BULLETIN

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Hirano's Observations in the Genus *Hedychium* (circa 1997)

Robert Hirano
(Lyon Arboretum, retired)

The genus *Hedychium* was established by J. Koenig, based on the type specimen, *Hedychium coronarium*, the fragrant white ginger. The name *Hedychium* is derived from the Greek words "hedys", meaning sweet and "chion", meaning snow, perfectly describing the type species.

The genus comprises over 40 species mainly from central and southeast Asia, with the only exception from Madagascar, *H. pereqrinum*.

H. coronarium

Here in Hawaii the more common species are *H. coronarium* (white ginger), *H. flavescens* (yellow ginger), and *H. gardnerianum* (kahili ginger). Other lovely species occasionally seen are *H. thyrsiforme* (small curly white ginger), *H. coccineum* (orange/red ginger), *H. greenei* (red butterfly ginger), and *H. longicornutum* (an epiphytic ginger). In addition some early Hawaiian hybrids such as 'Annie Bishop' (light orange) and 'Waipio' (white with yellow center), and a few new ones like 'Kalihi Anne' (yellow with orange center) and 'Betty Ho' (orange/yellow with dark orange center) now adorn the local landscape.

Some general observations of the taxa used in this study should be noted:

Time of flower opening / Duration remaining open
H. flavescens opens at random, any time / one day
H. gardnerianum opens in morning / 2 days
H. coronarium opens about noon / 1 day
H. coccineum opens morning / 2 days
H. thyrsiforme opens morning / 2 days
'Waipio' opens about noon / 1-1 ½ days
'Anne Bishop' opens morning / 2 days
'Kahili Anne' opens morning / 2 days
'Betty Ho' opens morning / 2 days

H. flavescens

The inflorescence of these gingers generally fall into two distinct types. In one type, the flowering bracts are overlapped, forming a tight head like those of *H. coronarium* and *H. flavescens*, while the other type has flowering bracts that are separated and spread apart forming a loose head like those of *H. gardnerianum* and *H. coccineum*. This latter type is referred to as the kahili type because it looks very similar to the Hawaiian kahili (a staff with a head of flowers). Both *H. coronarium* and *H. flavescens* will open only one flower per bract at a time while *H.*

gardnerianum and *H. coccineum* both tend to open two flowers per bract simultaneously. Because of this fact, individual inflorescences of *H. coronarium* and *H. flavescens* have a longer flowering period when compared with those of *H. gardnerianum* and *H. coccineum*. These characteristics are useful in determining parentage of hybrids.

H. gardnerianum, Kahili ginger

Chromosome numbers published for some *Hedychium* species are: *H. flavescens* 2N=34, 50, 51; *H. coronarium* 2N=18, 34,51,52,54; *H. gardnerianum* 2N=34,54; *H. greenei* 2N=36; *H. coccineum* var. *angustifolium* 2N=52. Obviously with these kinds of numbers it is difficult to determine which counts are accurate. If we assume that the N number is 9, then we can account for 2N=18, 36 and 54. These numbers include *H. coronarium* and *H. gardnerianum* (both fertile species) and *H. greenei* which is not known to produce seeds but plantlets from the inflorescence. If this assumption is correct, then *H. flavescens* is probably an aneuploidy, and this appears to be the case.

In compatibility studies conducted at Lyon Arboretum using *H. flavescens* as a female parent, we found that it would not self nor cross with *H. coronarium, H. gardnerianum* and *H. coccineum*. As a male parent, it would only cross with *H. gardnerianum* and 'Kalihi Anne' but not with *H. coronarium* or *H. thyrsiforme*. These studies also showed that as a female parent, *H. coronarium* crossed with *H. gardnerianum*, *H. coccineum*, and 'Waipio' but not with *H. flavescens* and 'Betty Ho'. As a male parent *H. coronarium* crossed with *H. gardnerianum* and *H. coccineum* but not with *H. flavescens*. *H. gardnerianum* as a female parent crossed with *H. flavescens*, *H. coronarium*, *H. coccineum* and 'Waipio,' and as a male parent, crossed with *H. coronarium* but not with *H. flavescens* nor *H. thyrsiforme*. *H. coccineum* as a female parent crossed with *H. coronarium*, *H. gardnerianum* and *H. thyrsiforme* but would not self and as a male parent, crossed with *H. gardnerianum*. *H. thyrsiforme* as a female crossed with *H. coronarium*, *H. gardnerianum*, *H. greenei* and 'Kalihi Anne' but not with *H. flavescens*.

H. coccineum 'Tara'

The Purpose of HSI

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H. coccineum X *H. gardnerianum* 'Annie Bishop'

These studies confirm earlier observations of *H. flavescens* by Wright (1853), who states, "It seems very rarely to produce seeds. I do not recollect ever having seen its fruits." The Manual of Flowering Plants in Hawaii also states, "Capsules unknown." I, too, have never seen a single fruit on *H. flavescens,* and I have gone through hundreds of inflorescences on all of the major islands.

