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Interesting Use of *Calathea standleyi* Macbride (Marantaceae)

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Introduction

In the course of an ongoing botanical inventory of the Peruvian Alto Purús region, a variety of plants, including a number of Marantaceous taxa, have been collected. An ethnobotanical inquiry, conducted in conjunction with the botanical survey in and around the native Cashinahua community of Colombiana on the Rio Curanja, has documented the local names, knowledge of, and traditional uses for many of these collections. To date, 10 species in the genus *Calathea* have been identified¹. One of these species, *Calathea standleyi* Macbride (Graham & Schunke Vigo 1129, 1710), a plant known to the Cashinahua as *tsau mani*, is traditionally used in dental care, as a prophylactic against tooth loss and decay, and also was found to play a role in the Cashinahua initiation ritual.

The Cashinahua chew the immature petioles and leaf bases of *C. standleyi*, which, upon mastication, quickly turn the mouth a dark blue color. The plant material, typically consisting of several immature petioles and leaf bases, is chewed for a period of about ten minutes, but not swallowed. Within three minutes, a bright bluish-green color is observed in the saliva, and within ten minutes, the gums and tongue are stained bright blue (see Figure 1). The color from a single chewing will gradually disappear over several days. This treatment is believed by the Cashinahua to both protect the teeth from de-

cay, and to strengthen the gums, preventing tooth loss.

Discussion

Calathea standleyi is utilized by the Cashinahua in conjunction with the *nixpu pima* initiation ritual. *Nixpu pima* (literally *Piper* eating) is an important component of the Cashinahua ritual cycle, traditionally taking place over a period of several weeks every few years in individual Cashinahua villages. Children who have lost all their milk teeth and have developed a complete set of adult teeth are initiated into adulthood through participation in this ritual, a part of which includes the utilization of the young twigs of either of several different *Piper* species². These are chewed or lightly tapped against the teeth of the initiates, temporarily turning them black. The bright blue tongue and gums produced by chewing of *C. standleyi*, in conjunction with the tooth blackening provided by the *Piper*, in addition to producing a more profound cosmetic effect, can be interpreted as enhancing both the physical and spiritual protection afforded by the use of these traditional medicines in the ritual context. According to Cashinahua belief, a person possesses a physical body that is animated by a number of individual spirits³, one of which includes a tooth spirit, *xeta yuxin*. Tooth decay and tooth loss are thus not only linked to the physical body, through the physical effects of diet and dental hygiene, but are also associated with a loss of this tooth spirit from the body. The chewing of *C. standleyi* in conjunction with the *nixpu pima* ritual helps achieve a



Figure 1

positive medical effect, not only through its prophylactic and cariostatic physiological activity, but by protecting the *xeta yuxin* and conserving it in the body.

The genus *Calathea*, well known for its ornamental horticultural value⁴, is also well represented in the ethnobotanical literature. One species, *C. allouia*, is commonly utilized for its edible tubers⁵. The leaves of a number of *Calathea* species are routinely used throughout the Amazonian region for wrapping and roasting food⁶. One description of the genus being used in dental care is found, in a review that includes a report of the seeds of an unidentified *Calathea* species being

chewed to protect the teeth⁷.

While *Calathea standleyi* has been reported to stain blue on injury⁸, the leaves of several other species have also been reported to contain a blue dye, including *Calathea loesneri*^{6,9,10} and *Calathea allouia*⁶. Chemotaxonomic surveys of flavonoids and flavonoid glycosides in the Zingiberales have identified the Marantaceae as the chemically most diverse group in the order¹¹, but flavonoid distribution within the family does not follow closely the existing tribal and generic groupings.

Conclusions

Anecdotal evidence from the Cashinahua communities appears to support the claim that chewing *Calathea standleyi* acts to protect against decay and tooth loss, although several factors, including recent changes in the diet, as well as the concurrent chewing of various *Piper* species, are confounding influences that will need to be addressed. Further analysis is needed, in order to assess the potential safety and clinical efficacy of this plant.

Reports of blue dye being obtained from the several *Calathea* species mentioned herein is of potential interest, and should be investigated more fully, both taxonomically and chemically.

As the influences of acculturation multiply, not only among the Cashinahua, but among Amazonian indigenous groups in general, along with an increasing ambivalence among the younger generations about the value of their ancestral heritage, novel methods to conserve indigenous traditions and culture are urgently needed.

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A New Classification of the Gingers (Zingiberaceae) Based on DNA Evidence

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Introduction

Recently, in the American Journal of Botany, we (Kress et. al., 2002) published a paper that fundamentally changes botanists' understanding of the classification and evolutionary relationships of the Zingiberaceae. Rather than relying solely on morphological characteristics to unite different groups of genera and species (as all previous classifications of the gingers have done), we sequenced and analyzed the DNA of the plants themselves. Phylogenetic analysis of DNA sequences is today considered the most reliable method of reconstructing the evolutionary relationships or "family tree" of all organisms, including plants. The goal of this paper is to inform the readers of the HSI Bulletin, including those who are not scientists, of our findings and how they will affect the way we classify the Zingiberaceae.

Traditional classifications of the gingers (e.g. Schumann, 1904; Holtum, 1950; Burt and Smith, 1972; Larsen et. al., 1998) have divided the family into four tribes based on characters such as lateral staminodes, ovaries, and plane of leaf distichy (Table 1). These tribes differed greatly in size, with 48 of the 53 genera in the family belonging to the Alpinieae and Hedychieae (Table 1). It should be noted that *Costus* and its relatives, once considered a subfamily of the Zingiberaceae (i.e. Costoideae), are now recognized at the family level (i.e. Costaceae) by all modern workers. Although this classification was known to be problematic, a better system was not available. Our study aimed to analyze the evolutionary relationships among the genera of gingers and devise a new classification based on those relationships.

