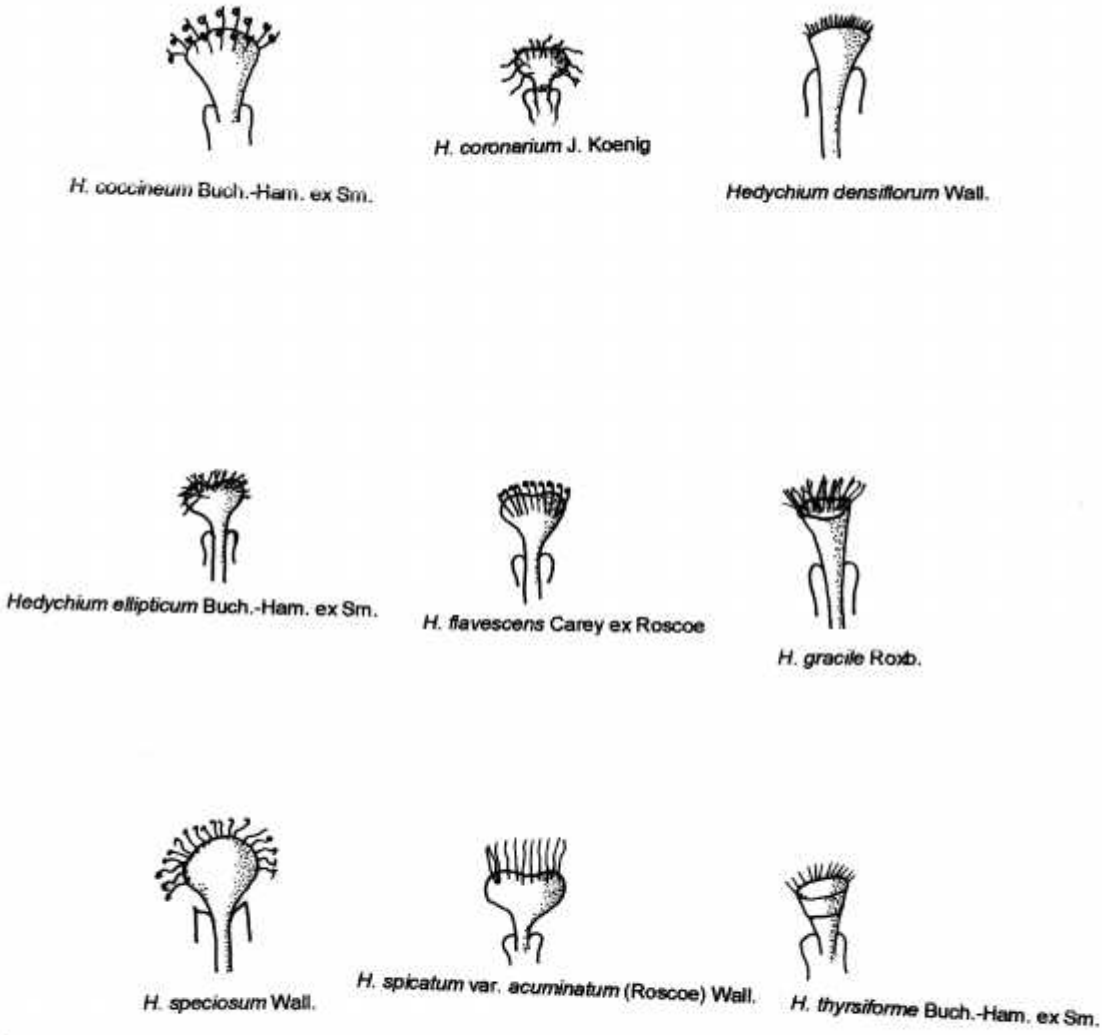


Figure 9. Stigmas of *Hedychium*

5.2 Phenology

Table 1: Phenology of *Hedychium*

Species	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Hedychium coccineum												
H. coronarium												
H. densiflorum												
H. ellipticum												
H. flavescens												
H. gracile												
H. speciosum												
H. spicatum												
H. thyrsiforme												

The above phenology chart was prepared based on the information on herbarium specimens and field observations. Information from literatures other than local floras is excluded so as to give more precise information about the flowering and fruiting of the Nepalese species of *Hedychium*. Accordingly, the flowering season of the genus starts from June and continues till November. The species that had longest flowering period (up to four months) were *Hedychium coronarium* (Aug-Nov), *H. spicatum* (Jun-Sep) and *H. thyrsiforme* (Aug-Nov). The species having three months flowering season were *Hedychium coccineum* and *H. densiflorum*. The early bloomers (starting in June) were *Hedychium ellipticum*, and *H. speciosum*, whereas *H. thyrsiforme* started flowering in the latter most part of year (August) and continued to bloom till November.

6. TAXONOMIC TREATMENT

6.1 Keys to the Species

1. Bracts imbricating, main axis concealed……..2
+ Bracts convoluted, main axis not concealed……..3

2. Bracts subtending single flower, filaments longer than labellum..
… **H. ellipticum**
+ Bracts subtending multiple flowers, filaments shorter than labellum……..4

3. Bracts subtending single flower……..5
+ Bracts subtending multiple flowers……...6

4. Labellum longer than wide, flowers yellow……**H. flavescens**
+ Labellum equal to or wider than long, flowers white……..**H. coronarium**

5. Filaments shorter than labellum, labellum cleft not more than half the length….. …….. ……**H. spicatum**
+ Filaments longer than labellum, labellum cleft more than half the length……7

6. Bracts subtending not more than 2 flowers, calyx-2 lobed, flowers white……...**H. thyrsiforme**
+ Bracts subtending more than 2 flowers, calyx-3 lobed, flowers yellow or red…….....8

7. Ligule apex 1-lobed, bracts oblong, flowers yellow……...**H. densiflorum**
+ Ligule apex-2 lobed, bracts ovate, flowers cream white……**H. gracile**

8. Leaves petiolate, elliptic, flowers lemon yellow……..**H. speciosum**
+ Leaves sessile, linear-lanceolate, flowers orange or red…..**H. coccineum**

6.2 Hedychium coccineum Buch.-Ham. ex Sm., Cycl. 17: Hedychium n. (1811). Baker in Fl. Brit. Ind. **6:**231 (1892). EFPN 1: 60 (1978). ACFPN: 330 (2000). FPN: 166 (2001).

Hedychium aurantiacum Roscoe, Monandr. Pl. Scitam.: t. 61 (1828).

Hedychium angustifolium Roxb., ; Pl. Coromand. 3: t. 251 (1815).

Hedychium coccineum var. *angustifolium* (Roxb.) Baker, ; in Hook. f., Fl. Brit. Ind. 6: 231 (1892).

Hedychium roscoei Wall.; in Roscoe, Monandr. Pl.: sub Hedychium, *verso* (1828).

Pseudostems upto 1.5m. *Leaves* sessile, linear-lanceolate, 45--49 X ca. 3.1--7.5 cm, acuminate, sparsely pubescent along the mid-rib adaxially; ligules oblong or deeply 2-lobed, ca. 2cm, membranous, glabrous. *Inflorescence*, spikes ca.24.5cm, almost quadrangular, laxly flowered, main axis not concealed; bracts convolute, oblong, ca. 3.6 X ca.1.6 cm, apex obtuse-acute, margin membranous, apex pubescent, sparsely pubescent throughout, number of flowers subtending 3-4; bracteoles 1-lobed, light green, ca. 2X0.7cm, apices acute with dense hairs. *Flowers* scarlet or orange red, fragrant; calyx ca. 2.2--2.3 cm, sparsely pubescent, apex 3-lobed, densely pubescent or glabrous, shorter than bract; corolla tubes orange red, 2.8-3cm, slightly longer than bract, corolla lobes ca. 3cm, linear, apex white- yellow, acute, margins inrolled without touching each other; lateral staminodes linear-oblanceolate, clawed, ca. 2cm, margin slightly undulate, labellum orbicular, ca. 2cm, 2-lobed more than half the length of labellum; filaments red, ca. 4.2 cm, more than twice longer than labellum, anthers dark red ca. 0.7 cm; stigma with hairs uniquely coiled on the tips; ovary pubescent, dense at the bottom, hairs pointing upwards.

Flowering season: June-August

Fruiting season: October

Type: Nepal, Wallich (**Isotype BM!** det. by Tom Wood 2002), Collected by Dr. Buchanan at Suembu, on June 8, 1802.

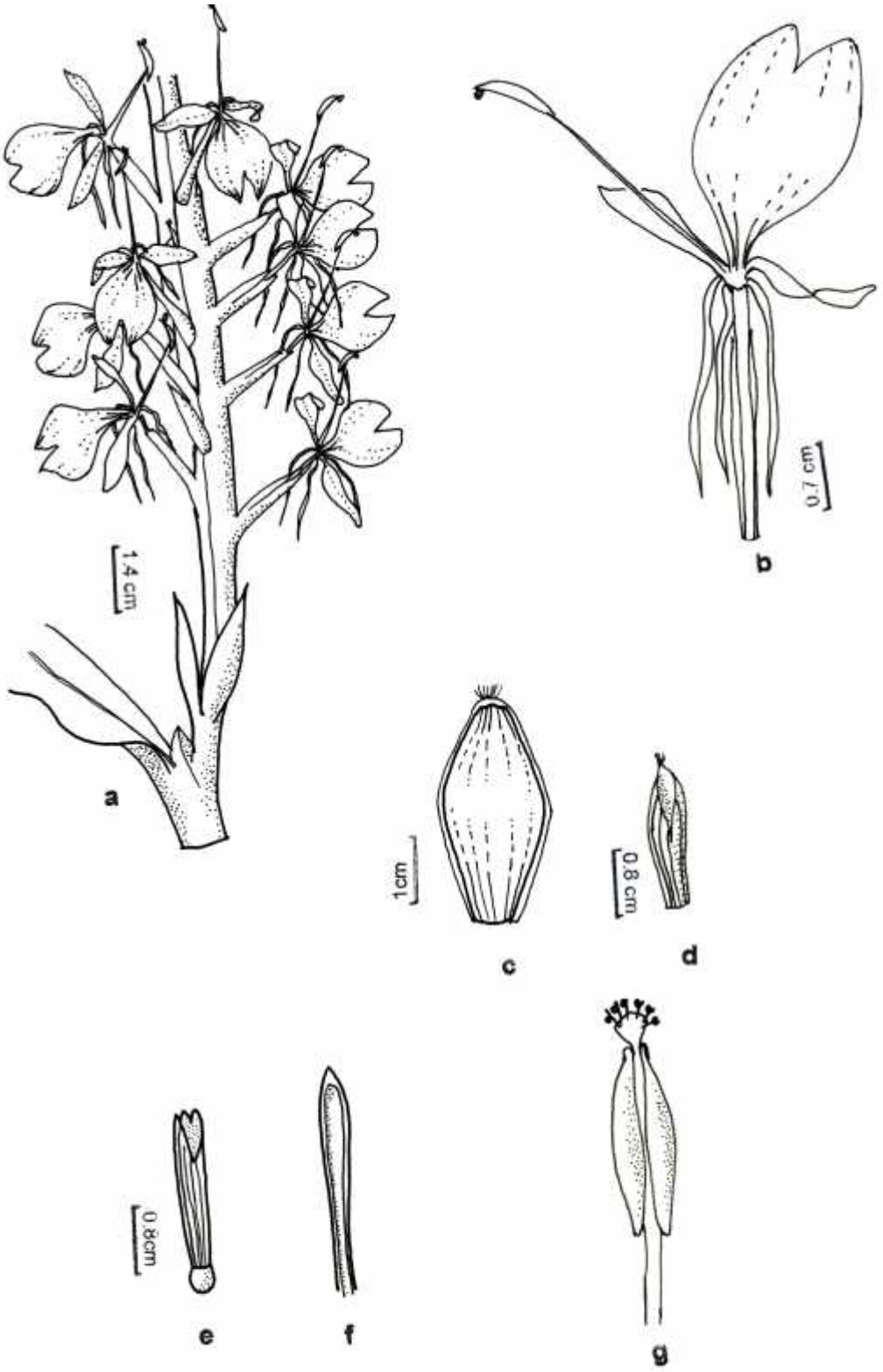


Figure 10. *Hedychium coccineum* Buch.-Ham. ex Sm. **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged), (Mishra, S. 703 TUCH).

Notes: EFPN (1978) and Press *et al*. (2000) have enumerated *Hedychium coccineum* Buch.-Ham. ex Sm and *H. aurantiacum* Rosc. as two different species. Current study treats *Hedychium coccineum* Buch.-Ham. ex Sm. and *H. aurantiacum* Rosc. as single species. Hence proposes *Hedychium aurantiacum* Rosc. as a synonym of *H. coccineum* Buch.-Ham. ex Sm.

The following communication by Smith (1819) also provide some insight to the existence of the confusion about the possible two taxa: …."Dr. Buchanan observed what he conceived to be a variety of this fine species, chiefly differing in its more dense imbricated spike, and orange-coloured inner segments of the flowers. Its flower-stalk indeed was smooth, and calyx terminating in two teeth. We have no specimen of this, but are inclined to presume it may be a distinct species".

From the above text we can know that Smith (1819) was writing about *Hedychium aurantiacum* (orange-coloured) and that it might be a different species. However based on observations of this research, it can be argued that the 2-lobed calyx is just phenotypic plasticity, as this researcher has found 3-lobed calyces in orange coloured supposedly *Hedychium aurantiacum* as well.

A variety of *Hedychium coccineum* described by Baker (1892), *H. coccineum* var. *roscoei*, could possibly be *H. aurantiacum* Rosc, with the distinguishing character as "staminodes bright red, lip dull brick-red".

Smith (1994) has also treated the above two taxa as separate. In fact the only character Smith (1994) cites to differentiate between the two is "[*Hedychium aurantiacum*].....differs from *H. coccineum* in having bright orange-yellow flowers", whereas *H. coccineum* is reported to have "brick-red to orange/salmon-coloured flower". Shu (2000) only mentions *Hedychium coccineum* and does not mention *H. aurantiacum*.

Wood (2000) has treated *Hedychium aurantiacum* as *H. coccineum* itself. On personal communication with this author Dr. Wood opined that both the species are basically same and at most *Hedychium aurantiacum* could be a sub-specific taxon under *H. coccineum*, but certainly not a separate species.

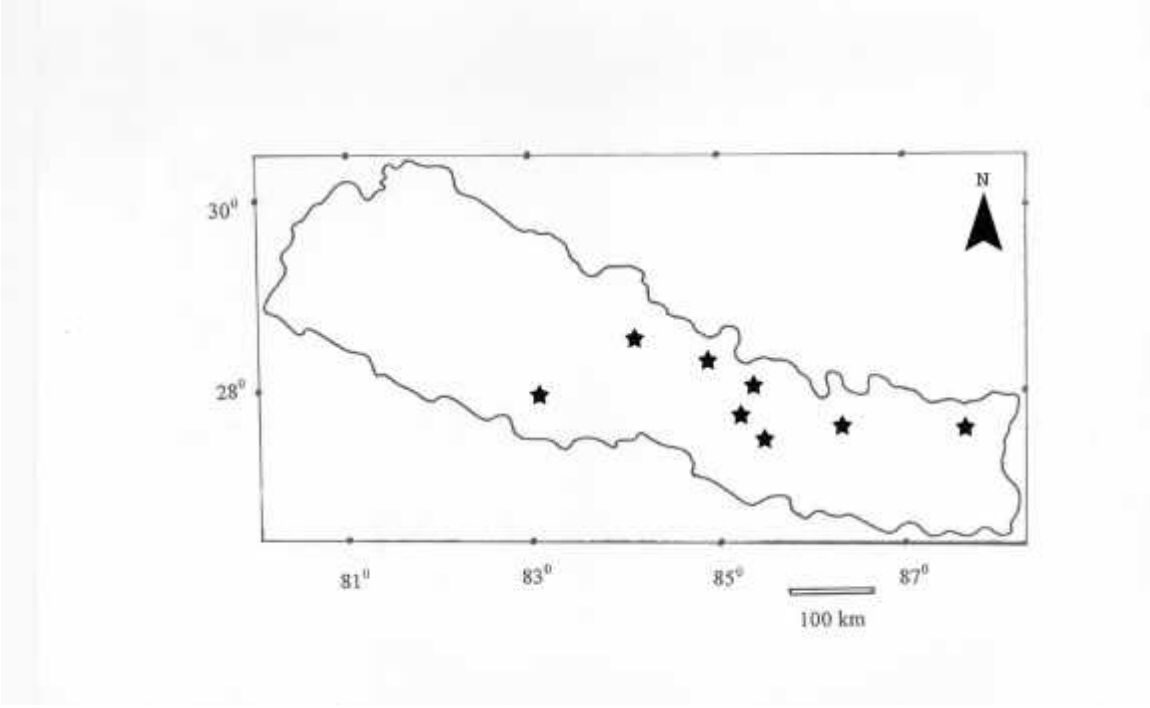
The characters between the putative two taxa are more or less similar except they are distinguished by colour, *Hedychium coccineum* (scarlet-red) and *H. aurantiacum* (orange-red). In the present study also there have not been much noteworthy variations except the colour.