So what is the origin of *H. flavescens*? No one knows for sure but it probably arose from a cross between *H. coronarium* x *H. gardnerianum* or its reciprocal and subsequent backcrosses. This is one of the mysteries for which we have sought answers.

Seedling populations from this cross and its reciprocal are being observed and evaluated. In general, the population is quite variable especially in terms of inflorescence size, flower size and flower color. Flower color ranged from nearly pure white to varying shades of yellow and some yellow with darker centers. All of the inflorescences were similar to those of *H. gardnerianum* (Kahili type). With a few exceptions most flowering bracts had one flower opening a day unlike *H. gardnerianum* which normally opens two flowers at a time. Flowers lasted for two days, so at times two fresh flowers could be seen at a bract. These plants are all self sterile and would not sib cross. However we were successful in obtaining seedlings from the following crosses:

Female parent		Male parent
1. *H. coronarium*	×	(*H. coronarium* × *H. gardnerianum*)
2. (*H. coronarium* × *H. gardnerianum*)	×	*H. coronarium*
3. *H. gardnerianum*	×	(*H. coronarium* × *H. gardnerianum*)
4. *H. gardnerianum*	×	(*H. gardnerianum* × *H. coronarium*)
5. *H. gardnerianum*	×	(*H. gardnerianum* × *H. flavescens*)

Analysis of seedlings from these crosses should shed some light on the origin of *H. flavescens*.

Thus far these studies have only revealed the parentage of 'Annie Bishop' as *H. coccineum* × *H. gardnerianum*. Our F1 population of this cross gave a fairly uniform progeny of individuals with inflorescences and flowers very much like those of 'Annie Bishop.'

'Kalihi Anne,' with its large, fragrant yellow with dark orange center, has flowers that last for two days and open in the morning. Its inflorescence is similar to that of *H. coronarium*. Its origin is probably an F2 or more likely a selection from a cross between *H. gardnerianum* and *H. coronarium*, since as a female, *H. flavescens* will not self nor cross with *H. coronarium*, *H. gardnerianum* and *H. coccineum*, and as a male parent, it crossed with both *H. gardnerianum* and 'Kalihi Anne' but not with *H. coronarium*. It is a highly sterile cultivar.

Hedychium 'Betty Ho'

'Betty Ho' is a selection from the cross 'Kalihi Anne' x 'Annie Bishop'. Its flowers open in the morning and last for two days and its inflorescence is like *H. coronarium*. When compared with 'Kalihi Anne' , its flowers are a much darker yellow with a deeper orange center. It too is highly sterile.

Hedychium 'Dr. Moy'

The origin of 'Waipio' is still rather vague. Its flowers seem to last for 1 ½ days and open at noon, and it has an inflorescence like that of *H. coronarium*. It probably is from a cross between *H. coronarium* x *H. gardnerianum*, but it surely does not show its *H. gardnerianum* parentage. Further back crossing and selection may reveal more conclusive information.

Photographs courtesy of R. A. Criley

Hedychium species or hybrid at Lyon Arboretum

Costus zamoranus: An endemic species to Zamora-Chinchipe Province in Southeastern Ecuador

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Of all the species in the family Costaceae, *Costus zamoranus* is one of the least well known. The species was described by Julian Steyermark in 1963(1) from a specimen(2) he had collected twenty years earlier along the Río Valladolid, near "Tambo" Valladolid in what is now Zamora-Chinchipe Province in Ecuador. His description emphasized the separate basal flowering stems and he said it was related to two other basal flowering species, *Costus geothyrsus* and *Costus erythrocoryne*. He distinguished it from those two species only by the differences in the shapes of the leaves and bracts and differences in hairiness. There was no description of the true flowers because his specimen was not in flower.

In 1972 when Dr. Paul Maas published his monograph(3) on neo-tropical Costaceae, he clearly struggled with its placement in the monograph: "*The position of this species is rather uncertain as nothing is known of its floral structure. It seems closest to* C. amazonicus*, from which it can only be distinguished by its calyx.*" Then in 1977 Dr. Maas published an update to his monograph(4). Here he described the flowers of *C. zamoranus* based on a different collection in Morona-Santiago Province by Harling & Andersson(5). It was described as an open-labellum type, with a yellow corolla and reddish-brown labellum. The illustration in this monograph was based on that Harling-Andersson(5) collection. Here he said the species was closely related to *C. laevis*!

Nowhere could any photos of this species be found, and the written descriptions of the species were rather incomplete with the flower description based only on a second collection from the next province to the north, and which could not really be verified as being like the type from Valladolid which was so poorly described. The only way anyone would know for sure what this species truly looked like would be to go to the type location and search for it.