Methods

DNA samples were collected from 104 species of Zingiberaceae representing 41 of the 53 known genera (i.e. every genus of gingers except *Aulotandra*, *Cyphostigma*, *Elettaria*, *Geocharis*, *Geostachys*, *Haplochorema*, *Laosanthus*, *Leptosolenia*, *Nanochilus*, *Paracautleya*, *Parakaempferia*, and *Stadiorchilus*, many of which have since been obtained and studied). A phylogenetic analysis using parsimony was conducted on sequences

from the *ITS* and *matK* regions of DNA. The resulting phylogenetic tree, or "phylogeny", shows the evolutionary relationships of the species and genera analyzed (much as a family tree shows relationships within a family of people). For a more detailed discussion of the methods and analysis used in this study, see Kress et. al. (2002), reprints of which can be obtained by contacting W. J. Kress.

Results And Discussion

The results of the phylogenetic analysis (Fig. 1) both confirms some long held beliefs about ginger relationships while concurrently discarding others. In all, four subgenera and six tribes are established for the Zingiberaceae (Tables 2 and 3) based on these results. Those familiar with technical characters can use the key provided (Table 4) to identify taxa of interest to subfamily and tribe.

One of the most interesting results of our phylogeny (Fig. 1) is that *Siphonochilus* (Fig. 2) is the first, and earliest, branching genus in the family and is in no way closely related to the Hedychieae, the tribe in which it had always been placed. When one compares the flowers of *Siphonochilus* (Fig. 2) to that of the Costaceae (Fig. 3; the Costaceae is the

Figure 1. Phylogeny of the Zingiberaceae (genera only). Boxes indicate delimitation of tribes. Brackets delimit subfamilies. "Incertae sedis" indicates tribal relationships are still uncertain. Numbers below lines are bootstrap values, an indicator of confidence in the relationships shown (higher numbers are better). Asterisks indicate relationships are poorly supported at that node. Numbers above the line are branch lengths.

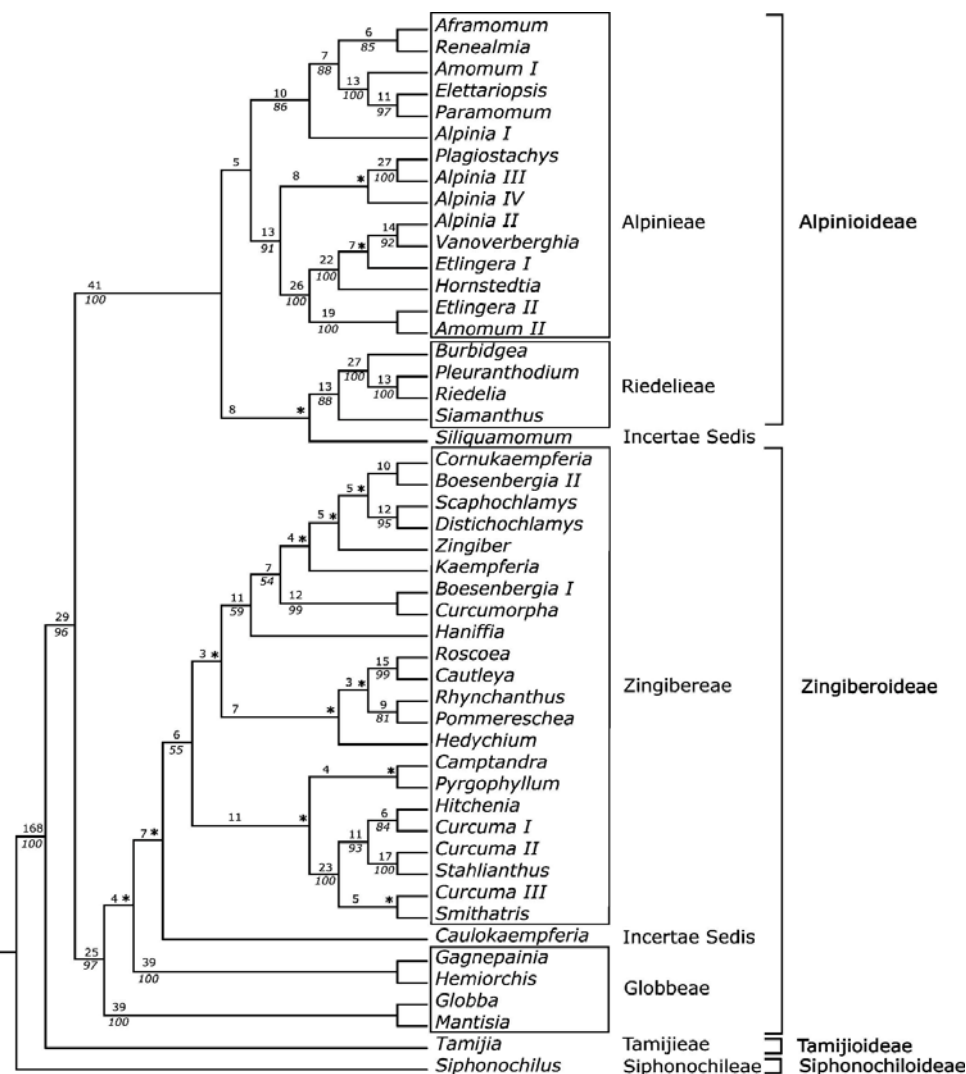




Fig. 2. *Siphonochilus kirkii* (Siphonochilioideae). This African genus forms the earliest branch of the Zingiberaceae tree. Note the great similarity of this flower to that of the Costaceae (Fig. 3).