During field study, this researcher has found both the taxa in close proximity of each other. In a population of *Hedychium coccineum* one or two *H. aurantiacum* would be found and vice versa. Furthermore, some individuals have been found with intermediate forms of colour (scarlet-orange).

It will require molecular technology and a thorough field study (pollination biology, morphogenesis, ontogeny) to shed valuable insight into this problem, which is out of scope of this study. Morphologically it can be argued that they are same.

Hence it is proposed that the erstwhile two species *Hedychium aurantiacum* and *H. coccineum* are one. As the priority of publication goes to *Hedychium coccineum* (1811), *H. aurantiacum* (1828) is designated as the synonym of the former.

Distribution: Nepal (CE), 1000-2000 m. Himalaya (Nepal to Assam), India, Myanmar, Indo-China.



Map 1: Distribution of *H. coccineum* Buch.-Ham. ex Sm.

Representative Collections:

Central Nepal: Kaski, Madi Khola near Pokhara, 4500 ft, 18.7.1954, Stainton, Sykes & William 6439 (BM); Bakhri Kharka, Madi Khola, 5500 ft, 17. 7. 1954, Stainton, Sykes & William 6403 (BM). **Nawalparasi,** Tomaspur forest, 150 m, March 1971, Makin 84 (BM). **Gorkha,** Buri Gandaki near Aalchok, 4500 ft, 23.7. 1953, New Zealand Himalayan Expedition, Gardner (BM). **Nuwakot,** Trisuli Valley, 6000 ft, 26. 7. … Polunin 1337 (BM). **Rasuwa,** Near Wangel, 1500m, 15. 7. 2001, Karkee *et al.* 159 (KATH); Syabrubesi, 4450ft, 18. 7. 1977, Manandhar 225 (KATH); Rasua Garhi, 5-6000 ft, 12.7. 1949, Polunin 979 (BM); **Kathmandu**, Champa Devi, ca. 1700m, 7. 6. 2002, Mishra, 703 (TUCH). **Lalitpur,** Godavari Garden, 1540m, 30.7.1976, Roy 9968/76 (KATH). **Makwanpur,** Palung, 21. 7. 2001, Gurau, 138 (TUCH); Palung, ca. 1900m, 5. 4. 058, Khadka, 137 (TUCH); Palung, 1900m, 20. 7. 2001, Bhattarai, 128 (TUCH); Palung, ca. 1900m, 5. 4. 058, Shreshta 112 (TUCH); Palung, ca. 1900m, 5. 4. 058, Adhikari, 142(TUCH). **Dolakha**, 1500m, 12.7.1977, Rajbhandari & Roy. 1208 (KATH); Gangar, Bhotekoshi, 4500 ft, 10. 7. 1 1975, Shakya *et al.* 29/4 (KATH). Chisey 16000 ft, 15. 8. 1931, Sharma 143 (BM).

Eastern Nepal: Sankhuwasabha, Arun Valley, Maghan Khola E. of NUM, 6500 ft, 30.6. 1956, Stainton 797(BM).

Locality Unknown: Jurauti Khola, 2000 ft, 9. 8. 1954, Stainton, Sykes & William 6839 (BM).

6.3 Hedychium coronarium J. Koenig. Obs. Bot. 3: 73 (1793). Baker in Fl. Brit. Ind. **6: 225**(1892). EFPN 1: 60 (1978). Hara in Fl. East. Him. 422 (1966). ACFPN: 30(2000). FPN : 166(2001).

Hedychium sulphureum Wall. ex Baker, ; in Hook. f., Fl. Brit. Ind. 6: 226 (1892), *pro syn.*

Pseudostems 1--2.5m. *Leaves* sessile, elliptic-lanceolate, 31-34X6.1--7 cm, apex acuminate, adaxial surface slightly hairy; ligules ovate, acute, 2--3X1.4--1.7 cm membranous, glabrous or hairy. *Inflorescence*, spikes ellipsoid, 10--14 cm, glabrous, densely flowered, main axis concealed; bracts imbricating, oblong-elliptic, up to 3 cm, apex acute, margin membraneous, coriaceous,hairy at the apex, number of flowers subtending 3-4; bracteoles 1-lobed, ca. 3.3 cm, apex acute, membranous, pubescent at the apex. *Flowers* white with yellow tinge at the bottom of labellum, 8--8.5 cm, highly fragrant; calyx 2-lobed, 3.3--3.4 cm, apices acute, membranous, shorter or longer than bract; corolla tube ca. 5 cm, longer than bract, corolla lobe ca. 2.2 cm, apex acuminate; lateral staminodes elliptic-obovate, ca. 3.3cm; labellums obcordate, 3.5--4cm, slightly 2-lobed to not more than half the length of labellum, equal to or wider than long; filaments white ca. 3 cm, subequal to labellum, anthers white ca. 1.5 cm; stigma densely pubescent with long curled hairs, ovary glabrous.
Flowering season: August - November
Fruiting season: November - December

Notes: *Hedychium coronarium* is also a widely cultivated ornamental species in Nepal. Many intermediates and horticultural hybrids are found, most of them are sterile. Smith (1819) writes on *Hedychium coronarium*, "….Dr. Buchanan found this plant, or at least a pale yellowish variety of it, wild about the borders of fields among the elevated mountains of Upper Nepal [Kathmandu?]….", giving the impression that the plant Buchanan collected could have been *Hedychium coronarium* or some other variety of it (*H. flavescens?* as it was till then just a variety of *H. coronarium*).

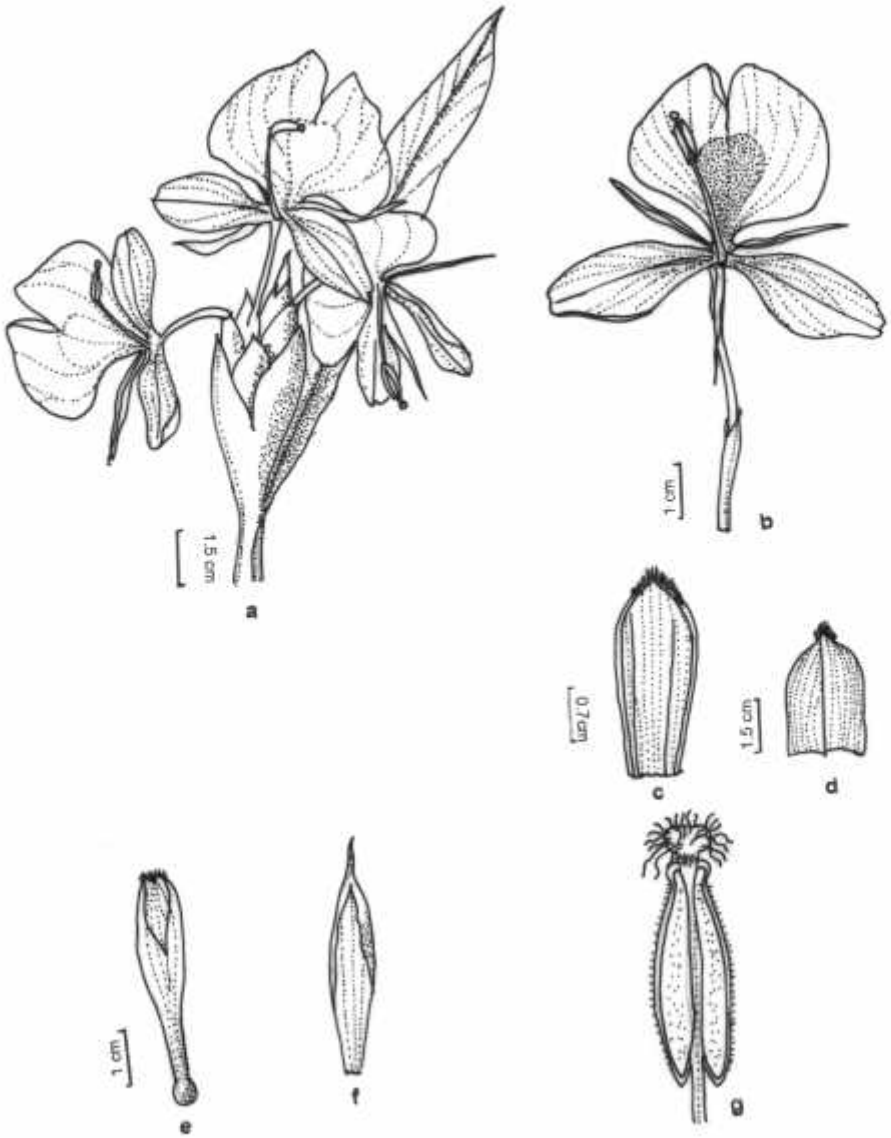


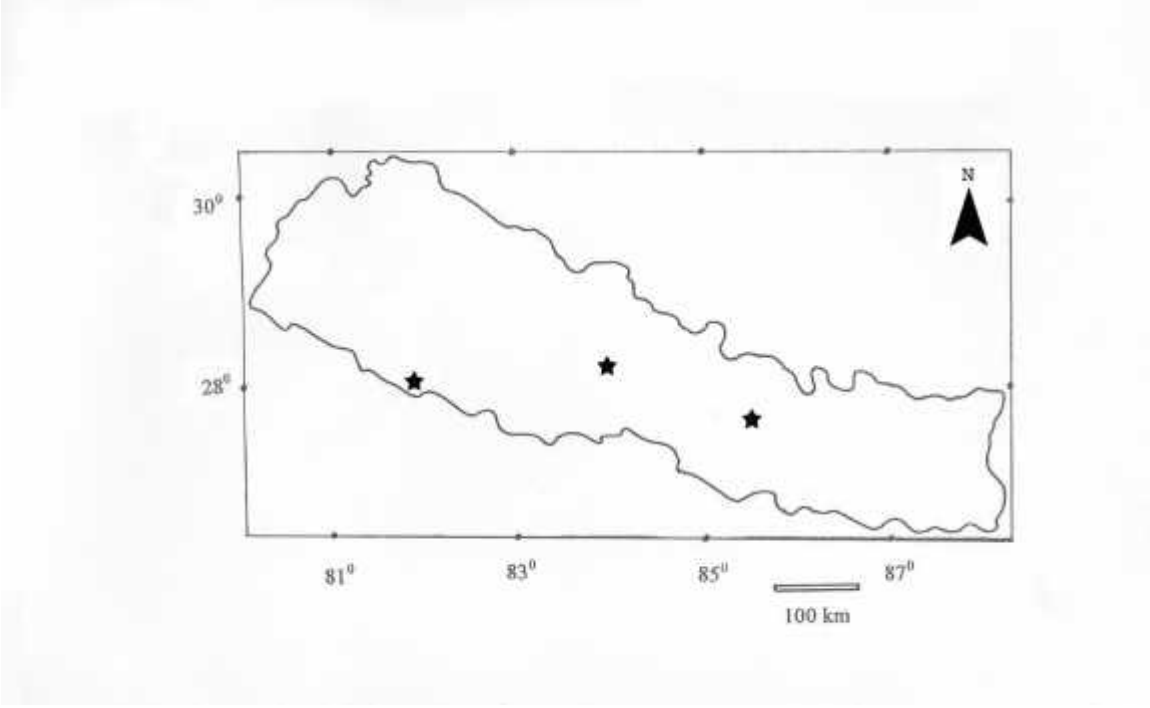
Figure 11. *Hedychium coronarium* J. Koenig, **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged), (Stainton, Sykes & Williams 8262, BM).

Orchard (1978) discusses in short the nomenclatural history of the species. Initially Koenig described it as a type genus, with several other sub-taxa under the *Hedychium coronarium* complex. Similarly Baker (1892) included five varieties under the species (*Vide* Literature Review 1.3), of which the current *H. flavescens* was also one.

Shu (2000), Smith (1994) and Baker (1892) have described the calyx as shorter than bract in *Hedychium coronarium*; the current study records the calyx as slightly longer than bracts as well. Similarly Baker (1892) has described the filament of the species as red; this research has found it as only white.

As the species is closely related to *Hedychium flavescens*, both are sometimes confused in herbarium specimens. Orchard (1978) mentions the stamens in *Hedychium flavescens* being slightly longer than labellum and the same in *H. coronarium* being shorter than labellum. The much easy character mentioned in Shu (2000) and also in this work is, in *Hedychium coronarium* the labellum is equal to or wider than long, and in *H. flavescens* the labellum is always longer than wide.

Distribution: Nepal (WCE), 150-1900 m. Himalaya (Nepal, Sikkim).



Map 2: Distribution of *H. coronarium* J. Koenig

Representative Collections:

Central Nepal: Kaski, Pokhara, 3500 ft, 5. 11. 1954, Stainton, Sykes & William 8262 (BM). **Kathmandu** , Chalnakhel, , ca. 1600m, 25. 8. 2006., Mishra 782 (TUCH); Sattewati, 6000 ft, 12.10.1954. Stainton, Sykes & William 8916 (BM); Nepal, 1821, Wallich 6553.

6.4 Hedychium densiflorum Wall. Hooker's J. Bot. Kew Gard. Misc. 5: 368 (1853). Baker in Fl. Brit. Ind. **6:** 227(1892). Landon in Flora of Nepal, Bibl. Him. 1, **16**: 334 (1925). EFPN 1: 60 (1978). ACFPN: 330(2000). FPN : 166(2001).

H. sinoaureum Stapf, Bull. Misc. Inform. Kew 1925: 432. 1925.

Pseudostems 1--1.2m. *Leaves* petiolate, 2.2—5cm, 26--35X6.5--9 cm, slightly pubescent on both abaxial and adaxial surfaces; ligules ovate, ca. 3.5X2 cm, obtuse, membranous, glabrous. *Inflorescence*, spike 16--28 cm, quadrangular, glabrous, densely flowered but main axis not concealed; bracts red-brown (as seen in the herbarium material), oblong, convolute, ca. 1cm, apex obtuse, glabrous, number of flowers subtending -1. *Flowers* yellow, ca. 1.8cm; calyx 2 (3)-lobed, 1--1.2 cm, apex obtuse, apices pubescent, slightly pubescent throughout, equals to the bract; corolla tube dark yellow, 1.2--1.5 cm, longer than bract; lobe 1--1.1cm, apex obtuse, margins inrolled without touching each other; lateral staminodes ca. 0.7 X 0.1 cm, clawed; labellum clawed-cuneate, ca. 1.2cm, 2-lobed more than half the length of labellum; filaments orange red, 2.1--2.7 cm, longer than labellum, anthers orange red, 0.4--0.6 cm; stigma with short straight hairs.

Flowering season: July

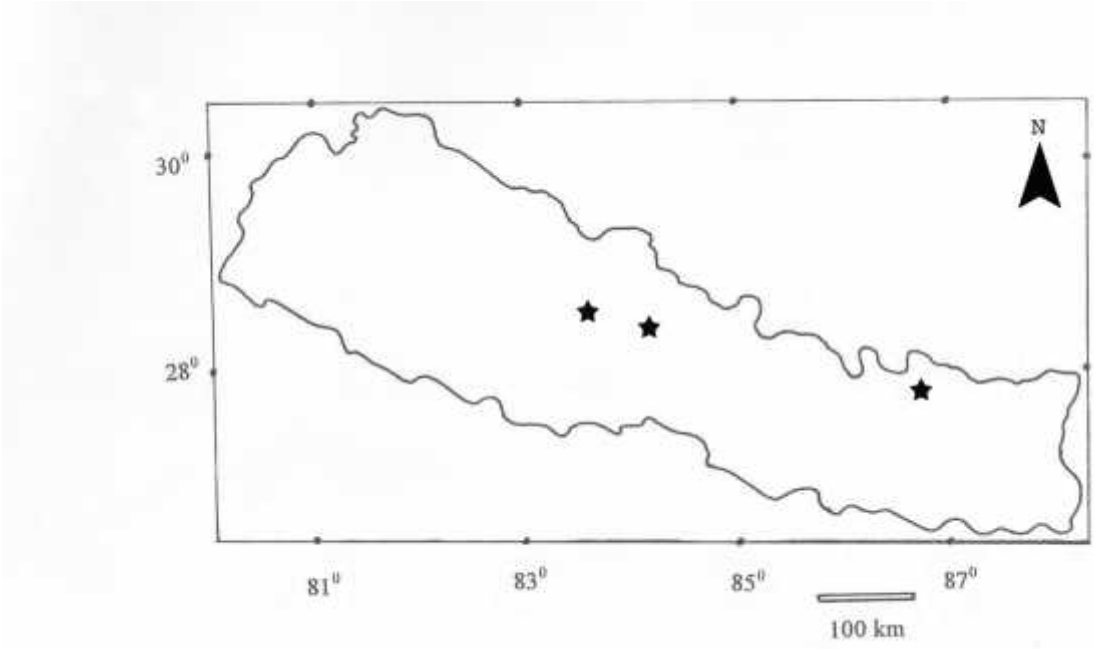
Type: Nepal, Wallich -6552 (**Isotype**, **BM!**).