In 2014 a revised IUCN Red List assessment was completed, based on the scant information available, and this species was assessed as "Vulnerable"(6). In February 2015, the authors, accompanied by Marco Jiménez León's father Marco Jiménez Villalta, traveled to the south of Ecuador to the village of Valladolid to search for *C. zamoranus*.

Valladolid lies within the Mayo-Chinchipe River watershed, the main bi-national hydrographical system born in the southwest of Zamora-Chinchipe Province in Ecuador and extending to northeastern Peru, emptying into the Marañón River. In Ecuador it has an area of 3,148.26 km^2 and its main tributaries are Palanda, Numbala, El Vergel, Isimanchi and Sangola rivers. The river that emerges from the confluence of the rivers Palanda and El Vergel is called

Mayo and originates from the sources of Jíbaro River (tributary of Palanda River) in the Yacuri National Park. On the way near the border with Peru, Mayo is renamed as Chinchipe River(7).

In Ecuador, the Mayo-Chinchipe River basin politically corresponds to two cantons of the province of Zamora-Chinchipe, these cantons are Palanda and Chinchipe. The climate of these two cantons is different, Palanda in the north is more humid, therefore the rainfall (1900 mm per year)(8) is higher due to the abundance of primary forests; on the contrary Chinchipe is drier and has less rainfall (1153 mm per year) influenced by the strong impact of slash and burn on the vegetation that has formed an anthropic ecosystem(9). It was only in the more humid area to the north and in other parts of Zamora-Chinchipe that we found forest fragments with *C. zamoranus*.

Approximately a dozen plants were seen in flower in a small forest remnant at the type locality along the Río Valladolid, across the river from the village. The plants that were found there are about 2 to 2 1/2 meters tall, sheaths glabrous, with ligules slightly lobed 5 to 10 mm long and petioles to 20 mm long. The leaves are glabrous on both sides, narrowly elliptic in shape and cuneate at the base.

C. zamoranus, ligule and petiole

All the plants found at the type location have their inflorescences on separate leafless stems about 1/2 meter tall.

C. zamoranus, 2 forms at type locality

C. zamoranus, at type locality

The inflorescences are all ovoid in shape but the bract and flower colors are somewhat variable among the plants seen at this location.

Some plants have mostly green bracts, pinkish red only at the base, and flowers with creamy white corollas and dark red labellum wings. Other plants have mostly red bracts, green only at the apex, and flowers with pink corolla lobes and overall the flowers appear pink in color. The former has green flowering stems while the latter has darker, reddish colored flowering stems.

C. zamoranus, 2 forms at type locality

The bracts are about 55 mm long by 40 mm wide, bracteole 33 mm long, calyx 17 mm long, shallow lobed. The corolla lobes are 75 mm long, stamen 45 mm long, and labellum 11 cm long by 5 cm wide when spread flat. This makes for a very large, showy flower on the basal inflorescence.

The next specimens of *Costus zamoranus* we found were in isolated forest remnants along the road to the village of Tapala, just a few kilometers from Valladolid.

C. zamoranus, along road to Tapala

The third locality in this region where we found *C. zamoranus* is near the Río Numbala just east of the town of Palanda. The plants here have especially beautiful deep pink flowers.

The bracts of this plant at Río Numbala are somewhat smaller than at the type locality, about 50 mm long by 30 mm wide. The bracteole is about the same, 35 mm long, and the calyx the same, 16 mm long, shallow lobed.

The flowers and their parts, although differing in colors, are about the same size as at the type locality. The corolla lobes are 78 mm long, stamen 53 mm long, and labellum 11 cm long by 5 cm wide when spread.

C. zamoranus, along road to Tapala

The habitat of the type specimen of *C. zamoranus* is next to Valladolid River, a tributary of Palanda River. The climate of Valladolid is characterized by an average temperature of 17 °C and a relative humidity varying depending on altitude

C. zamoranus, along Río Numbala

C. zamoranus, along Río Numbala bract, bracteole and calyx

and sun exposure, between 65% and 85%. The bioclimatic region is linked to the atmosphere and soil where vegetation develops and is the temperate humid type (tropical humid mesothermal)(8,10).

The landform is of hilly piedmont type. The constant erosion of rocks by the Valladolid River and its streams has led to the formation of bare rocks and sandy sediments in the riverbanks. The soils are of inceptisol order with horizon B weak, which are found on steep slopes, young geomorphic surfaces, and on resistant parent materials. The landform slope is steep and hilly ranging from 25-50 °(10).

C. zamoranus, along Río Numbala
corolla, stamen, labellum

The geology of the area is characterized by having metamorphic rocks such as schist, quartzite and gneiss of Paleozoic age corresponding to the geological formation known as Zamora Group(10). In the Mayo-Chinchipe area, the *C. zamoranus* we found was only growing in the coarse, sandy soil that was formed from this geology.

Over the next two weeks, as we continued to search the northern parts of Zamora-Chinchipe for other specimens of this species, we also found many examples of the two most closely related species - *Costus amazonicus* and *Costus laevis*. There would be no doubt about this species' existence, well justified as a separate species from the other two.