Fig. 3. *Costus* sp. The Costaceae is the sister family to the ginger.



Fig. 4. *Alpinia officinarum* (Alpinioideae: Alpinieae). Members of this subfamily lack lateral staminodes. Ongoing research may require us to divide this genus into several smaller genera.



Fig. 5. *Etlingera venusta* (Alpinioideae: Alpinieae). This is one of the best-known genera of the Alpinioideae because of the large inflorescences that look like a single flower (pseudanthium).



Fig. 6. *Burbidgea schizochelia* (Alpinioideae: Riedelieae). Most of the species in this small tribe of subfamily Alpinioideae have long, narrow fruit and nectaries on the leaves.



Fig. 7. *Mantisia wengeri* (Zingiberoideae: Globbeae). This tribe of four genera (including the well known *Globba*) is distinctive in having ovaries and fruit with a single locule (chamber) instead of three as is found in the rest of the family.



Fig. 8. *Hitchenia glauca* (Zingiberoideae: Zingibereae). This rare and unusual genus from Myanmar is part of the problematic "Curcuma group" of genera.



Fig. 9. *Scaphochlamys rubescens* aff. (Zingiberoideae: Zingibereae). Like nearly all members of the subfamily (and unlike the Alpinioideae), this genus has prominent lateral staminodes.



Fig. 10. *Caulokaempferia saxicola* (Zingiberoideae: *incerte sedis*). Despite DNA evidence, the exact relationships of this small genus remain enigmatic. Its placement in the Zingiberoideae is clear, but whether it is a member of tribe Globbeae, Zingibereae, or a tribe of its own is uncertain.

Table 1. Characteristics and genera of the previously recognized tribes of the Zingiberaceae (after Schumann, 1904; Holttum, 1950; Burtt and Smith, 1972; Larsen et al., 1998).
 Authorities follow Reveal (2002).

Character	Tribes			
	Alpinieae A. Rich. (1841)	Hedychieae Horan. (1862)	Globbeae Meisn. (1842)	Zingibereae Meisn. (1842)
1) Plane of distichy of leaves	perpendicular to rhizome	parallel to rhizome	parallel to rhizome	parallel to rhizome
2) Lateral staminodes	small or absent, never petaloid	petaloid, free from labellum	petaloid, free from labellum and some- times connate to filament	petaloid, fused to labellum
3) Labellum	not connate to filament	not connate to filament	connate to filament in slender tube	not connate to filament
4) Stamen	medium-length	short-length	long with arching filament	anther crest elongated and wrapped around style
5) Ovary	3-locular (sometimes incompletely so)	3-locular (sometimes incompletely so)	1-locular	3-locular
6) Placentation	axial or free central	axial, basal, or free columnar	parietal	axial
7) Style	not exerted beyond anther sacs	not exerted beyond anther sacs	not exerted beyond anther sacs	exserted beyond anther sacs
8) Stigma	expanded	expanded	not expanded	not expanded
9) Placement of genera according to refer- ences cited above (number of species follows each genus)	<i>Aframomum</i> (50) <i>Alpinia</i> (225) <i>Amomum</i> (150) <i>Aulotandra</i> (6) <i>Burbridgea</i> (8) <i>Cyphostigma</i> (1) <i>Elettaria</i> (6) <i>Elettariopsis</i> (10) <i>Etingera</i> (70) <i>Geocharis</i> (7) <i>Geostachys</i> (18) <i>Hornstedtia</i> (50) <i>Leptosolena</i> (1) <i>Nanochilus</i> (1) <i>Paramomum</i> (1) <i>Plagiostachys</i> (20) <i>Pleuranthodium</i> (25) <i>Pommereschea</i> (2) <i>Renealmia</i> (75) <i>Rhynchanthus</i> (6) <i>Riedelia</i> (60) <i>Siamanthus</i> (1) <i>Stadiochilus</i> (1) <i>Tamijia</i> (1) <i>Vanoverberghia</i> (1)	<i>Boesenbergia</i> (60) <i>Camptandra</i> (4) <i>Caulokaempferia</i> (10) <i>Cautleya</i> (2) <i>Cornukaempferia</i> (2) <i>Curcuma</i> (50) <i>Curcumorpha</i> (1) <i>Distichochlamys</i> (3) <i>Haniffia</i> (2) <i>Haplochorema</i> (4) <i>Hedychium</i> (50) <i>Hitchenia</i> (3) <i>Kaempferia</i> (40) <i>Laosanthus</i> (1) <i>Paracautleya</i> (1) <i>Parakaempferia</i> (1) <i>Pyrgophyllum</i> (1) <i>Roscoea</i> (17) <i>Scaphochlamys</i> (30) <i>Siliquamomum</i> (1) <i>Siphonochilus</i> (15) <i>Smithatris</i> (2) <i>Stahlianthus</i> (7)	<i>Globba</i> (100) <i>Hemiorchis</i> (3) <i>Mantisia</i> (4) <i>Gagnepainia</i> (3)	<i>Zingiber</i> (100)

sister, or most closely related, family to the Zingiberaceae), the similarities are striking. In particular the fused staminodes and large, flattened anther crest are more similar to *Costus* than to other gingers. This suggests that millions of years ago, before the Costaceae and Zingiberaceae diverged, the flowers of the ancestral group were more like a *Costus* than a *Zingiber*. Also, the basal placement of *Siphonochilus*, a completely African genus, as sister to the rest of the family suggests the Zingiberaceae may have originated in Africa and then spread to Asia. This is interesting, as the vast majority of the ginger genera occur exclusively in Asia. Common sense would suggest that the region with the greatest diversity of genera and species would be the area of origin for the family, but, as this case shows, our assumptions and what actually happened during the course of evolution can be two very different things. Because of the distinct nature of *Siphonochilus*, a new subfamily (a taxonomic level between family and tribe) has been created for this genus, the Siphonochiloideae (Table 4).