Notes: Initially Wallich (1853) was not sure about *Hedychium densiflorum* being distinct from *H. gracile* as a species. The protologue text clearly mentions the species as having one flowers per bract, Smith (1994) concurs. Shu (2000) mentions *Hedychium densiflorum* as '1or (2) flowered'. However in the present study the species was found with only one flower per bract.

Similarly the protologue mentions the leaves of the species as glabrous; Shu (2000) concurs. However, in the specimens examined for this study the leaves were found to be sparsely pubescent on both the surfaces.

Smith (1994) mentions, that in Khasia Hills, the species are often epiphytic. In the information given on the herbarium specimens studied of Nepalese species, they are not reported to be epiphytic. In Nepal, *Hedychium densiflorum* is reported to be found on 'rocks' or 'among the shrubs'.

Distribution: Nepal (CE): 450 - 2800m. Himalaya (Nepal to Bhutan), NE India.



Map 3: Distribution of *H. densiflorum* Wall.

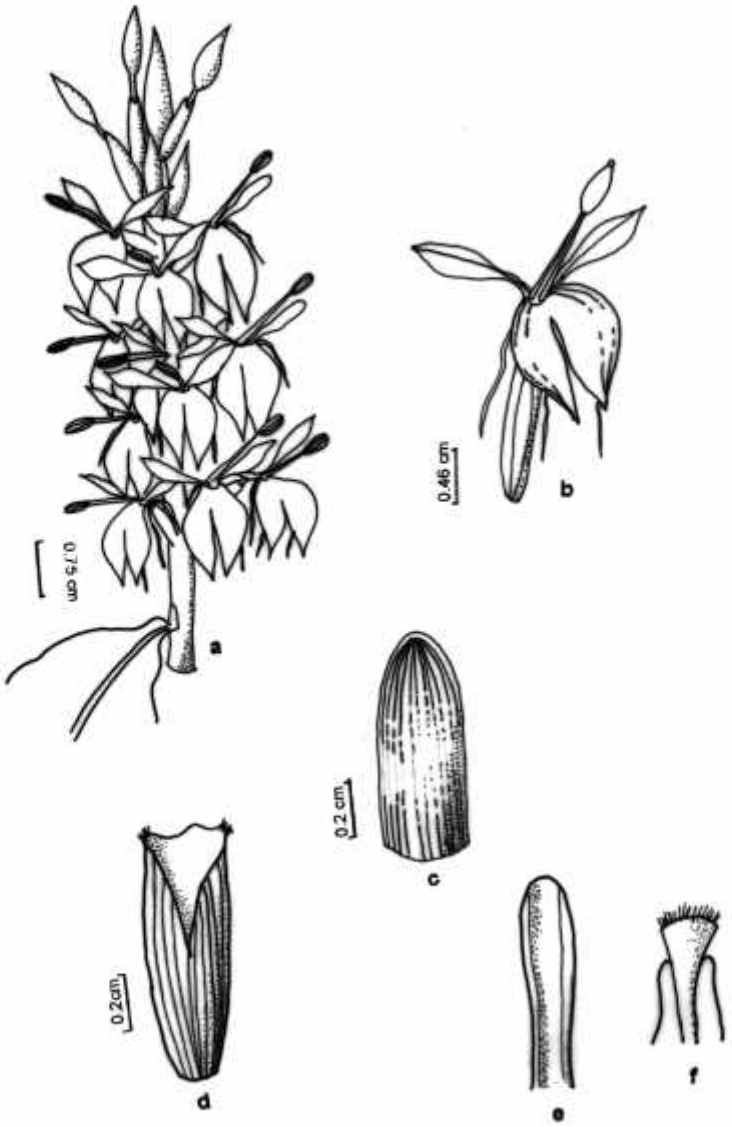


Figure 12. *Hedychium densiflorum* Wall., **a.** inflorescence, **b.** flower, **c.** bract, **d.** calyx, **e.** corolla tip (enlarged), **f.** stigma (enlarged), (Capt. Dhwoj, L., 090, BM).

Representative Collections:

Central Nepal: Myagdi, near Gurjakhani, 7500 ft, 18. 7. 1954, Stainton, Sykes & William 3541 (BM); **Kaski**, Seti Khola, 9000 ft, 26. 7. 1954, Stainton, Sykes & William 6509 (BM); Nepal, Wallich 655(BM).

Eastern Nepal: Solukhumbu, Phaploo, 8-9000 ft, 1930, Dhwoj (BM); Phaploo, 8-9,000 ft, 1930, Major. Dhwoj 90 (E).

6.5 Hedychium elatum R. Br., Edwards's Bot. Reg. 7:t. 526 (1821). Baker in Fl. Brit. Ind. **6:** 232(1892). EFPN 1:60 (1978). ACFPN: 330(2000). FPN : 166(2001).

Pseudostems ca. 3 m. *Leaves* lowermosts elliptic-lanceolate, uppermost oblong-lanceolate. *Inflorescence,* spike 18 cm, 3-flowered. *Flowers* calyx spathode, transparent, pubescence; corolla tube cylindric, yellow-white, corolla lobes-3, labellum clawed, ovate, 2-lobed, apex obtuse, filament longer than labellum, anthers linear, basifixed, bifid lobe polleniferous; sterile stamen(staminodes)-2, short, tapering; stigma cyathiforme, ciliated; ovary villous. (Description based on Brown, 1821).

Notes: During this research a single herbarium specimen of the species was located in E, of which only the digital image could be studied. It was from Wallich collection (Nepal, Wallich- 6549 A) later also determined by Rose Mary Smith (date not mentioned), as *Hedychium elatum*. The specimens of *Hedychium elatum* could not be located in BM, K, KATH and TUCH. On the digital specimen seen of the aforementioned specimen, only the bracts were clearly visible, and other floral parts were absent or not comprehensible. Hence in this text only the translation of the protologue text has been given in place of the regular description.

It has been distinguished from *Hedychium speciosum* in which the spike is much longer, fascicles scattered and 2-flowered, and the labellum of the flower entire and sharp-pointed, in *H. elatum* the spike is much shorter, fascicles in verticilli (whorls) of three, and 3-flowered, and the label bifid with bluntish lobes.

The deposition of the Wallich specimen in E can be taken as evidence of its existence, though it is noteworthy to mention that no other collection of the same has been made after that, given that Wallich's route was exclusively inside Central Nepal, and many explorations have been carried out in this area since then. As *Hedychium elatum* is distinguished from *H. speciosum* by reasons not so convincing given the range of phenotypic plasticity shown by the genus (regarding the inflorescence and the number of flowers per bract), it is very much probable that *H. elatum* could just be a synonym of *H. speciosum*, or that the putated *H. elatum* might not be so at all. However, to say so categorically will require further research and evidences, which appear not feasible during this study right now.

Roscoe also mentions in Monandr. Pl. Scitam (1828), "The samples formed part of a collection of Nepaulese plants transmitted by Dr. Wallich…".

Type: Nepal, Wall., Numer. List: 222 n. 6549 A (1832) (E)

Representative Collection: Nepal, Wallich- 6549 A (E)

Distribution: C, 1700m. Himalaya (Uttar Pradesh to Sikkim).

6.6 Hedychium ellipticum Buch.-Ham. ex Sm., Cycl. 17: Hedychium n. (1811). Baker in Fl. Brit. Ind. **6:** 228(1892). Hara in Fl. East. Him. 422 (1966). EFPN 1:60 (1978). ACFPN: 330 (2000). FPN : 166(2001).

Pseudostems 1--1.5m. *Leaves* petiolate 1--1.5 cm; light green, elliptic, 23--2X7.5--9 cm, apex acuminate, wavy texture, glabrous on both surface; ligules dark pink down to leaf sheath, ovate, 2.3--2.6X 1--1.2 cm, apex obtuse, membranous, glabrous. *Inflorescence* flat-topped, spikes 7--9 cm, ellipsoid, lax flowered, glabrous, main axis concealed; bracts imbricating, elliptic- lanceolate, up to 4 cm, apex acute, margin membranous, coriaceous, glabrous, number of flower subtending -1; bracteoles 1-lobed, 1.8--2cm, apex acute, margin membranous, coriaceous, glabrous. *Flowers* creamy yellow, mildly fragrant; calyx 2-lobed 1.3--1.5 cm, apices acute, sparsely pubescent throughout, shorter than bract; corolla tube 5.1--5.3 cm, longer than bract, corolla lobe 3.2--3.5, apex obtuse, margins inrolled without touching each other; lateral staminodes linear, 2.1--2.2 cm; labellum clawed-cuneate, 2.5--2.6 cm, 2-lobed not more than half

the length of the labellum; filament reds, 4.3--4.5 cm, longer than labellum; anthers red 1.4--1.5 cm; stigma pubescent with short straight hairs, ovary pubescent.

Flowering season: June-August

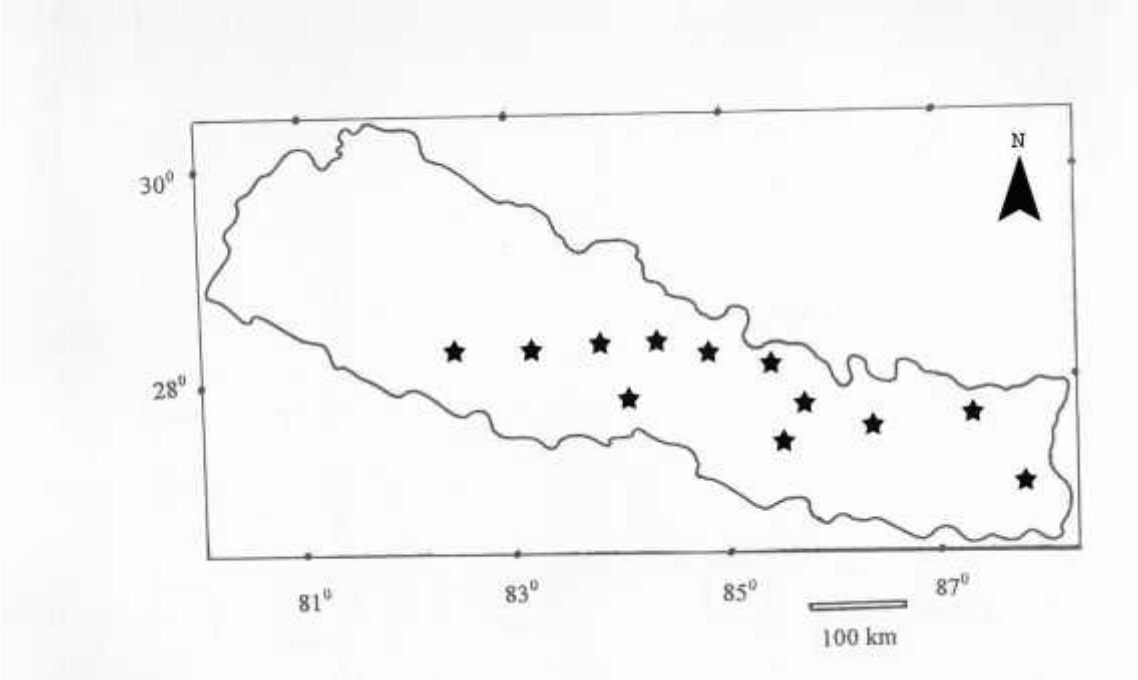
Fruiting season: September- October

Type: Nepal, Narainhetty, July 28, 1802, Buchanan – Hamilton *s.n.* (BM!), *vide* Smith (1819).

Notes: Smith (1994) mentions that the ligule of *Hedychium ellipticum* can either be entire or emarginated. The current research recorded only entire ligules. Also Smith (1994) has mentioned that length of calyx is equal to bract. However this research documented calyx as equal or shorter to bract.

The species is commonly found alongside trees and shrubs, especially in forest clearings or disturbed patches.

Distribution: Nepal (WCE), 300-3500 m. Himalaya (Uttar Pradesh to Bhutan), NE India.



Map 4: Distribution of *H. ellipticum* Buch.-Ham. ex. Sm.

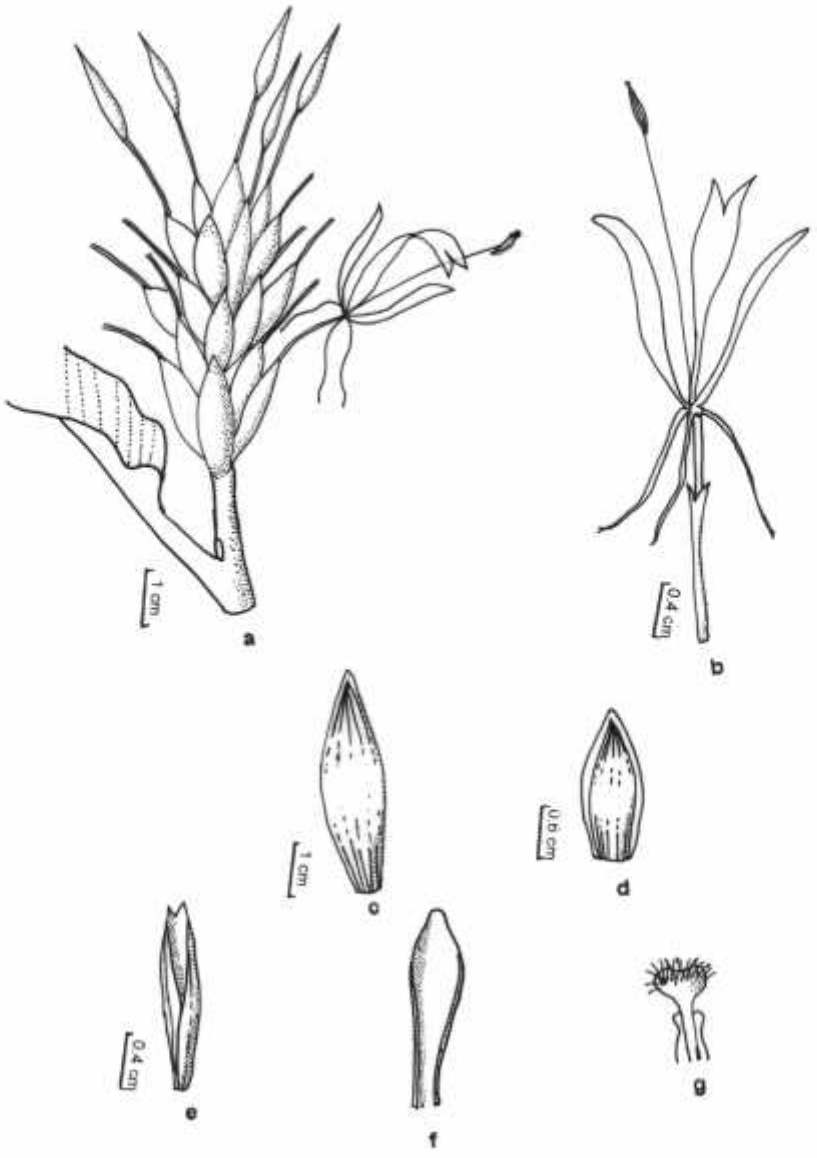


Figure 13. *Hedychium ellipticum* Buch.-Ham. ex Sm., **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged),(Codrington, De B. 150, BM).

Representative Collections:

Western Nepal: Salyan, Gupte Khola, 3200m, 20.8.1983, Kurmi 4580 (KATH); Marma Khola, 3500m, 24. 8. 1952, Polunin, Sykes & Williams 567 (BM); Ghara , 2000m, 1975, Joshi & Bhatta 73/3271 (KATH); Lothar, Rapti Valley, 12000 ft, 27^0 35' N, 84^0 45' E, 27. 8. 1967, Williams & Stainton 8307 (BM).

Central Nepal: Parbat, Sikha, 1800m, 22.7. 1974, Joshi & Bhattacharya 74/1898 (KATH). **Kaski**, Madi Khola, near Pokhara, 4000 ft, 19. 7. 1954, Stainton, Sykes & Williams 6455 (BM). **Lamjung**, Bangha Khet, 835 m, 5. 8. 1983, Manandhar 9489 (KATH); BM). **Gorkha**, Buri Gandaki, 8000 ft, 8. 7. 8. 7. 1953, Gardner 1176 (BM). **Chitwan**, 2800 ft, 27.8. 1967, Shakya 9140 (KATH). **Rasuwa**, Syaprubesi, 4450 ft, 18.7.1977, Manandhar 236 (KATH); Serebrahava, near Mulkharka, 6200 ft, 20.8. 1969, Malla 16010 (KATH). **Makwanpur**, Tistan Deorali, near Indo-Nepal Highway, 2000m, 26.7. 1969, Kanai 673303 (KATH).**Kathmandu**, Gokarna, 1341 m, 7.8.1966, Pradhan *et al.* 6440 (KATH); Nagarjun, 1828 m, 22. 3. 2035, Bista 9502 (KATH). **Lalitpur**, Phulchowki, 1828 m, 2.7. 1968, Pradhan 8107 (KATH); Phulchowki, 5000 ft, 13.7.1967, Manandhar *et al.* 7069 (KATH); Godavari, 5800 ft, 1956, Codrington 150 (BM); Phulchoki forest, Godavari, ca. 1700m, 29. 6. 2001. Mishra 622 (TUCH). **Dolakha**, Totala bari, 1150m, 13.7. 1977, Rajbhandari & Roy 1281 (KATH).