Costus amazonicus is a species that flowers both terminally and at the base on a leafless or nearly leafless stem. It is distinguished from *C. zamoranus* by having fibrous margins to the bracts and a shorter calyx. The leaves are broad, slightly plicate, and densely hairy compared to the narrow, glabrous leaves of *C. zamoranus*.

Costus laevis is a widely variable species, but is only found with a terminal inflorescence. We saw several forms of that species in southeastern Ecuador, but none of them have any resemblance to *C. zamoranus* as we now know very clearly. The "Podocarpus" form is a real giant, waxy, glabrous, with a huge terminal inflorescence and flower. Other forms were found with varying colors and indumenta.

C. amazonicus, with fibrous bract margins

C. laevis, "Podocarpus" glabrous form

C. laevis, "Podocarpus" glabrous form
with co-author Marco Jiménez León and his father

All these plants were clearly distinguishable from the *C. zamoranus* we were seeking.

C. zamoranus was successfully found in a few shady forest remnants in the more humid northern part of the Mayo -Chinchipe valley, but we needed to learn more about the extent of its range. After leaving the Mayo-Chinchipe region, we searched in other parts of the province to learn more about the distribution, population, habitats and threats to this species.

One area we visited was the Río Nangaritza region of the geologically different Cordillera del Cóndor(11). This region has only recently been explored botanically and has been found to have a very high number of local endemics. Here we found some plants that fit best in the species *C. zamoranus*, but they are distinctively different in several ways.

The plants in the Río Nangaritza region have a distinctive red margin to the bracts and a bright red nectar callus, compared to the green nectar callus at the type locality in the Valladolid area. There is also an omnipresent dark detritus deposited on the bracts, apparently by the ants.

The ligules are very short and truncate, only 2 mm long but the petioles are similar in length and shape as at the type locality. All parts are glabrous as in the type.

The bracts of the plants at Río Nangaritza are smaller and rounder in shape than at the type locality, about 37 mm long by 38 mm wide. The bracteole is shorter, 25 mm long, and the calyx only 8 mm long, very shallow lobed.

C. laevis, yellow flowering pubescent form

C. zamoranus, Río Nangaritza region

The flowers and their parts are also slightly smaller and differing in colors from the plants at the type locality. The corolla lobes are yellow, 60 mm long, stamen 42 mm long, and labellum red, 8 cm long by 4 cm wide when spread.

C. zamoranus, Río Nangaritza region

With all these differences, one might conclude that this is a different species altogether, or at the very least could be described as a separate subspecies or formally described variety.

The plants found in Valladolid grow on coarse sandy soil but the Nangaritza form of *C. zamoranus* grows on sticky gray clay soil, which shows that the type of soil is linked to kind of plants found over it.

The area where *C. zamoranus* is found is known as cloud montane forest of the Eastern Andes. It is characterized by high abundance of mosses, orchids, ferns, bromeliads and the unmistakable presence of the aromatic-leaved shrub *Hedyosmum translucidum*. This type of forest is probably one with the greatest abundance and plant diversity in this region(10).

Because of its flowers and showy inflorescences, *C. zamoranus* could be grown in public and private gardens. The ornamental potential of *C. zamoranus* and other species of *Costus* is immense because of their showy flowers: usually large, and of different colors, shapes and sizes, very similar to the orchids.

In addition, the inflorescences form whimsical, unique structures for each species, composed of brightly colored bracts. The delicate floral structure of these plants is used to attract insects and hummingbirds.

It is known that most *Costus* are medicinal. The first author, through various interviews in rural communities of Latin America has found that the best known medicinal use is to treat kidney stones. The species used doesn't seem to matter, but is usually the more common one in the area, like *Costus scaber* or other species.

In the Caribbean Islands and Mexico, *Costus* is used to treat diabetes. In Ecuador, specifically in the Zamora-Chinchipe Province, the Shuar, Kichwa and mestizo peoples chew these plants or decoct them, sometimes mixed with others, to treat headaches, diabetes, urinary tract infections, bruises, influenza, hepatic pains, kidney problems, stomach aches, diarrhea and bloating(12,13). Because of its medicinal properties, several people of Valladolid and Palanda use *C. zamoranus* and *C.* aff. *claviger* and include them in the preparation of a typical infusion of various plants known as *horchata*.

In addition to the Mayo-Chinchipe region and the Río Nangaritza area, a few plants of *C. zamoranus* consistent with the type were found in other locations(14) in the more northern parts of Zamora-Chinchipe Province, but the species is really quite rare compared to other species of *Costus* in the province. Based on what we have learned from this trip, it is possible that the Red List status will be downgraded from Vulnerable to Endangered. The species has been found now to be quite sensitive to the habitat destruction that is ongoing in this part of Ecuador. It was only found in small forest remnants in the more humid parts of the province. It is not a high altitude plant, as it was found only in a range between 900 and 1600 meters. The type locality altitude was incorrectly reported at 2000 meters.