The second surprise of the phylogeny is that *Tamijia*, a recently discovered and described genus endemic to Borneo, is the second earliest lineage of the Zingiberaceae. *Tamijia* was problematic for the authors who first described it, as it does not clearly fit into any of the traditional tribes of the Zingiberaceae. In light of the current study it becomes clear that their problem was due to the fact that it *does not* belong to any of the traditional tribes, but to one of its own. As such, the subfamily Tamijioideae is established (Table 4). The position of both *Tamijia* and *Siphonochilus* in this phylogeny suggests these groups have been diverged from all other gingers for an extremely long time, possibly for over 50 million years.

Aside from the two small subfamilies previously discussed, all gingers fit into one of two major groups, the newly created subfamilies Alpinioideae and Zingiberoideae (Fig. 1,

Table 4). Essentially, subfamily Alpinioideae consists of the genera assigned to the traditional tribe Alpineae. By contrast, tribe Zingiberoideae consists of almost all members of the traditional tribes Globbeae, Hedychieae, and Zingibereae. Besides *Siphonochilus*, the only genera to radically change position between the new and old classifications are *Pommerschea*, *Rhynchanthus*, and *Stadiochilus*. All three of these genera were placed into the Alpineae based on a lack of lateral staminodes, despite clear morphological affinities with the Hedychieae, so these findings are not surprising.

At the subfamilial level, the Alpinioideae are very distinctive because of the combination of no lateral staminodes (Fig. 4), plane of leaf arrangement perpendicular to the rhizome, and evergreen habit. The latter character is one never fully appreciated previously and one that can be difficult to properly interpret. All members of the Alpinioideae stay evergreen, even the species native to areas with seasonal dry periods. Even under especially dry conditions in the greenhouse, these species will not go dormant. Although several species of the Zingiberoideae are evergreen (e.g. some Globbas, Hedychieae, and Zingibers), all members of the subfamily either normally go dormant or can be forced into dormancy under especially harsh conditions.

Despite the distinctiveness of the Alpinioideae, the relationships of the genera in the subfamily are, in many cases, very poorly understood (Fig. 1). In particular *Alpinia* (Fig. 4), the largest genus of gingers, appears in at least four distinct, unrelated, species groups. *Amomum* and *Etlingera* each appear in a minimum of two distinct groups. The problem with this arrangement is that it means that these genera have "evolved" multiple, independent times. A genus consisting of species with differing origins is unacceptable to systematists as it does not properly reflect evolutionary history, and therefore requires

Table 2. Placement of genera in the new classification of the family Zingiberaceae. (Asterisks indicate taxa not sampled in the molecular phylogenetic analyses; these genera are tentatively placed based on morphological features.)

Subfamily Siphonochiloideae W. J. Kress	Subfamily Tamijioideae W. J. Kress	Subfamily Alpinioideae Link	Subfamily Zingiberoideae Haask.
Tribe Siphonochileae W. J. Kress	Tribe Tamijieae W. J. Kress	Tribe Alpinieae A. Rich.	Tribe Zingibereae Meisn.
<i>Siphonochilus</i>	<i>Tamijia</i>	<i>Aframomum</i> <i>Alpinia</i> <i>Amomum</i> * <i>Aulotandra</i> * <i>Cyphostigma</i> * <i>Elettaria</i> <i>Elettariopsis</i> <i>Etlingera</i> * <i>Geocharis</i> * <i>Geostachys</i> <i>Hornstedtia</i> * <i>Leptosolena</i> <i>Paramomum</i> <i>Plagiostachys</i> <i>Renealmia</i> <i>Vanoverberghia</i>	<i>Burbridgea</i> <i>Pleuranthodium</i> <i>Riedelia</i> <i>Siamanthus</i> Incertae Sedis <i>Siliquamomum</i>
			<i>Boesenbergia</i> <i>Camptandra</i> <i>Cautleya</i> <i>Cornukaempferia</i> <i>Curcuma</i> <i>Curcumorpha</i> <i>Distichochlamys</i> <i>Haniffia</i> * <i>Haplochorema</i> <i>Hedychium</i> <i>Hitchenia</i> <i>Kaempferia</i> * <i>Laosanthus</i> * <i>Nanochilus</i> * <i>Paracautleya</i> * <i>Parakaempferia</i> <i>Pommerschea</i> <i>Pyrgophyllum</i> <i>Rhynchanthus</i> <i>Roscoea</i> <i>Scaphochlamys</i> <i>Smithatris</i> * <i>Stadiochilus</i> <i>Stahlianthus</i> <i>Zingiber</i>
			<i>Gagnepainia</i> <i>Globba</i> <i>Hemiorchis</i> <i>Mantisia</i> Incertae Sedis <i>Caulokaempferia</i>

the establishment of multiple genera. These groups are now undergoing more intensive DNA and morphological study by Kress, Liu, and Newman (*Alpinia*); Xia, Kress, and Prince (*Amomum*); and Pedersen (*Etilingera*). The end result of these studies will certainly require either the splitting of these genera into several new genera, or reducing certain segregate genera into their larger counterparts. Readers should therefore be aware that some of the species they know as currently belonging to *Alpinia*, *Amomum*, and *Etilingera* (Fig. 5) may undergo a name change in the near future.