Eastern Nepal: Ilam, Sangoon Bhanjyang (collection from Eastern Nepal between Koshi and Kankai Mai, Chula chuli region), 4700 ft, 3.10. 2022, Shrestha *et al.* 72-398 (KATH); **Sankhuwasabha**, Arun Valley, Barun Khola, north of NUM, 10000 ft, 12. 6. 1956, Stainton 642 (BM).

6.7 Hedychium flavescens Carey ex Roscoe, Monandr. Pl. Scitam: t. 50 (1828). Hara in Fl. East. Him. 422 (1966). EFPN: 1: 60(1978). ACFPN: 30(2000). FPN: 166(2001).

Hedychium flavum auct. non Roxb.: Sims in Curtis, Bot. Mag. 50: t. 2378 (1823).
Hedychium coronarium var. *flavescens* (Roscoe) Baker, ; in Hook. f., Fl. Brit. Ind. 6: 226 (1892).

Pseudostems up to 1.5 m. *Leaves* petiolate, 7-9cm; elliptic-lanceolate, 42--44X 8--9.5 cm, apex acuminate, adaxial surface pubescent; ligules ovate, acute, 4.7--5X 1.8--2.1 cm, membranous with green streaks. *Inflorescence*, spikes ellipsoid, 14--16cm, main axis concealed, glabrous; bracts dark green, elliptic-obovate, 1-lobed, 4.5--4.7X5.5--7cm, apex acute, margin membranous, sparsely pubescent throughout, the apex densely pubescent, number of flowers subtending 2-4; bracteoles 2-lobed, 2.3--3 cm,membranous-coriaceous, deeply cleft, apex acute, apices densely pubescent, sparsely membranous throughout; inner bracteoles occasionally present, 1 or 2-lobed, ca. 1.4 cm apex acute, pubescent at apex. *Flowers* yellow with orange tinge at the bottom of labellum, fragrant, 8--10cm; calyx 1-lobed, 3.5--4cm, apex acute, hairy, shorter than bracts; corolla tube ca.6.6 cm, longer than bract, lobe ca 2.9 cm, apex aristate; lateral staminodes elliptic-obovate, unequally 2-lobed, ca. 4.5 cm; labellum up to 4.6 cm, obcordate, longer than wide, apices acute, cleft not more than half the length of labellum; filaments yellow, 3.5—4.2 cm, subequal to labellum, anthers yellow, 1.2—1.6 cm; stigma with hairs that are hooked on the top, ovary pubescent all over.

Flowering season: July - September.

Fruiting season: November - December

Type: Curtis Botanical Magazine figure 2379 (1828), *vide* Wood (2000).

Notes: *Hedychium flavescens* is also a cultivated ornamental species in Nepal. Most of the horticultural ones are found to be sterile or hybrids.

This species was initially categorized under the *Hedychium coronarium* complex, when Koenig described the genus for the first time. It was later given specific rank by Carey. Similarly Baker (1892) had placed it under *Hedychium coronarium* var. *flavescens* as well.

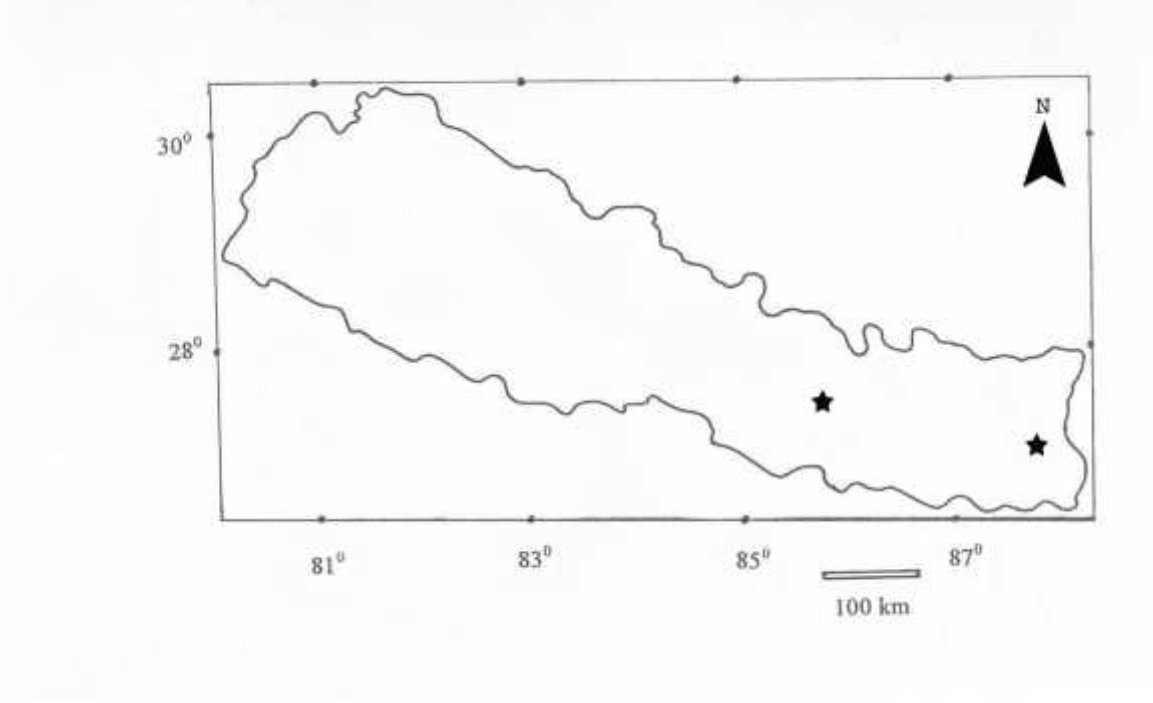
Much confusion regarding the identification of *Hedychium flavescens* in respect to *H. coronarium* (as the two are closely related) still persists. The protologue describes the species as having the 'filament scarcely the length of the lip' and 'filament about the tip of the lip'. Shu (2000) describes the same as 'filament subequalling the labellum'. Orchard (1978) mentions 'stamen longer than labellum'. The word 'stamen' has consciously been

avoided in the current work as it might create confusion since that terminology will also include anther length (and length may vary while adding the anther length). So current study describes 'the filament as slightly shorter than the labellum' concurring the protologue text. (Related discussion elsewhere, *Vide* chapter 6.3)

Furthermore, one character that differentiates *Hedychium flavescens* from *H. coronarium* is that its labellum is longer than wide, which is opposite in the latter.

Apparently there is a confusion regarding a synonym of the *Hedychium flavescens* as Hara *et al*. (1978) has given *Hedychium flavum* auct. non Roxb.: Sims in Curtis, Bot. Mag. 50: t. 2378 (1823) as its synonym, whereas Press *et al*. (2000) has given '*Hedychium flavum* auct.' as its synonym; amidst the fact that *H. flavum* Roxburgh is a valid species in its own regard, Wood (2000), Shu (2000).

Distribution: Nepal WCE, 1200-2000 m. Himalaya.



Map 5: Distribution of *H. flavescens* Carey ex Roscoe

Representative Collections:

Lalitpur, National Botanical Gardens, Godavari, ca. 1500m, 12. 9. 2001, Mishra 645 (TUCH).

Locality Unknown: Nepal, 18 June, 1802, Dr. Buchanan *s. n.* (BM).

Figure 14. *Hedychium flavescens* Carey ex Roscoe, **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** inner bracteole, **f.** calyx, **g.** corolla tip (enlarged), **h.** stigma (enlarged), (Mishra, S. 645, TUCH).

6.8 Hedychium gracile Roxb. Hort. Beng. 1814. Baker in Fl. Brit. Ind. **6:** 229(1892).

H. glaucum Roscoe, Monandr. Pl. Scitam.: 1. 53 (1828).
H. *gracile* auct. non Roxb.: Hook. f. in Curtis Bot. Mag. 108: t. 6638 (1882).
H. gracile Roxb. var. glaucum (Rosc.) Baker in Fl. Br. Ind. VI: 220. 1894.

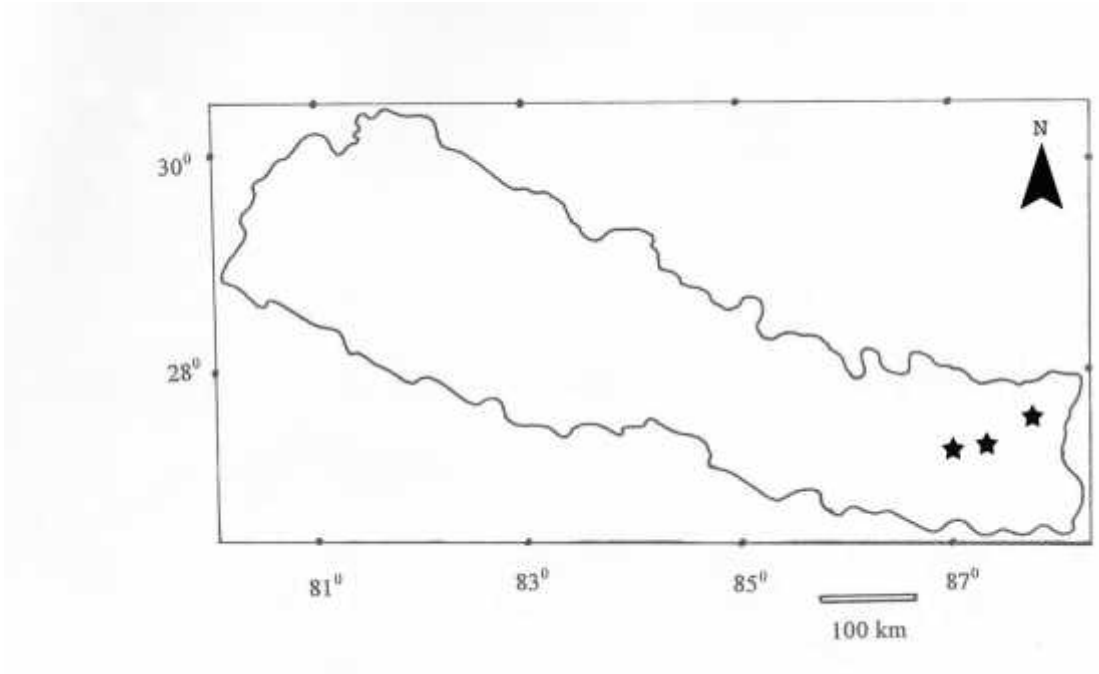
Pseudostems upto 1.5m. *Leaves* petiolate, 1.8--2 cm, elliptic-obovate, 13--27.5X3.5--5.5 cm, apex acuminate, abaxial surface glabrous, adaxial surface sparsely pubescent; ligules pink- red, apex 2- lobed, ca. 0.3 cm, glabrous. *Inflorescence*, spike 16-19 cm, slightly angular, glabrous, main axis not concealed; bracts convoluted, dark green, ca. 2.2X0.3 cm, margin slightly transparent, number of flowers subtending -1; bracteoles 1-lobed, less than 1 cm, apex obtuse, membranous, tufts of pubescence at apex. *Flowers* cream white, ca. 3 cm; calyx 2-lobed, ca. 2.2cm, tufts of pubescence at apex, equal to bract, corolla tubes 2--2.7 cm, equal to or longer than bract, lobes 0.1 cm, apex slightly red, margins inrolled not touching each other, shorter or longer than bracts; lateral staminodes 3--3.1X0.3 cm; labellum linear, ca. 1.8 cm, 2-lobed more than half the length of labellum, each lobe mildly cleft, obtuse; filaments 6.5 cm, more than twice longer than labellum; anthers 0.8--0.9 cm; stigma densely hairy with long hairs, ovary pubescent.
Flowering season: August-September
Type: India, Meghalaya prov. Khasia, Hort. Beng. Illus lower right corner of the plate of *H. angustifolium*, 1814, Roxburgh, *vide* Wood (2000).
Notes: There has been a nomenclature change of the erstwhile *Hedychium glaucum* as it is a synonym of *H. gracile* Roxb. Roscoe in Monandr. Pl. Scitam. In 1828, writes "….if the H*edychium gracile* of Roxburgh be the *H. gracile* of the plants of the Coast of Coromandel, fig. 251, it is a very different plant from that which is now figured, and to which we have therefore given the name of *glaucum*." Further he mentions, "In the *gracile*, the filament is not longer than the inner limb of the corolla; in the *glaucum*, it is twice the length". However Wood (2000) elucidates, apparently it was due to confusion,

as the Type of *Hedychium gracile* was a drawing in Coromandel Plants, which was erroneous.

Baker (1892) describes the species citing Wall. Cat. 5546 B. in Kew Journ. v. (1853) as having calyx longer than bract. Smith (1994) describes it as having calyx more or less equal to bract or slightly shorter. In this research the calyx in Nepalese species of *Hedychium gracile* was found to be more or less equal to bract, concurring the description in Smith (1994).

[The external examiner of this thesis pointed out and opined that, Hara *et al*. (1978) has in fact given *Hedychium glaucum* Roscoe as the valid name for the species and in synonym it has given *Hedychium gracile* Hook. f. and Not *H*. *gracile* Roxb., hence *Hedychium glaucum* Roscoe should be the valid name as per the priority of publication and *H*. *gracile* Roxb. its synonym. However, IPNI (International Plant Names Index, www.ipni.org) has put *Hedychium glaucum* Roscoe as a synonym of *H*. *gracile*, though the authority for the latter has not been provided. Hence, going by the references of Wood (2000) and IPNI list, the name *Hedychium gracile* Roxb. has been adopted in this text. The overall confusion aptly underscores the intricacies of the nomenclatural issues in the genus *Hedychium*. The author would like to emphasize that this nomenclature is only provisional and further research is imperative.]

Distribution: Nepal (E), 1300-1900m. Himalaya (Nepal to Bhutan), NE India.



Map 6: Distribution of *Hedychium gracile* Roxb.

Representative Collections:

Eastern Nepal: Dhankuta, Sanguri Lekh, N of Dharan, 4000 ft, 26^0 52' N, 86^0 20 E (BM). **Taplejung**, Tamur Valley, Thapabu Khola, North of Taplejung, 6,000 ft, 2. 8. 1956, Stainton, 1187 (BM), (E); Tamur River between Sinwa and Tawa, 27^0 28' N, 87^0 44' E, 1000m, 2. 9. 1989, KERKE-154 (E); Tamur River between Sinwa and Tawa, (Taplejung/Tehrathum) 27^0 28' N, 87^0 44' E, 1000m, 2.9.1989, Grey-Wilson 154 (KATH).

Locality Unknown: Mulghat, 26 53' N, 87 21' E, 1200m, 14. 8. 1972. Dobremez 1456 (BM).