C. zamoranus, Río Nangaritza region

Thanks to this field investigation, we can now verify the status of *C. zamoranus* as a valid species, and we are here publishing the first known photos of the species, including the details of the forms found in Zamora-Chinchipe. It is hoped that further steps will be taken to conserve this rare species and to protect its habitat.

Heliconia tortuosa selects its pollinators

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A study recently published in the Proceedings of the National Academy of Sciences (PNAS) shows why one species of heliconia is difficult to hand pollinate, and the mechanism is surprising: the heliconia recognizes only two favorite pollinators. Six hummingbirds and at least one butterfly visit *H. tortuosa* while carrying a load of pollen, but only two bird species are able to successfully pollinate it.

Matthew Betts of Oregon State University was the lead investigator on a series of studies carried out in southern Costa Rica at Las Cruces Biological Station, home of Wilson Gardens. The researchers say that to their knowledge, these findings provide the first evidence of pollinator recognition in plants. It is well-known that many pollinators recognize and specialize in particular flowers, and that plants have evolved to attract specialized pollinators. But until now, no one had seen a plant pick and choose between its pollen-carrying visitors.

Betts and his colleague Adam Hadley initially wanted to know how forest fragmentation affects the degree of pollen limitation. That is, would natural pollinators travel across pasture from one patch of forest to another? They chose to study pollination of *Heliconia tortuosa* because it is the most common herbaceous plant in the study area's forest floor and that they observed ten different hummingbirds visiting the plant. *H. tortuosa* plays such an important role in the local ecological system that it is considered a “keystone” species, which is one that affects the survival and abundance of many other species in an ecosystem.

The researchers intended to hand pollinate a control group of heliconia flowers, then compare the results to hummingbird pollinated plants. They checked their pollination success using epifluorescence microscopy of the styles of the flowers to observe pollen tubes developing, the first step in reproduction. The formation of a pollen tube does not guarantee seed set, but it is a positive indicator.

To their surprise (though perhaps not so much to ours at HSI!) hand pollination was almost universally unsuccessful, while birds continued to pollinate other flowers. What was going on? Betts and Hadley, and now John Kress, went to work to solve the puzzle.

They identified two potential causes of low hand pollination success. One, the quality of pollen brought by hummingbirds could be higher, ie: it came from a longer distance, or it was more genetically mixed. Two, the plant might recognize the pollinator, distinguishing better pollen indirectly by its carrier.

To test for the cause, they used small aviaries placed over heliconia plants and artificially placed pollen in the flowers. They then introduced selected pollinators that had been carefully cleaned of any stray pollen. Because some flowers were successfully pollinated, they learned that the plant recognizes the pollinator, rather than the pollen, which was uniform in the experiment.

What's more, they observed that flowers were fertilized after visits by only two of the six species of hummingbirds (the hummers violet sabrewing [(VISA) and green hermit (GREH)], and one butterfly in the experiment. These species have especially long bills, and they use the trapline forage method, sometimes traveling kilometers in a day, rather than defending a limited territory as the other four birds in the study do.

This was a surprising finding, so next they wanted to know what cue the plant used to allow pollination. They came up with an hypothesis based on the proven concepts that 1) through evolution plants have developed ways to select for high-quality pollen, 2) pollen from more distant plants is higher quality because it provides more genetic diversity, and that 3) a pollinator traveling long distances should reap greater reward for its efforts. Therefore, they reasoned, the more nectar a visitor extracts from a flower should predict more successful fertilization.

The next experiment, then, was to place pollen and to extract nectar by hand. Success! The flower accepted the pollen offered by the scientists when its nectary was emptied, and the flower was artificially pollinated.

This arrangement is good for the two specialized hummingbirds because they are able to harvest almost all of the nectar from flowers of *H. tortuosa.* But it's a highly specialized method, and what's in it for the plant? *H. tortuosa* had to do something, because heliconias lack two common impediments to indiscriminate pollen reception: self-sterility and time-separated pollen production and stigma receptivity. *H. tortuosa* could gain additional benefits in three possible ways:

1) The researchers found that there is more successful pollination in plants visited by birds that travel longer distances.

2) The two birds that successfully pollinate *H. tortuosa* also carry more pollen than the unsuccessful visitors. Though only three grains of pollen are enough to ferti lize all the seeds in an ovary, it has been shown that more pollen options leads to higher seed weight.

3) Pollen carried by traplining hummingbirds comes from farther away, and is less likely to be from the same clump or closely related individuals, thus avoiding in breeding.

So what does a choosy *Heliconia tortuosa* mean in the big picture?