Aside from the problems with certain genera of the Alpinioideae, two major groups were revealed in this study. The largest group contains genera such as *Alpinia* (Fig. 4), *Etilingera* (Fig. 5), and *Renealmia* and will comprise tribe Alpinieae. The other, smaller, group consists of four, possibly five, genera that, in most species, share the unique features of possessing nectaries on the leaves (instead of the flowers), and in having a long, narrow fruit (a silique-like capsule) that opens by longitudinal slits. This group, which contains genera such as *Burbidgea* (Fig. 6) and *Riedelia*, are placed in the new tribe Riedelieae. *Siliquamomum*, a rare genus which grows on limestone hills and cliffs along the China-Vietnam border, did not have a clear placement in the phylogenetic analysis and was not assigned to a tribe. However, morphological evidence would suggest a relationship for *Siliquamomum* with the Riedelieae.

The fourth subfamily of the Zingiberaceae is the Zingiberoideae, a group that contains nearly all members of the traditional tribes Globbeae, Hedychieae, and Zingibereae. Two tribes are here recognized in this subfamily. The first lineage to branch off within this subfamily is tribe Globbeae, which contains the large and familiar genus *Globba*, as well as three small and lesser-known genera *Gagnepainia*, *Hemiorchis*, and *Mantisia* (Fig. 7). The unique characteristic of the Globbeae is that the ovary is unilocular with parietal placentation (i.e. the ovary and fruit have no internal partitions and the seeds are attached to the sides of the fruit). Virtually all other gingers have a trilocular ovary and fruit with axile placentation (i.e. the fruit is divided into three parts and the seeds are attached in the middle of the fruit). The results of our study suggested that the Globbeae might not be monophyletic (i.e. sharing a unique evolutionary origin; Fig. 1). However, recent work by Williams, Kress, and Manos (unpubl.) on the Globbeae suggests the tribe does have a unique origin and should be retained.

The second, and largest, tribe in the Zingiberoideae is the Zingibereae. Although this tribe is essentially "the Hedychieae plus *Zingiber*", nomenclatural rules require that the tribe be named Zingibereae. Three major groupings are seen within the tribe (Fig. 1). The most complex group from a taxonomic standpoint is *Curcuma* and its relatives. Aside from *Camptandra* and *Pyrrophyllum*, all genera in this group appear to have evolved out of *Curcuma* itself. In other words, the only way to keep all the species we consider *Curcuma* as part of the genus would be to eliminate the genera *Hitchenia* (Fig. 8), *Stahlianthus*, *Smithatris*, and probably the newly described *Laosanthus*, and consider their species as part of *Curcuma*. A more likely result will be the preservation of some of the segregate genera with *Curcuma* itself being divided into two or more genera. An extensive DNA based phylogenetic analysis of *Curcuma* and its relatives is currently underway (T. M. Rehse and W. J. Kress unpubl.), and any nomenclatural changes

Table 3. Characteristics of the subfamilies and tribes of the new classification of the Zingiberaceae presented here (Burt, 1972; Burt and Smith, 1972; Larsen et al., 1998; Sakai and Nagamasu, 2000; W. J. Kress, personal observation). Some nondiagnostic features are included as a reference to the previous classification (see Table 1).

Character	Subfamilies and Tribes				
	Siphonochiloideae: Siphonochileae	Tamijioideae: Tamijieae	Alpinioideae: Riedelieae	Alpinioideae: Alpinieae	Zingiberoideae: Zingibereae
1) Seasonality	dormancy period	evergreen	evergreen	evergreen	dormancy period
2) Rhizomes	fleshy	fibrous	fibrous	fibrous	fleshy
3) Plane of distichy of leaves	perpendicular to rhizome	perpendicular to rhizome	perpendicular to rhizome	perpendicular to rhizome	parallel to rhizome
4) Extrafloral nectaries	absent	absent	present on leaf blades	absent	absent
5) Lateral staminodes	petaloid, fused to labellum	petaloid, fused to labellum	small or absent, never petaloid	small or absent, never petaloid	petaloid, free from labellum and sometimes connate to filament
6) Labellum	not connate to filament	not connate to filament	not connate to filament	not connate to filament	connate to filament in slender tube
7) Filament	short	short	medium	medium, sometimes arching	short to long, sometimes arching
8) Anther crest	petaloid	petaloid	petaloid or absent	petaloid or absent	spurred or absent
9) Ovary	3-locular (sometimes incompletely so)	1-locular	1- or 3-locular	3-locular	1-locular
10) Placentation	axial	parietal	axial or parietal	axial or free central	parietal
11) Capsule	fleshy	unknown	silique-like, opening by longitudinal slits	indehiscent or fleshy	globose and dehiscent

Table 4. A key to the subfamilies and tribes of a new Linnaean classification of the Zingiberaceae. Authorities follow Reveal (2002).