6.9 Hedychium speciosum Wall. Fl. Ind., 1:13. 1820. Baker in Fl. Brit. Ind. **6:** 231 (1892).

H. gardnerianum Sheppard ex Ker Gawl., Edward's Bot. Reg. 9: t.774 (1824)

H. gardnerianum Griff. -- Notul. iii. 419.

H. gardnerianum Wall. ex Spreng. -- Syst. iv. Cur. PoSt. 6.

H. gardnerianum Rosc. -- Scitam. t. 62.

Pseudostems 2.5--3m. *Leaves* petiolate ca. 6cm; dark green, ca. 42.5X ca.31.1cm, apex acuminate, margin membranous, coriaceous, glabrous, ligules green with magenta streaks in between, ca. 4cm, oblong, apex truncated, slightly coriaceous, glabrous. *Inflorescence*, spike ca. 34cm, main axis not concealed, densely flowered, glaucous; bracts convolute, oblong-elliptic, ca. 2-6 X 2.3 cm, apex acute, margin slightly transparent, glaucous, number of flowers subtending 2-3; bracteoles elliptic-oblong, 1-lobed, ca. 3.7cm, membranous. *Flowers* lemon yellow, mildly fragrant, ca. 7.8 cm, calyx 3-lobed , shorter than bracts; corolla tube 6.5--7cm, longer than bracts, corolla lobes 4.5--4.6 cm, apex acuminate, margins inrolled without touching each other, 3 distinct nerves on the corolla tube; lateral staminodes yellow with reddish tinge at the bottom, slightly clawed, 3.5--3.4 cm , base slightly pubescent; labellums elliptic-obovate, 3--3.3cm, 2-lobed not more than half the length of the labellum, concave in the

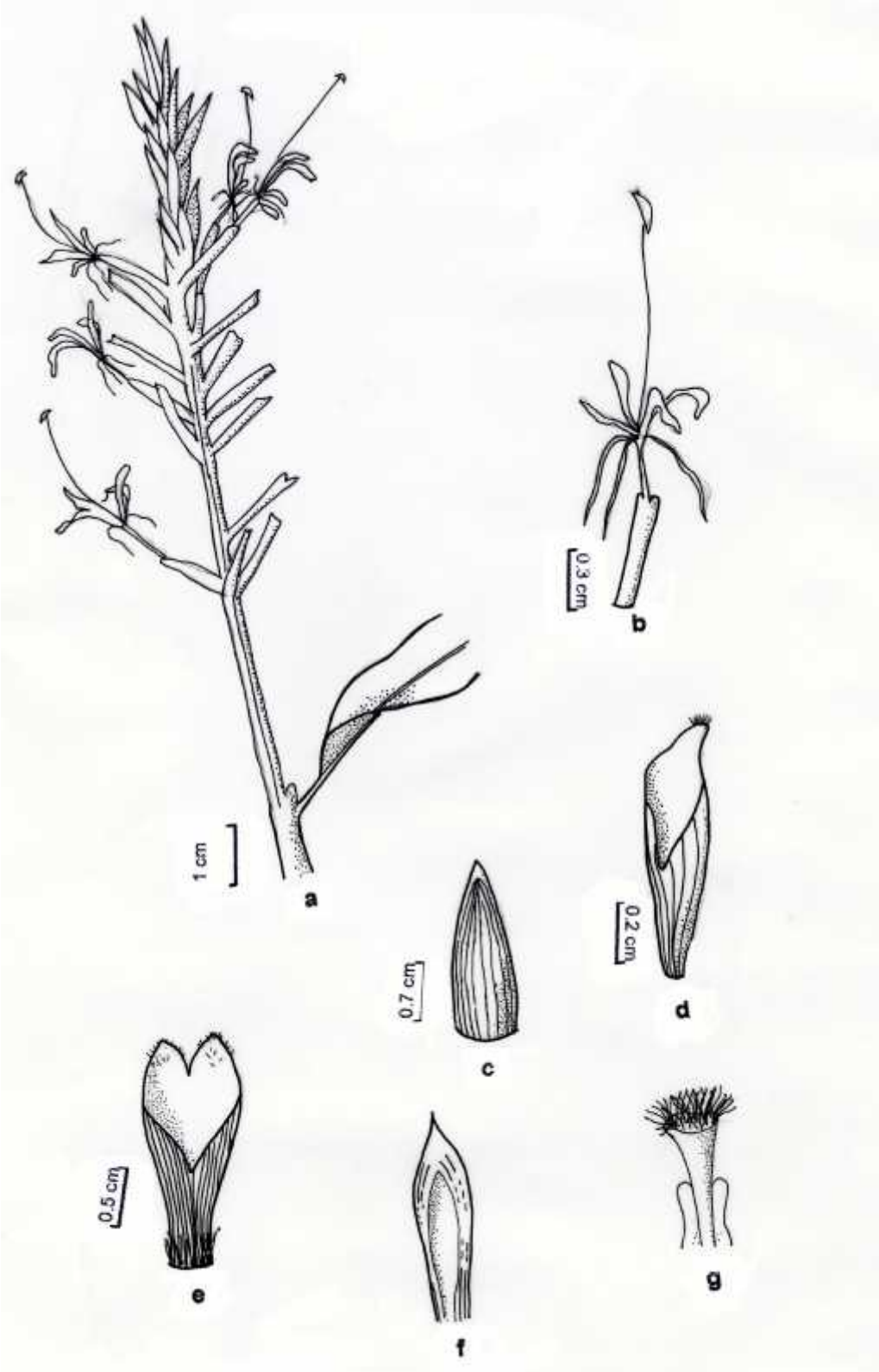


Figure 15. *Hedychium gracile* Roxb., **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged) (Williams, Stainton, 8331, BM).

upper part and the limb forming a narrow furrow; filaments orange red, 5.5--7.2 cm, longer than labellum, anthers dark red 1cm; stigma slightly hairy; ovary glabrous.

Flowering season: June-August
Fruiting season: September-October

Type: India, Silhet, in forest, Gomez s. n. (**Lectotype K**!) *vide* Wood (2000). Not seen!

Notes: *Hedychium speciosum* is the most robust of the *Hedychium* species recorded in Nepal. *Hedychium speciosum* Wall. is annotated as *H. gardnerianum* Sheppard ex Ker Gawl. in EFPN 1: 60 (1978) and Press *et al.* (2000). Wood (2000) mentions, initially Wallich had described a species with the name *Hedychium speciosum* having an 'entire labellum'. Also, a similar species with a 2-lobed labellum was described as *H. gardnerianum*. However later Wallich acknowledged that 'my *Hedychium speciosum* and my *H. gardnerianum* are identically one and the same species. I retain the latter name, being that of a very valued and honored friend'. It was named after Mr. Gardner and also called Mr. Gardner's Garland - flower. As the name *Hedychium speciosum* was already published validly 34 years earlier, the retention cannot be allowed, hence the nomenclatural change of the species. The IPNI (International Plant Names Index) is not clear about the status of the names *Hedychium gardnerianum* and *H. speciosum*.

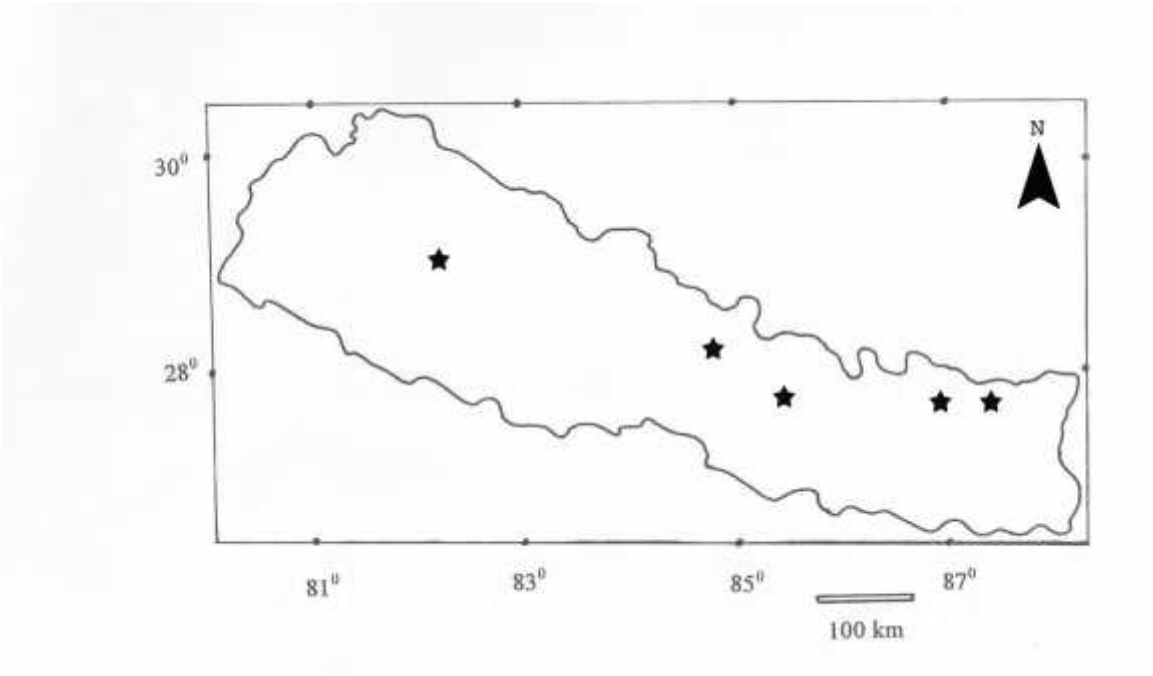
The cause of confusion in this case labellum is in fact reported in literatures as variable. Smith (1994) describes the labellum as 'shortly bilobed or entire', Baker (1892) describes the labellum as '2-3-fid'. However the Nepalese specimens observed in this work records only 2-lobed labellums.

Similarly Smith (1994) describes the calyx more or less equal to bract; Baker (1892) describes the same as shorter than bract. In Nepalese specimens, the calyx is found to be always shorter than bract.

Also, Smith (1994) mentions the bracts as subtending 1-2 flowers. However in Nepalese specimens the bracts have been found subtending 2-3 flowers.

[The external examiner of this thesis has rightly pointed out that since Hara *et al*. (1978) has given *Hedychium gardnerianum* Sheppard ex Ker-Gawler as the valid name, apart from citing Wood (2000) and writing about *H*. *gardnerianum* Wall, it would have bolstered the argument in a better manner if this text was also able to elaborate on why the former must be a synonym of *H. speciosum* Wall..]

Distribution: Nepal (WCE), 1900-2100m.Himalaya (Nepal to Sikkim), NE India.



Map 7: Distribution of *H. speciosum* Wall.

Representative Collections:

Western Nepal: Jajarkot, Samela , 7000 ft, 19. 8. 1952, Polunin, Stainton & Williams 508 (BM).

Central Nepal: Gorkha, Buri Gandaki, near Halchok, 5000 ft, 23. 7. 1953, Gardner 1500, New Zealand Himalayan Expedition, (BM); **Kathmandu,** Chalnakhel, ca. 1600m, 16. 6. 2002, Mishra 680 (TUCH); Panighat Khola, Hattiban, ca.1320m, 24. 3. 2001, Burlakoti 21 (TUCH).

Eastern Nepal: Solukhumbu, Phaploo, 8-9000 ft, 1930, Dhwoj 089 (BM).

Sankhuwasabha, Gogane, 1920m, 30.8.1986, Shrestha *et al*. (KATH).

Locality Unknown: Nepal, Wallich.

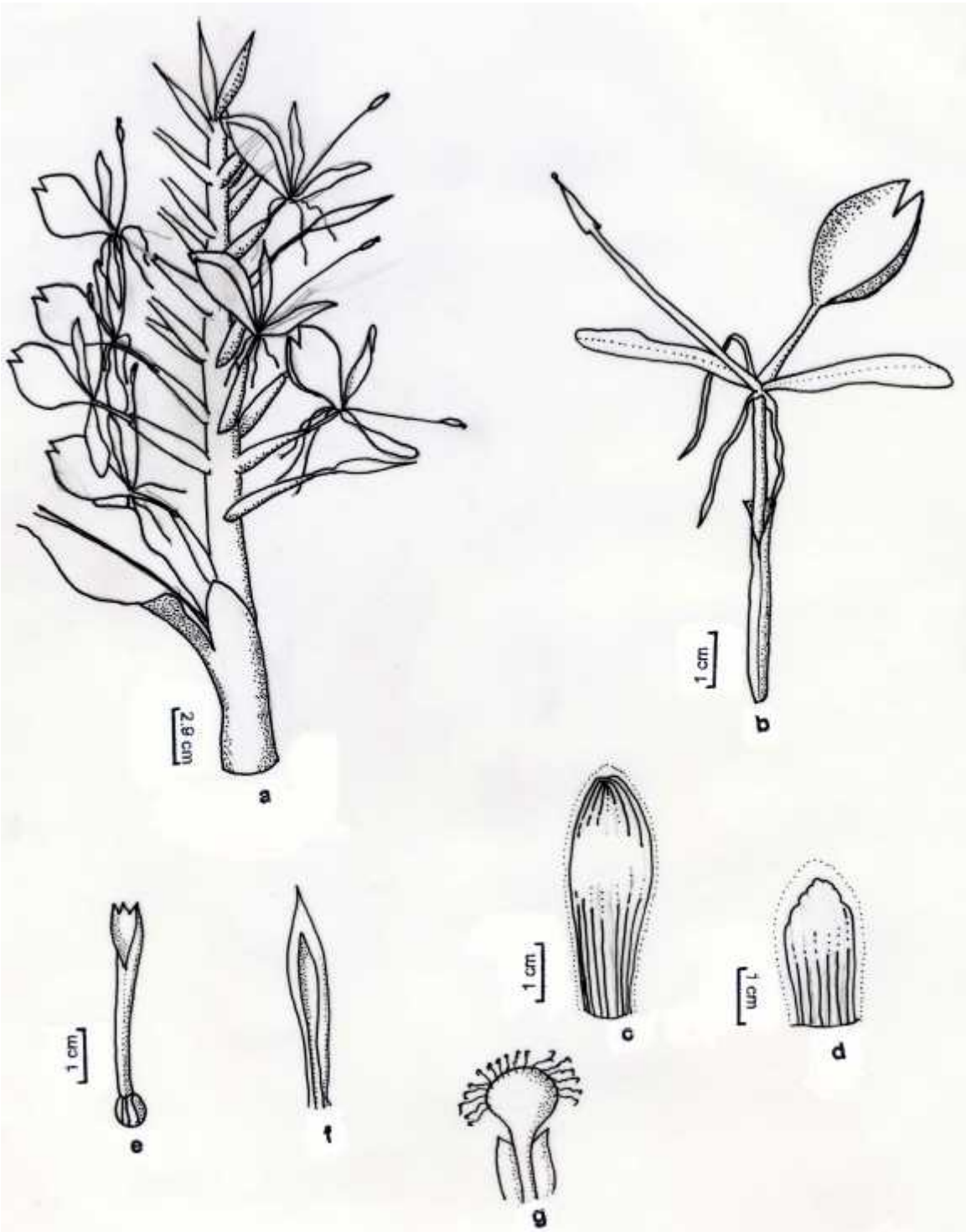


Figure 16. *Hedychium speciosum* Wall. , **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged), (Mishra, S. 732 TUCH).

6.10 Hedychium spicatum var. **acuminatum** (Roscoe) Wall., Hooker's J. Bot. Kew Gard. Misc. 5: 328 (1853). Baker in Fl. Brit. Ind. **6:** 227(1892). Landon in Flora of Nepal, Bibl. Him. 1, **16**: 334 (1925). EFPN 1: 61 (1978). ACFPN: 330(2000). FPN : 166(2001).

H. acuminatum Roscoe Monandr. Scitam. t. 47

Hedychium album Buch.-Ham. ex Wall., ; in Hook., J. Bot. Kew Gard. Misc. 5: 328 (1853), *pro syn.*

Pseudostems ca.1.2m. *Leaves* sessile; elliptic-lanceolate, 40--45X ca. 7.7 cm, apex acuminate, slightly pubescence on abaxial and adaxial surfaces, wavy; ligules ovate-oblong, 1or 2-cleft, 2.5--3.7 cm, glabrous. *Inflorescence*, spikes 18--24 cm, angular, lax flowered, glabrous, main axis not concealed; bracts light green, convoluted, ca. 2 cm, apex acute, tuft of hairs present at the apex, number of flowers subtending-1; bracteoles 1-lobed, 3--3.5X1.5 cm, apex acute with tufts of hairs, membranous. *Flowers* cream-yellow with limbs bright red colored, upto 6 cm; calyx 2-lobed, 4.3--4.7 cm, apices acute, glabrous, longer than bract; corolla tubes ca. 7.5 cm, longer than bracts; lobes cream-yellow with the bottom part slightly red, ca. 3.3 cm, apex acuminate, margin inrolled without touching each other; lateral staminodes clawed, ca. 3.5X0.2 cm; labellum cream-yellow with red streaks at the limb, 2-lobed not more than half the length of labellum, 4.5--4.7 cm; filaments light red ca. 2cm, shorter than labellum, anthers red, ca. 1.5 cm; stigma with dense perfectly straight hairs; ovary glabrous

Flowering season: June-September

Notes: The EFPN 1 : 61 (1978) and Press *et al.* (2000) mentions the existence of three varieties of *Hedychium spicatum*, namely *H. spicatum* var. *acuminatum* (Roscoe) Wall, *H. spicatum* var. *spicatum* Sm. and *H. spicatum* var *trilobum* (Roscoe) Wall.
According to protologue and literatures:
-*Hedychium spicatum* var. *spicatum* has densely flowered spikes and the flowers are yellow.

-*Hedychium spicatum* var. *acuminatum* has laxly flowered spikes and the flowers are generally yellow with the apex of corolla tube, base of corolla lobes and lateral staminodes and labellum tinged with purple-red colour.
-*Hedychium spicatum* var. *trilobum* differs from the above two by having a small third lobe in the middle of the labellum.

In the present study all the herbarium specimens that were studied (BM. E, KATH and TUCH) and the living plants that were observed had purple-red colour at the base of their labellums slotting them under *Hedychium spicatum* var. *acuminatum*. Though there were 'densely flowered' and 'laxly flowered' types, the red tinges were present consistently nevertheless. Thus, excluding them from the possibility of being *Hedychium spicatum* var. *spicatum* in which the protologue mentions them as only being yellow (without mention of the red patch). Hence, going by this observation *Hedychium spicatum* var. *spicatum* was found absent in this study.

Hedychium spicatum var *trilobum* was also found absent in other herbarium specimens and field study (as none of the specimens studied had a third lobe in between the labellum), save for the two TYPE specimens, Wallich, 6554 BM (**Lectotype**) and Wallich, 6554, E (**Type**), of which only the digital image was studied of the latter. Upon examination of the type specimens however, the identifying character 'the third lobe between the labellum' could not be observed as the herbarium specimen did not have extra flowers in it and the inflorescences were firmly flattened and glued in the herbarium sheet.