For one, it was thought that this species of heliconia was a generalist in terms of pollinators – more than six species

of birds and some insects visit it, all taking and leaving pollen. But this study shows that *H. tortuosa* is dependent on healthy populations and natural traplining movements of just two hummingbirds for successful fertilization. Previous work by the authors showed that *H. tortuosa* plants in forest fragments were less likely to produce seeds, indicating that the hummingbirds didn't visit plants in isolated forest patches as often. So, dependence on just two pollinators could make populations of *H. tortuosa* vulnerable to environmental changes.

Second, because the heliconia works together with just two pollinators, rather than the seven visitors in the study, there is greater potential for rapid coevolutionary changes in *H. tortuosa* with violet sabrewings and green hermits.

Dr. Matt Betts answered a few additional questions for HSI.

Q: *What was the hand pollination success rate?*

A: You can see in Fig. 2c that our success rate was ~1 pollen tube per style with nectar extraction and <0.25/ style with just hand pollination. This means that we haven't become as efficient as the most specialized bird species. At the moment, our obstacle is figuring out a way to extract nectar without damaging the flower (which seems to eliminate the chance the plant will turn on).

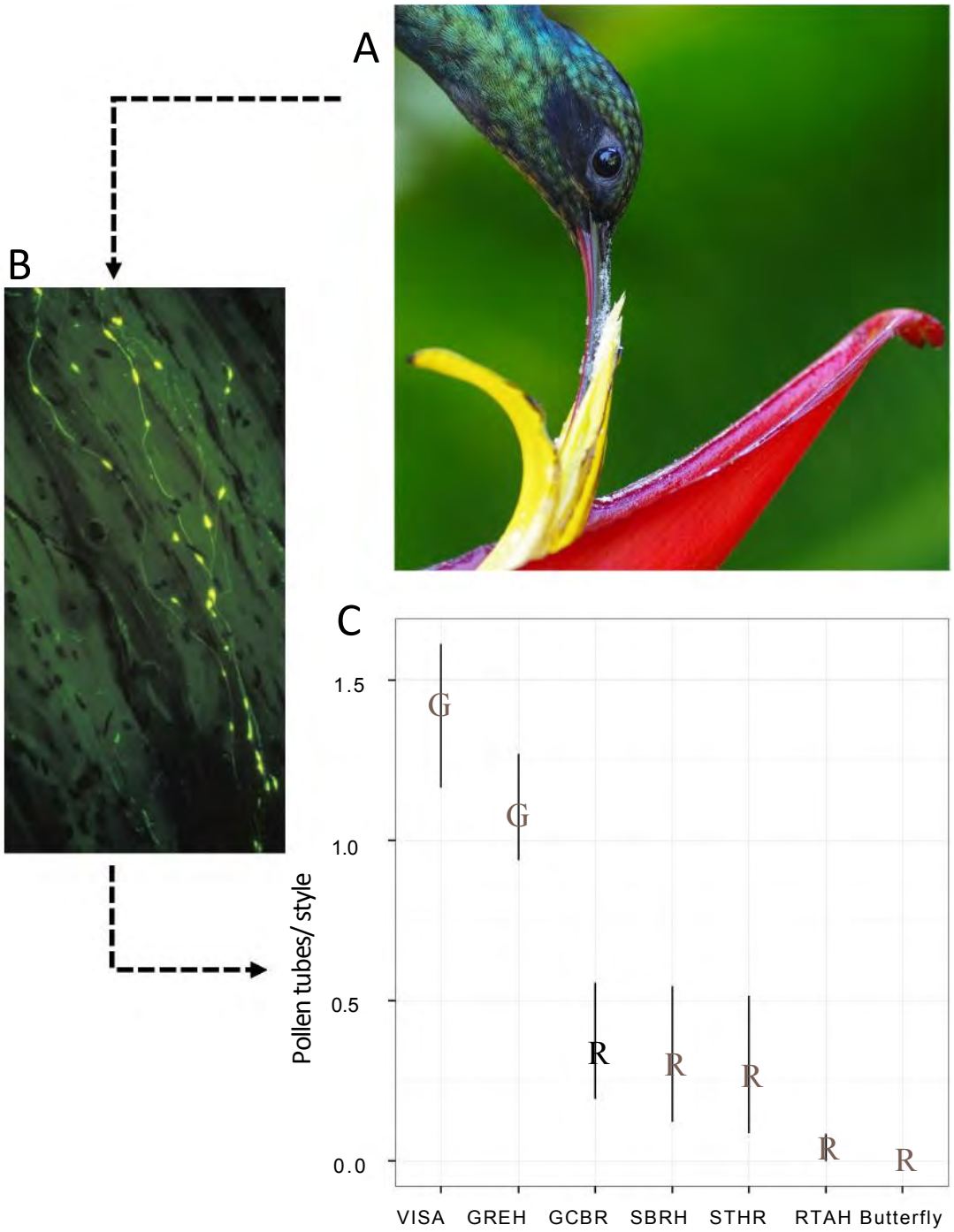

Fig 1. Results of aviary experiments, where flowers were visited by pollen-free pollinators after being hand-pollinated under controlled conditions. (A) A bract of *H.tortuosa* with-male green hermit hummingbird. (B) Pollen tubes, the first step in reproduction, viewed in the style of *H. tortuosa* using epifluorescence microscopy. (C) Experimental addition of hummingbirds strongly influenced the abundance of pollen tubes, but this effect was species-dependent. Means and SEs are shown. *P* values for contrasts are reported in Table 1. Green represents those species stimulating pollen tube growth, and red indicates less-effective species. Butterfly, *A. fatima*; GCBR, green-crowned brilliant; GREH,green hermit (*Phaethornis guy*); RTAH, rufous-tailed hummingbird; SBRH, scaly-breasted hummingbird; STHR,stripe-throated hermit (*Phaethornis striigularis*); VISA, violet sabrewing.

Q: *Are there any ideas about how the flower senses that the nectar is removed?*

A: No, but this is the next step in the research. We are working with geneticists to search for the gene that turns on when the nectar is extracted. We are looking for a plant physiologist who will look for the hormone signals involved.

(Continued on page 13)