1. Plane of distichy of leaves perpendicular to rhizome.
 2. Lateral staminodes well developed and fused to labellum.
 3. Plants evergreen with fibrous rhizomes; ovary unilocular with parietal placentation. Tamijioideae W. J. Kress, subfam. nov. et Tamijieae W. J. Kress, tribus nov.
 3. Plants with seasonal dormancy period and fleshy rhizomes; ovary trilocular with axial placentation..... Siphonochiloideae W. J. Kress, subfam. nov. et Siphonochileae W. J. Kress, tribus nov.
 2. Lateral staminodes reduced or absent..... Alpinioideae Link (1829)
 4. Extrafloral nectaries present on leaf blades; fruits silique-like opening by longitudinal slits..... Riedelieae W. J. Kress, tribus nov.
 4. Extrafloral nectaries absent; fruits fleshy or indehiscent..... Alpinieae A. Rich. (1841)
1. Plane of distichy of leaves parallel to rhizome Zingiberoideae Haask. (1844)
 5. Ovary trilocular with axial, basal or free columnar placentation; labellum usually not connate to the filament. Zingibereae Meisn.
5. Ovary unilocular with parietal placentation; labellum often connate to filament in a slender tube. Globbeae Meisn.

will await the results of this study.

A second group within the Zingibereae consists of the genera *Hedychium*, *Roscoea*, *Cautleya*, *Pommereschea*, and *Rhynchanthus* (Fig. 1). While the group as a whole had never been recognized before, and lacks strong molecular support, the group has characteristics that suggest this grouping is accurate. Except for *Hedychium*, all of these genera are confined to mid- to high-elevation (1000-4000 m.) regions of the Himalayas and adjacent mountainous ranges (especially China, India and Myanmar). *Hedychium* occurs as far south as Indonesia, and several species grow in lowland areas, but the bulk of diversity is in the same region and elevations as the other genera. *Roscoea* and *Cautleya* are very similar morphologically and have long been allied to each other. In addition, *Rhynchanthus*, *Cautleya*, and many species of *Hedychium* are epiphytic, while *Pommereschea* occurs in extremely rocky, cliffside habitats (i.e. xeric conditions very similar to growing on a tree). These features suggest a common ancestor who may have developed as an epiphyte in the mid- to higher elevation areas of the Himalayas.

The third, and largest, group of the Zingibereae contains such familiar genera as *Zingiber*, *Kaempferia*, and *Boesenbergia*. While no clear-cut morphological feature distinguishes this group from the other members of the tribe, many genera lack or have a very short pseudostem. *Cornukaempferia*, despite having vegetative similarity to *Kaempferia* and an anther crest nearly identical to that of *Zingiber*, is most closely related to *Boesenbergia* (some species), *Scaphochlamys* (Fig. 9) and *Distichochlamys*. *Boesenbergia* is the most problematic genus within this group, as the species sampled belong to two groups that are completely unrelated to each other. Besides the group of *Boesenbergia* that are closely related to *Cornukaempferia*, another group of *Boesenbergia* are most closely related to *Curcumorpha* (a genus sometimes considered to be part of *Boesenbergia*). Therefore, one of these groups will have to be transferred out of *Boesenbergia*.

Within the Zingiberoideae, the genus whose relationships are the least clear is *Caulokaempferia* (Fig. 10), a small group of species with a preference for growing in moist, rocky areas. The species sampled in this analysis (e.g. *C. saxicola*) are members of the yellow flowered group and are very small (10-20cm.) and grow along rocky streambanks, especially near waterfalls. Exact placement of this group is uncertain, as DNA evidence does not favor a placement sister to the Zingibereae

over positions sister to the Globbeae or to the entire subfamily itself. The plants themselves are enigmatic, as vegetatively they resemble a small *Globba*, but the flower has a short stamen and large labellum more typical of the Zingibereae. The ovary itself is especially confusing and it is trilocular with axile placentation for much of its length (a Zingibereae characteristic), but near the top it changes to unilocular with parietal placentation (a Globbeae characteristic). Even more surprising are the results of recent DNA sequencing (not shown) of some white flowered species endemic to the sandstone plateau mountains of northern Thailand (e.g. *C. alba*). These species show no relationship to the yellow flowered species at all, and appear to be very closely related to the *Boesenbergia-Curcumorpha* group. These results are preliminary and are part of a larger study of *Boesenbergia*, *Curcumorpha*, and *Caulokaempferia* by Williams, Kress and Larsen (unpubl.).

The results of the study provide both a solid classification of the gingers based on evolutionary relationships as well as a red flag to problem areas within the family that need further study before the relationships can be fully understood. While the classification and relationships of certain large genera such as *Alpinia* and *Curcuma* will change with further study (using more species and regions of DNA), the four subfamilies presented here almost certainly will not be altered. *Siphonochilus* has very strong support as the first branch of the Zingiberaceae family tree and it is unlikely that one of the genera yet to be sequenced will prove to be older (although another African endemic, *Aulotandra*, may be equally old and belong to the same subfamily, Kress and Prince, unpubl.; Newman, pers. comm.). The Zingiberoideae and Alpinieae are very well demarcated subfamilies, both on a morphological and molecular level, and further sequencing is unlikely to change this. One probable result of further study within the Zingiberoideae is the division of the Zingibereae into two or more tribes. This was not done in our study as it was felt to be premature, since DNA support for the three main groups was weak. Sequencing of additional regions of DNA may clarify these relationships.

It is hoped that by sharing these results in the HSI Bulletin, members will see the different species and genera they grow as members of a larger family with differing relationships and affinities, not a static units equally distinct from one another. Also, this study demonstrates the dynamic nature of plant systematics. Just because a botanist classified a spe-

cies 200 years ago (or even two years ago) does not mean it is necessarily correct. Plant systematics has changed and will continue to change over time, but always with the goal of trying to understand the evolution and classification of plants as accurately as possible. Over the past two decades new methods of phylogenetic analysis and molecular systematic studies, such as the one presented here, have fundamentally changed our ability to study the evolution of plants. No longer do we have to simply guess at which morphological characters are important for classification, now we can look to the DNA of the organism itself to tell us the history of its evolution. This does not discount the importance of morphological characters; in fact, combining DNA data with studies of morphology is the most accurate way we have to properly classify organisms of all types, including the gingers.