Wallich (1853) mentions, that *Hedychium spicatum* var *acuminatum* is the most common in 'Nipal'. *H. spicatum* var. *trilobum* was 'originally introduced into the Calcutta Garden in 1817, by the Hon. E. Gardner, and afterwards observed by me in the great valley of Nipal, but sparingly', suggesting *H. trilobum* was rare even Wallich's own observation.

Smith (1994) also states, " two varieties have been described: var. *acuminatum* (Roscoe) Wall. with consistently orange stigma, and var. *trilobum* Wall. with a small tooth between the lobes of the lip. Most Bhutanese collections belong to the former, but intermediates exist."

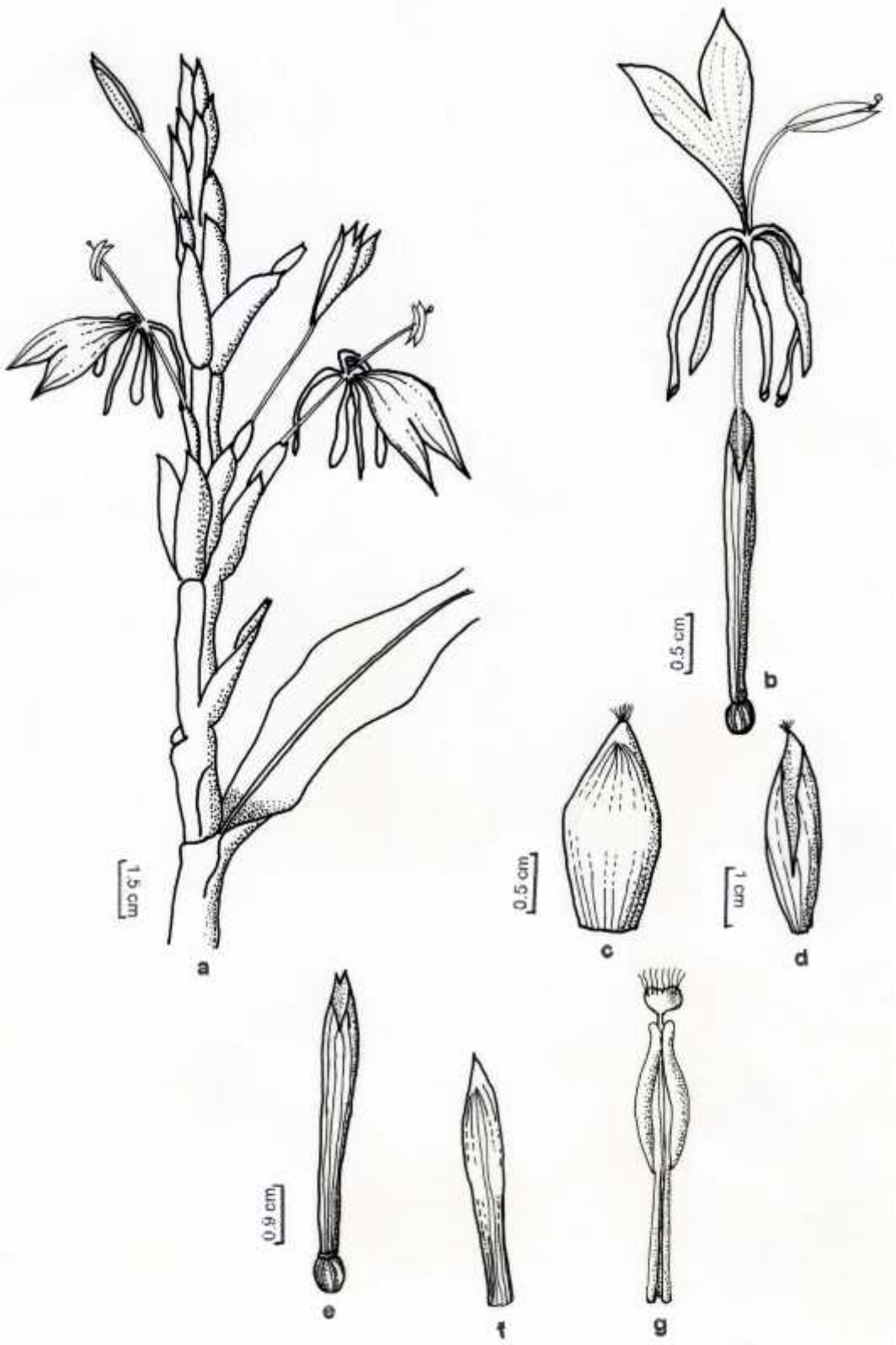


Figure 17. *H. spicatum* var. *acuminatum* (Roscoe) Wall. , **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged), (Mishra, S. 622 TUCH).

Apparently in Nepal, there is evidence of the existence of two varieties at most, (i) *Hedychium spicatum* var. *acuminatum* and (ii) *H. spicatum* var. *trilobum* (from the two type specimens each from BM and E), *H. spicatum* var. *spicatum* being altogether absent.

When delimiting the varieties, literatures including the protologue use terms like 'densely flowered' and 'laxly flowered'. These are not scientific terms so long as they are not defined objectively in 'number of flowers per unit length of the spike'. Furthermore, Wood (2000) mentions in reference to *Hedychium spicatum* var. *trilobum* and the genus overall that 'the third lobe in the middle of the labellum is the result of a common developmental abnormality seen in this species and a number of other species in the genus, particularly when grown under water stress'.

It seems imperative that the technology and techniques available in the present times (Molecular, Morphogenesis, field study at population level) be utilized to test the validity of the infra-specific delimitations of this particular species that were circumscribed in the 19th century (*Hedychium spicatum* var*. spicatum* in 1811, *H*. *spicatum* var. *acuminatum* in1853 and *H. spicatum* var. *trilobum* in1853).

Hedychium spicatum is found in wet, open slopes and gullies alongside shrubs and sometimes found as epiphyte on trees, though not any particular species. In South-East Asia this species is reported to be entirely epiphytic. Generally this species have bracts subtending a single flower and in Nepalese species they have been found with single flower per bract only. However, from Peninsular India, this species have been reported with both single flowered and 2-3 flowers per bract in a single inflorescence (Sabu, 2000).

[The external examiner pointed out an important fact regarding *Hedychium spicatum* var. *spicatum* that had happened to be missed out by this author. Apparently this author could not examine the Type of *H*. *spicatum* var. *spicatum* (Buch. Ham. s. n.), and Wallich 6553, that Hara *et al*. (1978) have enumerated. Hence, it will not be proper scholarship to argue that *H*. *spicatum* var. *spicatum* may altogether be absent, without critically examining the aforementioned specimens. So while strongly maintaining that the infra-

generic classification of *Hedychium* needs to be reviewed with modern scientific tools, the variety *Hedychium spicatum* var. *spicatum* in Nepal is acknowledged in this thesis.]

The current study maintains the existence of three varieties of *H. spicatum* namely,

H. spicatum var. **acuminatum** (Roscoe) Wall., Hooker's J. Bot. Kew Gard. Misc. 5: 328 (1853).

Hedychium acuminatum Roscoe Monandr. Scitam. t. 47

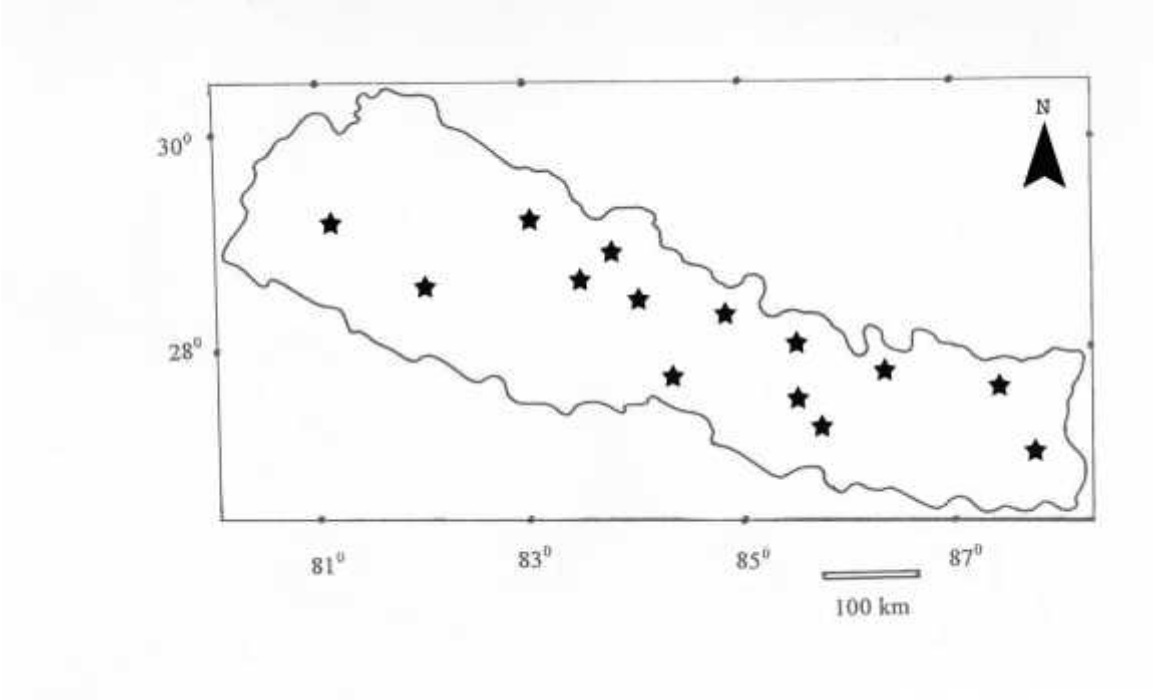
H. spicatum var. **spicatum** Sm., Cycl. 17: Hedychium n. (1811).

H. spicatum var. **trilobum** (Roscoe) Wall., Hooker's J. Bot. Kew Gard. Misc. 5: 328 (1853)

Hedychium trilobum Wall. cat. n. 6554

Type: Wallich, 6554 (**Lectotype**, BM!); Wallich, 6554 (**Type**,E!) (Only digital image seen)

Distribution: Nepal (WCE), 1500-2400m. Himalaya (Nepal to Bhutan), Sikkim, NE India.



Map 8: Distribution of *H. spicatum* (Roscoe) Wall.

Representative Collections:

Western Nepal: Doti,Telelekh, 2000m, 28.7.1972, Bista & Joshi 93 (KATH). **Dolpa**, Karnali Valley, between Colangri and Lumra, 7000 ft, 26. 8.1952, Polunin,

Sykes & Williams 3043 (BM). **Salyan,** Kaure, 5600 ft, 2. 11. 1969, Featt 143 (BM).

Central Nepal: Mustang, Ghasa, South of Tukucha, Kali Gandaki, 7500 ft, Stain, Sykes & William 1570 (BM); Titre, north of Dana, Kali Gandaki, 6000 ft, 29. 8. 1954, Stainton, Sykes & William 7537 (BM). **Myagdi**, Near Lumsum, 8000 ft, 17. 7. 1954, Stainton, Sykes & William 3518 (BM). **Kaski**, Thak to Taprang, before Ghatti Khola, ca. 1500 m, NE of Pokhara, South of Siklis, South of Annapurna, 25.8. 1976, Troth 915 (BM). **Lamjung**, Gajat, 1350m, 8.10.1983, Manandhar 9616, (KATH). **Gorkha**, Barpak village, 6-8000 ft, 1929, Dhwoj 258 (BM). **Chitwan**,Jyandala, 1650m, 11.16.1989, Manandhar 13999 (KATH). **Rasuwa**,Timure, 1750 m, 22.9.1986, Bhattarai 86/888 (KATH); Syabrubensi - Syarpagaon, 5 - 8000 ft, 30. 7. 1949, Polunin 1288 (BM). **Kathmandu**, Hattiban, 1500m, 5. 8. 2001. Luhar 118 (TUCH); Hattiban forest,1600m, 5. 8. 2001, Adhikari 57 (TUCH). **Lalitpur**, Aghor, Phulchowki, 4500ft, 28.8.1960. Malla *et al.* (KATH); Godavari, 1500m, 2. 9. 1966, Nicolson 2208 (KATH); Kukurkate Bhanjyang, Phulchowki, 2133m, 31.7.1969, Manandhar *et al.* 12983 (KATH); Godavari,1500 m, 2. 9. 1966, Nicolson 2208 (BM). **Makwanpur**, Hetauda, 1800ft, 22.8.1967. Shakya 9317 (KATH). **Dolakha**, Simigaon, 2100m, 30.7.1977, Rajbhandari *et al.* 1999 (KATH); Likhu Khola, 9000 ft, 27^0 30' N. 86^0 15' E, 18. 7. 1964, McCosh 421 (BM); Nipal, Wallich (BM).

Eastern Nepal: Ilam, Bisnetar-Kawal Dhar (Between Koshi & Kankai Mai),1300ft, 25.9.1972, Kanai & Shakya 72/231 (KATH). **Sankhuwasabha**, Chhoyang Khola, West of NUM, 8000 ft, 24. 6. 1956, Stainton 757 (BM); Above Sedua, 8000 ft, 7. 10. 1975, Beer 25582 (BM).

Locality Unknown: Mang Ning, 5000 ft, 13. 8. 1935, Bailey's Collectors (BM); Colanna, 6500 ft, 12. 10. 1952, Polunin, Sykes & William 5605 (BM); Nepal, 1819, Wallich, (BM).

6.11 Hedychium thyrsiforme Buch.-Ham. ex Sm., Cycl. 17: Hedychium n. (1811). Baker in Fl. Brit. Ind. **6:** 230(1892). EFPN 1: 61(1978). ACFPN: 330(2000). FPN : 166(2001).

Hedychium heteromallum Lindl., in Edwards, Bot. Regist. 9: t. 767 (1824).

Hedychium tocucho Buch.-Ham. ex Wall., ; in Hook., J. Bot. Kew Gard. Misc. 5: 327 (1853).

Pseudostems up to 1.5m. *Leaves* sub-sessile; dark green, elliptic-obovate, 33--34X8.5--9 cm, apex acuminate, slightly unequally divided by mid-rib, adaxial surface pubescent; ligule light green, ovate-lanceolate, 3.5--3.7X1.3--1.5 cm, apex acute, membranous, pubescent at apex. *Inflorescence*, spike 8--10 cm, glabrous, main axis not concealed; bracts convolute, elliptic-lanceolate, 2.1--2.3X0.9 cm, margin membranous, tufts of pubescence at apex, number of flower subtending 1 or 2; bracteoles 1-lobed, 1.5--1.7 cm, apex acute, membranous, glabrous. *Flowers* white, mildly fragrant, ca. 6 cm; calyx 2-lobed, 2.9--3 cm, apices acute with few strands of hair, membranous, longer than bract; corolla tube ca. 3.5 cm, longer than bract, corolla lobe 3.4--3.5cm, apex acute-acuminate; lateral staminodes linear, ca. 2.8 cm, curled upwards; labellum clawed, 2.3--2.5 cm, tip of lobes bent backwards, 2-lobed to more than half the length of the labellum; filaments white, 5--5.2 cm, more than the length of labellum, anthers white, ca. 1cm, perpendicular to the filament; stigma sparsely pubescent with short straight hairs, ovary pubescent around the bottom.

Flowering season: August-October
Fruiting season: December-January.

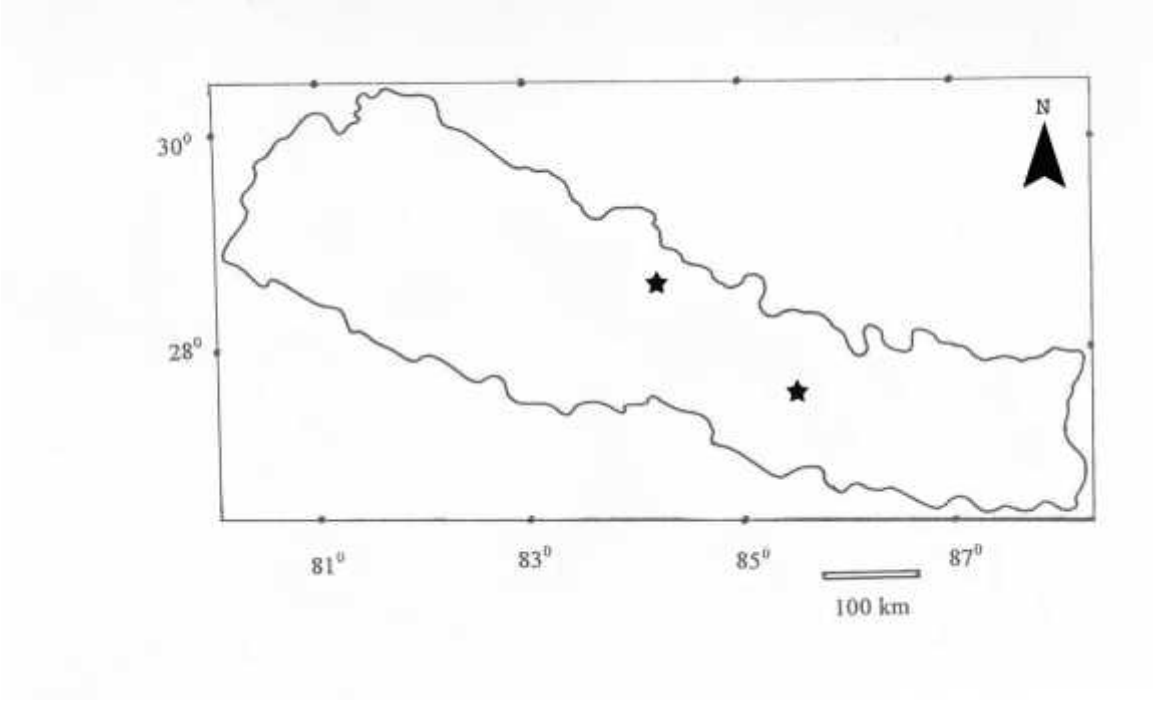
Type: Nepal (Not sure)

Notes: Smith (1819) states that in *Hedychium thyrsiforme* 'calyx moreover has three teeth'. In the current study the calyx is recorded to be 2-lobed.