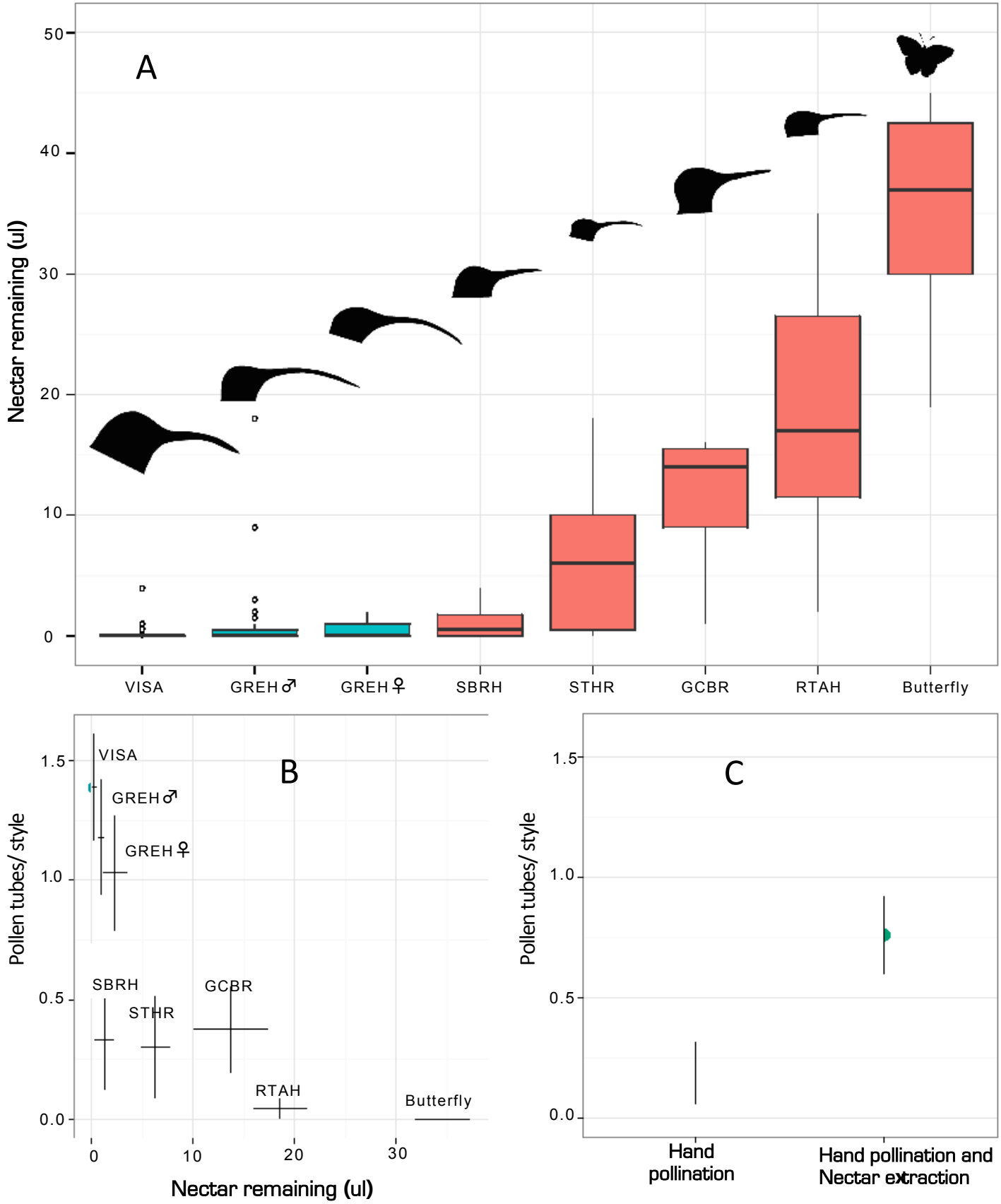

Fig.2. (A) Boxplot showing how nectar extraction efficiency in *H. tortuosa* varies across pollinator species. Boxes show first and third quartiles of data. The bill shapes/sizes of the species are to scale in relative terms. Green represents successful pollen tube growth, and red represents limited growth. (B) Relationship between nectar remaining after pollinator visitation and the number of pollen tubes per style for each species (species abbreviations are the same as in Fig.1). Nectar extraction capacity of hummingbirds strongly influenced the abundance of pollen tubes (r = -0.73). (C) Effect of hand pollination only vs. hand pollination combined with nectar extraction on pollen tube abundance. Pollen tubes were 3.5 times more common when nectar was experimentally extracted than when flowers were hand-pollinated only. Error bars in B and C are +/- SE.

Finally, you might mention that we have plans to set up a 'citizen science' project where we provide people with the tools to do hand pollinations and nectar extractions on different species of heliconia. I am curious how receptive members of HSI might be to that.

(I assured Dr. Betts that at HSI we are very interested in hand pollination, and that we would help him contact you, our members, via email when the project is ready.)

My thanks to Dr. Betts for his additional help with this article.

HSI thanks the Proceedings of the National Academy of Sciences (PNAS) for permission to reprint figures from:
Pollinator recognition by a keystone tropical plant
Matthew G. Betts[a], Adam S. Hadley[a], and W. John Kress[b] (2015)
a Department of Forest Ecosystems and Society, Oregon State University, Corvallis, OR 97331
b Department of Botany, National Museum of Natural History, Smithsonian Institution, Washington, DC 20013-7012
Proceedings National Academy of Science

Read the full paper at:
http://www.pnas.org/content/early/2015/02/26/1419522112.full.pdf

Video of hummingbird visiting *H. tortuosa*:
http://movie-usa.glencoesoftware.com/video/10.1073/pnas.1419522112/video-1

Heliconia tortuosa

Heliconia tortuosa

Heliconia tortuosa

HSI Awards For Botanical And Horticultural Research Projects on the Zingiberales

The Heliconia Society International sponsors a small grants program supporting research projects on any aspects of the botany and horticulture of the Zingiberales conducted by undergraduate, graduate and post-doctoral students enrolled at recognized universities and research institutions. Annual grants up to $1,000 are available. A student or postdoc can receive a single grant in a three year period. Proposals may be submitted at any time and will be reviewed periodically by the Society's Grants Committee.