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Hot Rio Nights in Hawaii

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Abstract

As part of a research study on growth and flower production of 20 commercial heliconia cultivars, plants were established at the Waimanalo Research Farm (Oahu) of the University of Hawaii in July 1999. This report focuses on a heliconia hybrid, 'Hot Rio Nights.' Five plants in 7.6 L pots were planted at spacings of 2.5 M in row, with between row spacings of 3 M. Beginning a month later, newly emerged shoots were tagged every four weeks. At flowering, the shoots were harvested and leaf counts made. The information derived from the data include time frame from shoot emergence to flower, rate of shoot production, percentage of shoots from each tag date that flowered and the periodicity of flowering in a two year period. The range of times from shoot emergence to harvest was 231 to 367 days. In the first 12 months following planting, the average cumulative new shoot production since planting was 60 shoots per plant. 'Hot Rio Nights' evidenced periodic flowering behavior that suggested it is a short-day plant for flower initiation.

Introduction

This research was undertaken as a part of a larger project funded by a USDA Special Grants Program for Tropical and Subtropical Agriculture (T-STAR agreement 98-34135-6783) to evaluate heliconia species for their adaptability, productivity, and suitability as cut flowers. 'Hot Rio Nights' is a purported hybrid of *Heliconia bihai* with either *H. caribaea* or *H. pendula* (Berry, 1995), or, as seems more likely (J. Kress, personal communication) between *H. caribaea* X *H. pendula* that was introduced by botanist Dimitri Sucrei from the gardens of Roberto Burle Marx (J. Abalo, personal communication). This cultivar was a very productive cultivar during the study period of 1999-2001. It is suitable for either cut flower or landscape use.

The specific objectives of this study were 1) to determine the rate of shoot and flower production, 2) to determine the time from shoot emergence to harvest of the inflorescence, and 3) to determine the effect of season on growth and development characteristics.

Materials and Methods

Five plants of the heliconia cultivar 'Hot Rio Nights' in 7.6 L pots were transplanted into a prepared field at the Waimanalo Research Farm (Oahu) of the University of Hawaii on 1 July 1999. The between-row spacing was 3 M and the in-row spacings were 2.5 M. A drip-emitter irrigation system was installed initially that provided 36L water/hr/plant, and irrigation was provided twice a week for 3 hours each time; the system was changed to a spray stake (24 L/hr twice a week for 3 hours each time) after 10 months as the clump diameters had increased beyond the range of the drip emitters. Beginning a month after planting, shoots that had emerged in the previous month were identified with color-coded tags representing the month of shoot emergence (SE). While every effort was made to tag every shoot, inevitably, some were missed; thus the percent of flowering shoots harvested exceeded 100 for some months. At flowering (harvest = H) the shoots were cut at

ground level and leaf counts were made.

From the data we derived information on the rate of flower and shoot production, percentage of shoots from each tagging date that flowered and the time from shoot emergence to harvest (SE→H). Data-recording operations were performed at 28-30 day intervals in the first year and at one and two week intervals in the second; thus the mean values for dates of harvest reflect the variation among shoots that emerged over a 30-day period.

Results

About three months after planting, SE began to increase from 2.6 new shoots per plant in September 1999 to 8.6 new shoots per plant in August 2000, but reflected an up and down pattern in alternate months during the year of observation. In the 13 months following planting, each plant produced more than 60 new shoots (Fig. 1) for a potential of more than 300 inflorescences from 5 plants. Figure 2 shows the number of shoots tagged and flowers produced from them. For some of the SE tagging dates, 100% of the shoots produced an inflorescence, and overall, 93.5% of all tagged shoots were harvested (Fig. 3). (Thefts of ready-to-harvest inflorescences from the experimental plots decreased the final yields and counts.)

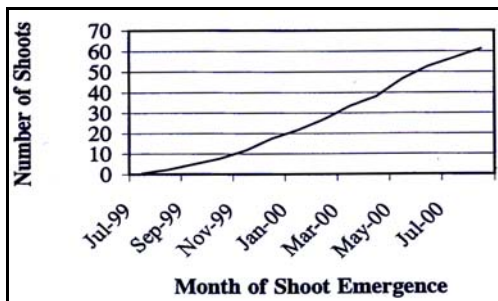


Figure 1. Pattern of cumulative shoot emergences from July 1999 through August 2000 for heliconia 'Hot Rio Nights.'

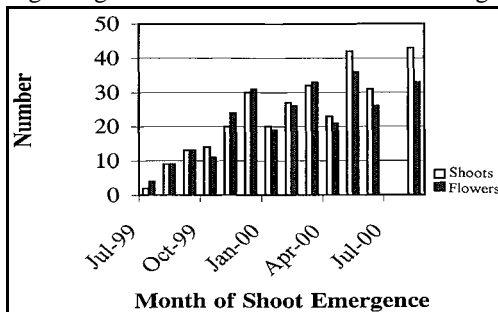


Figure 2. Relationship of inflorescences harvested per tagging date of newly emerged shoots of heliconia 'Hot Rio Nights.'

'Hot Rio Nights' had long periods in both 2000 and 2001 during which inflorescences could be harvested, but there were also periods with little or no flower production (Fig. 4). The days from SE→H varied with plant age as well as the time of year when shoots emerged (Fig. 5). In 2000, during a 50-day period for which 48 of 77 inflorescences were harvested, SE → H ranged from 231 to 252 days, but in 2001, over a 56 day period for which 199 tagged inflorescences (of 252) were harvested, the SE → H ranged from 244 to 343 days (Fig. 6). Since data were recorded at 30 or 14 day intervals, greater precision was not possible.