Also, Smith (1994) and Baker (1892) mention the calyx of *H. thyrsiforme* to be shorter than bract. However in the current study only the specimens with calyx longer than bract have been encountered. These slight variations in the morphology indicate a degree of phenotypic plasticity in the species.

Hedychium thyrsiforme in Nepal is basically a terrestrial plant, however in some cases it has also been found to be epiphytic on *Castanopsis* and *Zizyphus spp*. . It is a limestone species and loves damp and shady slopes and gullies.

Distribution: Nepal C, 1200 -1500m. Himalaya (Uttar Pradesh to Sikkim), NE India



Map 9: Distribution of *H. thyrsiforme* Buch.-Ham. ex Sm.

Representative Collections:

Central Nepal: Manang, Marsiandi Valley, 4000 ft, 19. 8. 1984, J. D. A 8895 (BM); **Kathmandu**, Hattiban, ca. 1600, 3. 9. 2003, Mishra 691 (TUCH); napalia, 1819, Wallich *s.n.* 34 (BM).

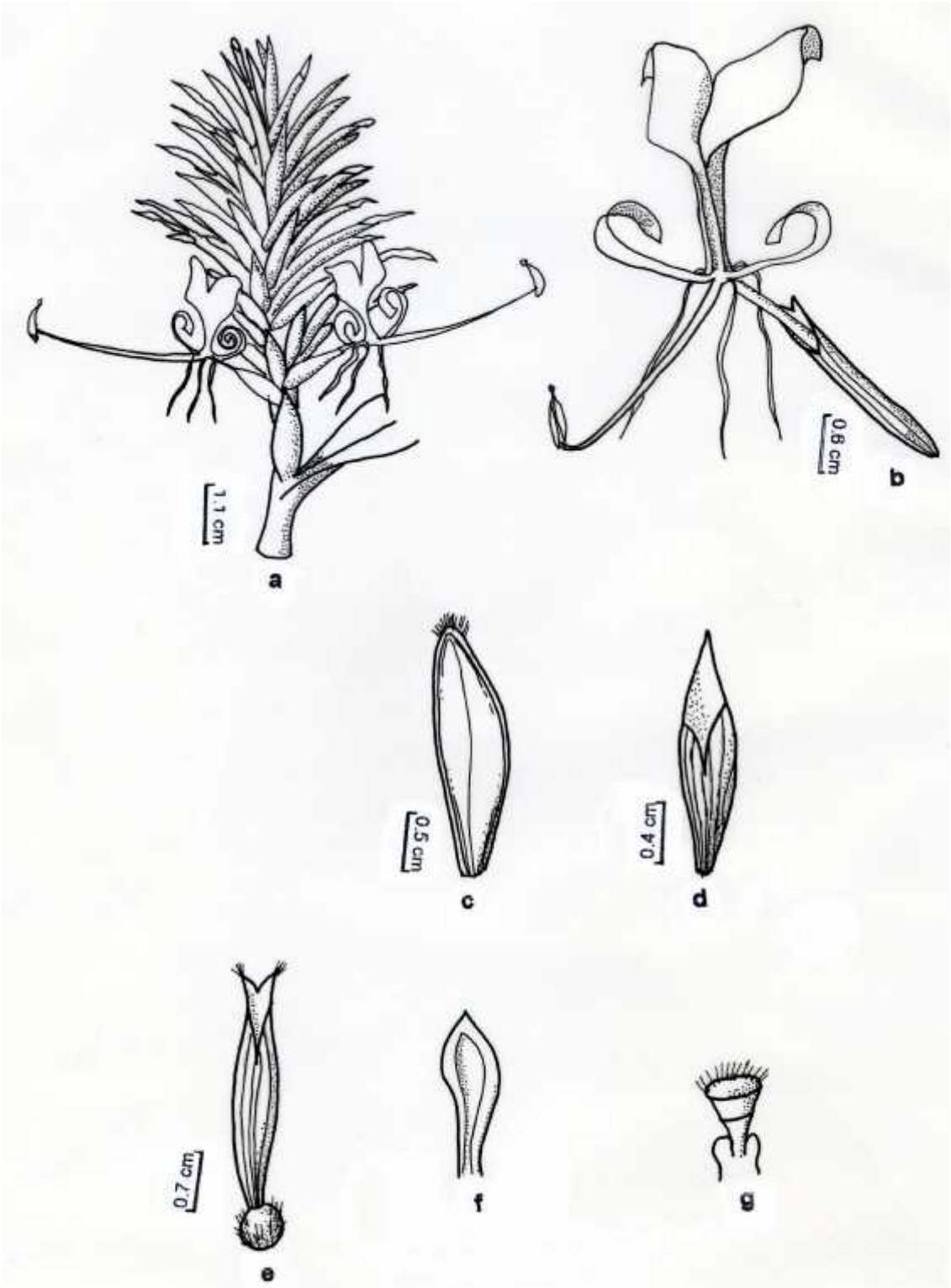


Figure 18. *Hedychium thyrsiforme* Buch.-Ham. ex Sm., **a.** inflorescence, **b.** flower, **c.** bract, **d.** bracteole, **e.** calyx, **f.** corolla tip (enlarged), **g.** stigma (enlarged), (Stainton, Sykes & Williams, 6455 BM).

6.12 Doubtful Species

6. 12. 1 Hedychium villosum Wall. in Roxb., Fl. Ind. (Roxburgh) 1: 12 (1820). EFPN 1: 60 (1978). ACFPN: 330(2000). Baker in Fl. Brit. Ind. **6:** 228(1892).

Pseudostems 1-2m. *Leaves* petiolate, oblong-oblanceolate, glabrous or pubescent adaxially; ligule lanceolate-oblong. *Inflorescence*, spike 15-25 cm, densely flowered; bracts 2-3 fid, oblong, pubescent, number of flower subtending 2 or 3. *Flowers* white, fragrant, calyx longer than bract; corolla tube ca. 3.5 cm, longer than bract, corolla lobes reflexed linear; lateral staminodes slightly wider than corolla lobes; labellum oblong-obovate, clawed; labellum 2-lobed; filaments purple-white, longer than labellum, anthers white, sagittate; ovary pubescent. (Description based on (Roxburgh, 1820; Baker, 1892; and Shu, 2000)

Notes: *Hedychium villosum* was found absent throughout this study. No specimen of *H. villosum* was found in the herbaria of TUCH, KATH, BM, E, K. However one Type specimen of the species was found deposited at NY (Wallich, 1832; barcode no. 00320248), without any reference to geographical location. *Hedychium villosum* was first described by Roxburgh (1820) from Khasi Hills, in the North East of India. Baker (1892) also mentions Nepal in the distribution of *H. villosum* (along with Silhet, Assam, Khasia Hills and Munipur) though no reference has been provided for it.

More importantly Hara *et al*. (1978) has also cited Baker (1892) for including *Hedychium villosum* among the Nepalese *Hedychium* species and no particular specimen of any herbaria has been cited as representative collection. As the distribution of *Hedychium villosum* is traced eastwards from North-East India and not westwards into Nepal, it could be the reason why there has been no representative collection so far. The possibility of finding the odd Nepalese specimen of *Hedychium villosum* at regionally important herbaria like CAL, DD, LKW, cannot be ruled out, nevertheless its existence could not be traced during this investigation; hence giving plausible reasons to put the species into ‘doubtful species’ category.

Distribution: Nepal, NE India (Meghalaya, Manipur).

6.12.2 **Hedychium forrestii** Diels. Not. Roy. Bot. Gard. Edin. V: 304. 1912.

Pseudostems 1.5-2m. Leaves sessile; narrowly linear, glabrous. *Inflorescence*, spikes cylindric, dense, glabrous or sparsely villous; bracts oblong, coriaceous, sparsely pubescent, number of flower subtending -3. *Flowers* red; calyx 3-lobed, sparsely pubescent at lobes; corolla tube slightly longer than calyx; lateral staminodes lanceolate, labellum orbicular, apex deeply 2-cleft; filament a. 5 cm; anther 7-8 mm; ovary pubescent. (Description based on Shu, 2000)

Notes: During this study, a herbarium sheet from BM (Nepal, Wallich-6553, 1821, barcode no. 000574704) had two different species. One was determined as *H. forrestii* Diels by Dr. Thomas Wood (for a monograph work on *Hedychium*) in Jan, 2002. The inflorescence of the specimen only contained the spike and the bracts, the other parts of flowers were absent. The bracts show resemblance to the Type image (Dali Valley, Yunnan, China, E!). If the species is indeed *H. forrestii* then it will be a new record to Nepal Flora. However, this study has felt the need for further supporting evidences (for e.g. other specimens of the same recorded from Nepal) to make the argument more credible.

6.13 Distribution of Hedychium species in Nepal

6.13.1 Horizontal Distribution

Present study confirms the distribution of *Hedychium* throughout east to west in Nepal. Four species viz. *Hedychium coronarium*, *H. ellipticum*, *H. speciosum* and *H. spicatum* were found distributed in all three geographical regions (WCE) of Nepal. *Hedychium coronarium* was previously reported only from Central Nepal. Similarly, *Hedychium speciosum* was previously reported from Central and Eastern Nepal only.

Hedychium coccineum and *H. densiflorum* were found in Central and Eastern regions, indicating an affinity towards eastern himalayan elements.

Hedychium elatum was recorded from Central Nepal only. As it was a Wallich specimen, it can be slotted in Central Nepal by default, though the exact locality cannot be ascertained.

Herbarium specimens recorded *Hedychium thyrsiforme* only from Central Nepal. Press *et al.* (2000), also gives the distribution of this species as Central Nepal. However, Hara (1966) records its distribution in Eastern Nepal too. Flora Himalaya database (http://www.leca.univ-savoie.fr/tmp/FloHy/infos.html) enlists *Hedychium thyrsiforme* as Himalayan endemic. The same database also gives the distribution of *Hedychium thyrsiforme* in all three regions, Western, Central and Eastern Nepal. The current study does not trace *Hedychium thyrsiforme* from Western Nepal.

Hara (1966) recorded *Hedychium flavescens* from Dhankuta. In the present study a herbarium sample was collected from National Botanical Garden Godavari. Though it is assumed that natural distribution of *Hedychium flavescens* is in Eastern Nepal, being a horticulturally popular plant, some populations probably escaping cultivation and getting naturalized in the wild can be seen in Kathmandu Valley and widely throughout Nepal as well.

Similarly *Hedychium gracile* was recorded from East Nepal only, indicating its affinity towards eastern himalayan elements.

Press *et al.* (2000) mentions the presence of *Hedychium villosum* in Nepal, however it does not give the distribution. In the present study the species was found altogether absent.

The interesting observation is that none of the Nepalese *Hedychium* species were found distributed exclusively in Western region. This suggests that all *Hedychium* species may be eastern himalayan elements, with some species migrating westwards.

Table 2: Horizontal Distribution of *Hedychium* species in Nepal

Taxa	East	Central	West
Hedychium coccineum Buch.-Ham. ex Sm.	□●	□●	
H. coronarium J. Koenig	●	□●	●
H. densiflorum Wall.	□●	□●	
H. elatum R. Br.		●	
H. ellipticum Buch. – Ham. Ex Sm.	□●	□●	□●
H. flavescens Carey ex Roscoe	□	□●	
H. gracile Roxb.	□●		
H. speciosum Wall.	□●	□●	●
H. spicatum Roscoe	□●	□●	□●
H. thyrsiforme Buch.-Ham. ex Sm.	□	□●	

● = Distribution on the basis of representative collection seen in present study

□ = Distribution based on the survey of literatures

□● = Distribution based on the representative collection also supported by literature survey.

6.13.2 Vertical Distribution

Present study traces the altitudinal distribution of Nepalese *Hedychium* from 150 m - 3500m. Two species *Hedychium coronarium* and *H. densiflorum* are reported from tropical to sub-tropical climate. *H. ellipticum* is found from tropical (150 m) to

sub-alpine (3500m). Seven species namely *Hedychium coccineum*, *H.elatum*, *H. flavescens*, *H. speciosum*, *H. gracile*, *H. spicatum* and *H. thyrsiforme* are found in sub-tropical climate. Among these, *Hedychium ellipticum* has the widest range of distribution and *H. speciosum* having the narrowest range of distribution from 1900-2100 m.

Table 3: Horizontal vs. Vertical Distribution of *Hedychium* in Nepal

S.No.	Taxa	Elevation (m)	Horizontal
1	*Hedychium coccineum* Buch.-Ham. ex Sm.	1000-2000	CE
2	*H. coronarium* J. Koenig	150-1900	WCE
3	*H. densiflorum* Wall.	450-2800	CE
4	*H. elatum* R. Br.	1700	C
5	*H. ellipticum Buch. – Ham. ex Sm.*	300-3500	WCE
6	*H. flavescens Carey ex Roscoe*	1200-2000	CE
7	*H. gracile* Roxb.	1200-1900	E
8	*H. speciosum* Wall.	1900-2100	WCE
9	*H. spicatum Roscoe*	1500-2400	WCE
10	*H. thyrsiforme Buch.-Ham. ex Sm.*	1200-1500	CE

7 CLADISTIC ANALYSIS

Phylogenetic Analysis of Monocot groups have been dealt with comprehensively around the world, providing insights to the diversity and evolution of the group. Wood *et al.* (2000) has tried to hypothesize the phylogeny of the genus *Hedychium* through cladistics using DNA extracts.

The present study attempts the cladistic analysis of the Nepalese species on the basis of morphological characters. As plants do not entertain political boundaries, the question may well arise about the validity or utility of attempting to trace the phylogenetic relationship exclusively among the Nepalese species. However the purpose here is not to establish a phylogenetic relationship between Nepalese species but to provide 'a testable hypothesis' Stuessy (1990), by exploring the possibility of finding out potential clades and groups that may also provide useful insights when compared with works done on the genus and related taxa from other geographic regions, or even worldwide.

7.1 Character Coding

The character selection and coding was done based upon Kitching *et al*. (1998) and Elredge and Cracraft (1980). For the Outgroup the genus *Canna* (Cannaceae) was chosen as a closely related group based upon Chase *et al.* (1995).

The characters and character-states were chosen based upon their consistency traced in the present study. Hence it has been exclusively drawn from the descriptions given in the Results and Taxonomic Treatment chapters. As only the primary data derived from this study have been used, two species *Hedychium elatum* and *H. villosum* could not be incorporated as only a digital image of the former could be observed and the latter was found altogether absent. Similarly, *H. spicatum* var. *spicatum* and *H. spicatum* var. *trilobum* also could not be incorporated as the former was found altogether absent and useable morphological data could not be obtained from the latter.

Care was taken to avoid ambiguous and overlapping characters. Only qualitative characters were chosen for optimum reliability. After identifying the character and character -states 'multi-state' character coding was done.