For the most part, every tagged shoot ultimately produced an inflorescence (Fig. 3), and little or no flower abortion was observed. Low yields often reflected the theft of flowers

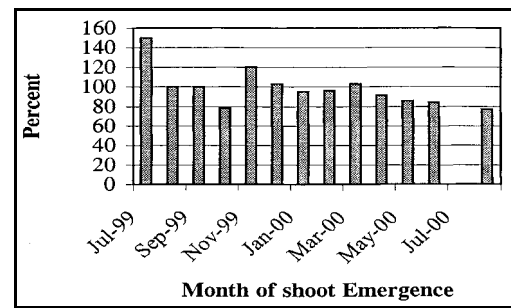


Figure 3. Flower yields as a percentage of monthly shoot emergences for heliconia 'Hot Rio Nights.'

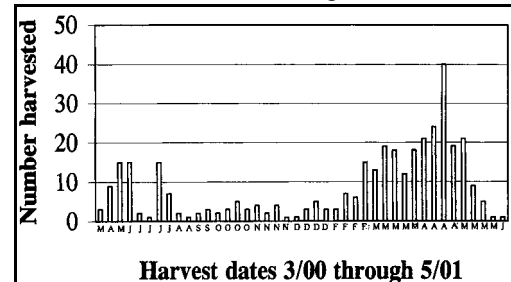


Figure 4. Flower yields of five plants of 'Hot Rio Nights' at each harvest in the period March 2000 through May 2001.

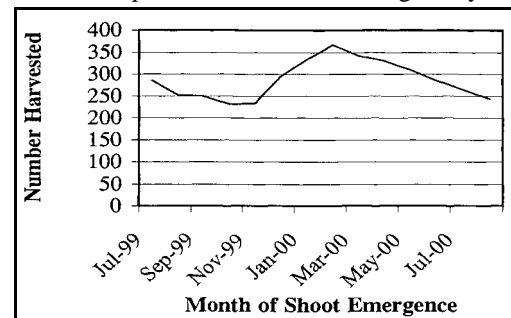


Figure 5. Mean number of days to harvest from shoot emergence based upon the month of shoot emergence for heliconia 'Hot Rio Nights.'

from the field before they could be harvested. Shoots produced during fall 1999 took fewer days to reach harvest than did shoots that emerged in winter 2000, while shoots that emerged during summer 2000 took longer to mature and flower (Fig. 7). The differences ranged from about 333 days for January shoots (24 flowers) to 231 days for October shoots (14 flowers) and 285 days for June shoots. Viewed from the date of harvest (Fig. 7), emergence to harvest periods increased from about 245 days for flowers harvested in April to June (97 flowers) to about 345 days for December-February flowers (57 flowers).

Leaf number subtending the inflorescence may be considered a measure of development rate as no new leaves are produced following inflorescence initiation. On young plants, shoots emerging in the first 3 months following planting produced, on average, 7.0 to 7.6 leaves before initiating an inflorescence. From that point, however, leaf count declined, and shoots emerging at the end of August, 2000 produced about 4 leaves before flowering (Fig. 8). Concurrent with this steady decline in leaf number subtending the inflorescence, days to flower showed a marked difference with season of shoot emergence. The longest periods for SE→H were for shoots emerging in December to February while the shortest periods were for shoots that emerged in the September to November period (Fig. 9).

An ornamental banana in Finland*

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Musa laterita E.E.Cheesman is a small banana with origins in North East India, Myanmar (Burma), and Northern Thailand. It belongs to the section *Rhodochlamys* in the genus *Musa*. The name is derived from the color of the bracts, which are rather like the brick-red tropical soil called laterite. In Finland it is a greenhouse or pot plant. The vegetative plant suckers freely. Unlike most bananas, the suckers are born at the end of long rhizomes. Fortunately, the plant is quite amenable to pot culture where the long rhizomes will not be apparent until the plant is repotted. The leaf blades are a bright green, robust and taper very gradually into the leaf stalk or petiole.

The plant flowers when it reaches a height of 1 to 1.5 meters, which takes an average of one year if the plant is started from a corm, and longer if started from seed. The inflo-



Fig. 1.

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Fig. 2.

rescence is upright and has brick-red bracts subtending yellow female flowers borne at the ends of little green bananas. (Figure 1.) The fruits become yellowish when ripe but are not edible, the flesh being insipid and full of small black seeds.

I have grown *Musa laterita* here in Kotka – Finland (latitude 60.5 degrees North) as a pot plant. In the summer 2000 I got a corm from France and planted it in a pot, using peat as a growing medium. Five months later, when the plant had grown 13 leaves and the pseudostem had reached a height of 85 centimeters, it started to flower. It produced 9 female flowers; of which I managed to hand pollinate the four upper flowers using the pollen from its own male flowers. When the first male flowers are opening in the morning the last female flowers can be pollinated if the time between openings is not longer than 48 hours. It must be noted that the plant is not normally self-pollinated like some others in the same section.

Three months after being pollinated, fruits were ripening, and I harvested from the four fruits 71 ripe and 10 unripe seeds. (Figure 2.) The ripe seeds are quite viable.

If we grow the plant from seed, we can expect to wait for 18 months before harvesting. On the other hand it is rather difficult to locate the seeds, as they are usually not available commercially.

Musa laterita is commonly sold in the United States under the commercial names *Musa ornata* 'Bronze' or *Musa ornata* 'Red Salmon'.



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