Table 4: Character and Character states

1	Petiole	0= absent, 1= present
2	Bracts	0= petaloid, 1=non-petaloid, convolute; 2= non-petaloid imbricate
3	Bracts	0= no. of fls. subtending 1, 1= no. fls. subtending 2, 2=no. fls subtending>2, 3=no. of fls. subtending 1 or 2
4	Sepals	0= free, 1= connate, 2-lobed, 2= connate, 3-lobed, 3-connate, 1-lobed
5	Sepals	0=shorter than bract 1= longer than bract, 2=more or less equal to bract
6	Petals	0=free, usually unequal, 1= connate, usually equal
7	Petals	0=free, 1= connate, tube longer than bract, 2= connate, tube shorter than bract, 3= connate, tube equals to bract
8	Lateral staminodes	0= present in numbers 2or 3, 1= present consistently in numbers 2,
9	Lateral staminodes	0= lateral staminodes 2 or 3, 1= lateral staminodes glabrous at base, 2= lateral staminodes pubescent at base
10	Labellum	0= made of 1 androecial member, 1= made of more than 1 androecial member
11	Filament	0= staminodial, 1= clasping type
12	Filament	0 = shorter than labellum; 2= longer than labellum
13	Anther	0= partly fertile, 1= fully fertile
14	Style	0= flattened petaloid, 1= non petaloid
15	Stigma hairs	0= absent, 1= present straight, 2= present coiled or hooked
16	Ovary	0= hairs absent, 1= hairs present

Table 5: Data Matrix

		Characters															
No.	**Taxon**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
0	*Canna indica*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
1	*Hedychium coccineum*	0	1	2	2	0	1	1	1	2	1	1	1	1	1	2	1
2	*H. coronarium*	0	2	2	1	1	1	1	1	1	1	1	0	1	1	1	0
3	*H. densiflorum*	1	1	0	1	2	1	1	1	1	1	1	1	1	1	1	0
4	*H. ellipticum*	1	2	0	1	0	1	1	1	1	1	1	1	1	1	1	1
5	*H. flavescens*	1	2	2	3	0	1	1	1	1	1	1	0	1	1	2	1
6	*H. gracile*	1	1	0	1	2	1	3	1	1	1	1	1	1	1	1	1
7	*H. speciosum*	1	1	2	2	0	1	1	1	2	1	1	1	1	1	1	0
8	*H. spicatum* var. *acuminatum*	0	1	0	1	1	1	1	1	1	1	1	0	1	1	1	0
9	*H. thyrsiforme*	0	1	3	1	1	1	1	1	1	1	1	1	1	1	1	1

7.2 Data Analysis

The Data Matrix given above (Table 3.) was created in the Winclada Version 1.00.08 (developed by K. Nixon in 1999) following standard procedures. For analyzing the matrix, heuristics method was employed with the following parameters:

Maximum trees to keep: 100

Replication: 100

Starting tree: 10

Random seed: 1

Multiple TBR+TBR

The above specifications generated two trees, one of them with better values (Consistency Index (ci): 72, Retention Index (Ri): 65) was then Bootstrapped with 100 replicates. Bootstrapping gave 103 trees, out of which the most parsimonious one has been discussed below. The tree has white ellipsis as homoplasious characters and black ellipsis as non-homoplasious characters.

The cladogram supports the hypothesis of monophyly of *Hedychium*, as the bootstrap value is 100. *H. spicatum* forms the first clade.

It is followed by second clade that has *Hedychium coronarium* which forms a third clade with *H. thyrsiforme* and rest of the species. The clade of *H. thyrsiforme* and others is joined with *H. coronarium*.

The fourth clade consists of two sub-clades. First one consist of *Hedychium ellipticum* that pairs with a sub-clade of *H. densiflorum* and *H. gracile*. Here all the species have bracts subtending only one flower each.

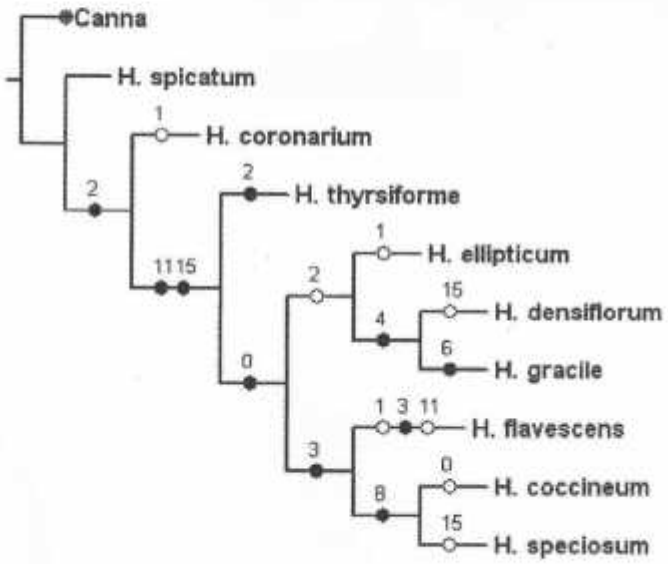
The second one consist of *Hedychium flavescens* that pairs with a sub-clade of *H. coccineum* and *H. speciosum*. Here all the species have bracts subtending more than one flower each.

The cladogram shows characters 2, 3, 4, 6, 8, 11, 12 and 15 as non-homoplasious ones. A non-homoplasious character can be either a synapomorphy or sympleisomorphy. Study of character table and data-matrix indicates the following as shared derived characters (synapomorphies) in the genus:

Character no. 4 (sepals shorter than bract/sepals longer than bract)

Character no. 3 (number of flowers subtending in each bract)

Character no. 15 (stigma hairs absent, present straight or present hooked).



Cladogram of Nepalese *Hedychium species*

8 DISCUSSION

Hedychium with 10 species and three varieties is the largest genus in the family Zingiberaceae (comprising altogether 12 genera and 43 species) in Nepal. There has not been any detailed taxonomic work on the genus or on other members of the family in the country.

So far the taxonomic work of the family is limited to generalized enumerations and checklists (*Malla et al.* 1976, Hara *et al*. 1978, Press *et al*. 2000) and a handful of regional and local floras (Hara 1966, Anonymous 1969, Malla *et al*. 1973, Malla *et al*. 1986, Miyamoto 2000 etc.) with very brief descriptions, if at all.

Since the aforementioned works were not exclusively focused on the ginger group, it cannot be asked of those to provide detailed scientific information for better understanding of the taxa. In that respect, even the basic essentials for proper documentation (the location, locality and images of Types; updating the synonymies, taxonomic descriptions, illustration, data on phenology, distribution maps etc.) about the family Zingiberaceae were lacking.

In such a scenario, an attempt to work on any member of this economically and taxonomically important family would prove to be challenging and rewarding. Stearn (1978) has also mentioned the need to work on the taxonomy of *Hedychium*. This author believes, the taxonomic work on *Hedychium*, being the largest genus in the group and with rather complicated taxonomy, will add some valuable information in the understanding, not only of this genus, but also to the Zingiberaceae family as a whole. The importance of the *Hedychium* is accentuated by the fact that while most of the species are wild, some like *Hedychium coronarium* and *H. flavescens* are also popular horticultural plants in Nepal.

This study has been able to give information on the detailed account of the genus. The account includes information on Types, detailed synonymy,

taxonomic description, detailed illustration, morphological variation, phenology and distribution among others. So far as distribution is concerned, this work has mapped the distribution both vertically and horizontally. General distribution has been plotted on the maps and also classified locality-wise in the 'representative collections'. This work has also given detailed notes on some morphological variations observed in Nepalese species as compared to species described in neighbouring regions like India, Bhutan and China.

Earlier, 12 species of *Hedychium* with three varieties were reported (Press *et al.* 2000, Hara *et al.* 1978). This study has confirmed the existence of 10 of them with three varieties. One species, *Hedychium villosum* was found to be absent. One species (*Hedychium forrestii* Diels.) can be a potential new record. While our *Hedychium* diversity with our neighbouring floras, Baker (1892) described 24 species from British India of which 11 are common to Nepal; Smith (1994) described 13 species from Bhutan of which 10 are common to Nepal; Shu (2000) described 28 species from China of which eight are common to Nepal. While a country like China with around 30, 000 species report 28 species of *Hedychium*, it is a promising sign that Nepal with an estimated species count of 6,500, can boast of 10 species.

As the species diversity of *Hedychium* is concentrated eastwards, 'northeast India (24 spp.), Burma (11), China [in Yunnan province (18), Guangxi province (8), Guangdong and Hainan (2)' Wood (2000), it gives an indication that most of the species of the genus is of eastern himalayan origin. So Eastern Nepal can always be hotspot for finding and studying *Hedychium*. As this work has only focused on general morphology only, the need for further critical research on the taxon is strongly felt. Further works can be carried out by observing the taxon in its habitat (at least growing in an exclusive garden) and explore its other aspects like, pollination biology, chemo-taxonomy and molecular taxonomy, among others.

The species of *Hedychium* also show some phenotypic plasticity. Some species show a bit more than others. The plasticity can be traced mainly in ligule, calyx, ratio of the length of calyx to bract; pubescence, number of flowers per bract (in case of multiple flowers), and rarely also the shape and colour of labellum.

Ligules in *Hedychium coccineum* have been found to be both obtuse and 2-lobed (deeply cleft). Similarly the ligules of *Hedychum spicatum* var. *acuminatum* also range from acute to obtuse apex. Likewise, pubescence on the leaf surfaces, are not consistent characters.

One species showing a wide range of phenotypic plasticity is *Hedychium coccineum*. It has calyx lobes with apices acute to obtuse, calyx densely pubescent to sparsely pubescent. Labellum is deeply lobed to slightly less lobed, and the colour from scarlet to red.

The calyx in *Hedychium flavescens* is found to be pubescent as well as glabrous. Likewise, the character of the calyx lobes in the genus is always plastic. In *Hedychium densiflorum* the calyx lobe ranges from 2-3 lobed. The calyx in *Hedychium coronarium* ranges from shorter than bract to slightly longer than bract.

Four species of the genus had bracts subtending a single flower, namely *Hedychium densiflorum*, *H. ellipticum*, *H. gracile* and *H. spicatum*. In the remaining species which had bracts bearing more than flowers the number was not constant. In *Hedychium coccineum* each bract had number of flowers 3-4. Similarly it also varied in *H. coronarium* (3-4), *H. speciosum* (2-3), *H. flavescens* (2-4) and *H. thyrsiforme* 1 or 2.

Furthermore, *Hedychium* tends to hybridize naturally, producing sterile or sometimes fertile hybrids that show considerable phenotypic plasticity creating confusion about the status of the taxa. For example, Wood (2000) opines that *Hedychium elatum* is a natural hybrid between *H. coccineum* and *H. stenopetalum*.

9 CONCLUSION AND RECOMMENDATIONS

Hara & Williams (1978) and Press *et al.* (2000) enumerated 12 species of *Hedychium* in Nepal with three varieties. The present study confirms the presence of ten of them, with three varieties of *Hedychium spicatum*, *H. spicatum* var. acuminatum, *H*. *spicatum* var. *spicatum* and *H. spicatum* var. *trilobum*. The current study also mentions a potential new species *Hedychium forrestii* Diels. .

Hedychium villosum Wall. was found altogether absent in the herbarium specimens studied (BM, E, KATH & TUCH), and herbaria searched (K).

No herbarium specimens of *Hedychium elatum* R. Br. could be studied, save a digital image of the same from E from Wallich collection, determined by Rose Mary Smith. So far this author could trace this as the only evidence of the existence of the species in Nepal.

Hedychium aurantiacum Roscoe and *Hedychium coccineum* Buch.-Ham. ex Sm. Cycl. has been merged as *H. coccineum* Buch.-Ham. ex Sm. Cycl.. Two species have undergone nomenclatural changes, *Hedychium gardnerianium* Sheppard ex Ker. Gawl. into *H. speciosum* Wall. Similarly *Hedychium glaucum* Roscoe is changed into *Hedychium gracile* Roxb. .

Palynological studies could have yielded results interesting from the taxonomical point of view. However could not be carried out as the logistics required for the palynological studies of the Zingiberaceae was not available.

Cladistic study of the Nepalese species of the genus was done with *Canna indica* (Cannaceae) as Outgroup. The clade revealed some important relationships owing to the number of flower per bracts.

Previously the altitudinal distribution of *Hedychium* had been quoted as 150-3100m. Based upon the study of herbarium specimens it has been revised as 150-3500m. *Hedychium ellipticum* was recorded at 3500m (Polunin, Sykes & Williams 567, BM). This is not only a new statistics for *Hedychium* in Nepal, but possibly for the genus throughout the world (Wood *et al.* (2000) mentioned the range of the genus up to 2400m, Rogers (1984) up to 3000m, Shu (2000) up to 3400m). The present study confirms the vertical distribution of the genus *Hedychium* from tropical to sub-alpine.

Study of any member of the family Zingiberaceae (the case in point *Hedychium*) is best done not on the herbarium specimens but on living plants. Institutions forefront in ginger research world over have vast ginger gardens viz. Edinburgh, Smithsonian, Kew, Calcutta, Singapore Botanic Gardens etc. to assist their studies. Without the facility of a ginger garden the research on gingers is a steep uphill task. It is imperative to study gingers at least in living conditions in the gardens if not the natural habitat.

The herbarium specimens of *Hedychium* or any other ginger taxa give less information than required for study. On pressed specimens of gingers the vital 3-D characteristics essential for proper identification and classification are lost. Hence, along with making herbarium specimens it is equally important if not more, to pickle the ginger specimens in 50 % ethanol for it to be useful for study.

As this present study suggests and literatures also support, the genus *Hedychium* is a predominantly Eastern Himalayan taxon. Hence there are strong possibilities of finding new species if explorations are carried out in the East Nepal.

Like some members of the family Zingiberaceae, the majority of *Hedychium* found in Nepal are limestone-philic. Limestone regions in Central and Eastern Nepal can be potential places to explore possible new species of *Hedychium* and ginger taxa as a whole.

10 SUMMARY

The current research work ‘Systematics of the genus *Hedychium* (Zingiberaceae) in Nepal’, is based on morphological characters observed in herbarium specimens of KATH, TUCH, BM and E (digital images only) and personal collection of the author. The plants were also observed in living state also so far as possible.

The species show little variations in the vegetative characters. The leaves are petiolate (*Hedychium densiflorum*, *H. ellipticum*, *H. gracile* and *H. thyrsiforme*) sub-sessile or sessile (*Hedychium coccineum*, *H. flavescens*, *H. speciosum* and *H. spicatum*). Leaf shapes range from lanceolate, ovate, obovate, and elliptic and their intermediates.

Ligules are membranous, except in *Hedychium speciosum* it is slightly coriaceous. Apex of the ligules may be acute, obtuse, truncate, emarginate, and 2-cleft. Bracts in the genus are either imbricate or convolute.

The Nepalese species of Hedychium show considerable variations in the reproductive characters. Six species viz. *Hedychium coronarium*, *H. densiflorum*, *H. ellipticum*, *H. gracile*, *H. spicatum* and *H. thyrsiforme* have 2-lobed calyx; two species, viz. *H. coccineum* and *H. speciosum* have 3- lobed calyx and one species H. flavescens is observed with 1-lobed calyx. The tips of the corolla lobes are found to be acuminate, acute, acute-acuminate, obtuse and aristate.

Variations in lateral staminodes range from linear, elliptic-obovate and clawed. In *Hedychium thyrsiforme* the lateral staminodes are found to be coiled upwards when observed in living specimens. Two species (*Hedychium coccineum* and *H. speciosum*) are found with small tuft of pubescence at the bottom of the claw.

Labellums are 2-lobed in Nepalese species of *Hedychium*. Shapes of labellum vary from linear, obcordate, to elliptic-obovate. Three species (*Hedychium coronarium*, *H. flavescens* and *H. spicatum*) have filaments that are subequal to their respective labellums. Six species, viz., *Hedychium coccineum*, *H. ellipticum*, *H. gracile*, *H. speciosum* and *H. thyrsiforme* have filaments longer than their respective labellums.

Out of around 65 valid species of Hedychium in the world, 12 species were earlier reported from Nepal with three varieties. The current research has confirmed the presence of 10 of them, namely *Hedychium coccineum*, *H. coronarium*, *H. densiflorum*, *H. elatum*, *H. ellipticum*, *H. flavescens*, *H. gracile*, *H. speciosum* , *H. spicatum* (with three varieties, var. *acuminatum*, var. *spicatum* and var. *trilobum*) and *H. thyrsiforme*. Two species are found to be of doubtful existence, *Hedychium villosum* is found absent in the study; *Hedychium forrestii* Diels. can be a possible new record, however further evidence is desirable for confirmation.

Hedychium aurantiacum Roscoe is proposed as the synonym of *Hedychium coccineum* Buch.-Ham. ex Sm. Cycl.. *Hedychium gardnerianium* Sheppard ex Ker. Gawl. has undergone nomenclature change into *H. speciosum* Wall. Similarly *Hedychium glaucum* Roscoe has been changed into *H. gracile* Roxb. .

Current work has established the vertical distribution of the genus from tropical to sub-alpine climate (150-3500m). *Hedychium ellipticum* is the species with the highest range of distribution from the tropical climate (150m) to sub-alpine) climate (3500m). The horizontal distribution of the *Hedychium* species stretches from East to West, with four species common to all three regions; three species recorded only from CE; two species recorded only from one region each, *Hedychium elatum* (C) and *H. gracile* (E).

The genus *Hedychium* in Nepal is generally found to be terrestrial species. However, two of the species are found to be both terrestrial and epiphytic as well; namely, *Hedychium spicatum* and *H. thyrsiforme*.

Taxonomical researches are always important and in this case it has, the author believes, helped to document at least one genus of the plant-diversity of Nepal in its own way; particularly as there has not been previous detailed works on the members of Zingiberaceae family. The author believes the current work though undertaken in a small scale can be an important stepping stone in better understanding the genus *Hedychium* but further researches on the topic are imperative.

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