Applicants should submit their information as indicated below and anticipate a response in 2-4 days. Applicants (Continued on page 15)

Heliconia Society International XIX International Conference Ubatuba, Brazil, November 2016

Organising committee:
Dr. Carlos Castro ccastro@iac.sp.gov.br (president)
Dra. Ana Cecilia Ribeiro de Castro
cecilia@cnpat.embrapa.br
Dr. Charleston Gonçalves charleston@iac.sp.gov.br
Dra. Vivian Loges vloges@yahoo.com

XIX HSI Conference and Tours: São Paulo (Ubatuba, Holambra, Campinas) and Amazonia

CONFERENCE

The HSI Ubatuba conference will be held in November 2016. We are trading with Hotel Itamambuca, a resort next to the beach on the Atlantic Ocean, near São Paulo City, Brazil. It will be organized by Dr. Carlos Castro, a well know researcher of tropical flowers. The final banquet dinner will be in an amazing setting and will include the auction. Don't forget to bring special things from your country!

This hotel is near Ubatuba, the last *city* on the north coast of Sao Paulo and one of the few places that still manages to preserve its nature.

During the conference we will visit the Agronomic Institute (IAC) Heliconias and other tropicals collection under the responsibility of Carlos Castro and Charleston Gonçalves. We also will enjoy a field trip to commercial

PRE-CONFERENCE TOURS

We have approximately 5,000 cut flower farms in Brazil, with an average size of 2 hectares. The industry provides about 90,000 direct jobs and has an estimated value of $300 million per year.

About 75% of Brazilian floriculture industry is located in Sao Paulo state, mainly in Holambra and surrounding areas. http://turismoholambra.com.br/

We will visit the farm of HSI member Christian Dierberger at Limeira (http://www.dierbergertropicais. com.br/) and will see landscaping with natural flora in the Atlantic forest climate in our way to Ubatuba.

POST-CONFERENCE TOURS

For the post-conference tour we will arrange an exciting 4 days packed with visits to producers and the natural flora in the Amazon forest.

In Manaus we will visit the Botanical Garden and will also take a comfortable boat on an Amazon river cruise.

Start planning now! There are three great opportunities for conference attendees: the Pre-conference tour in São Paulo State; the Conference itself in Ubatuba, Litoral of Sao Paulo; and a Post-conference tour in Amazon River. The Bulletin 21(4) will have all the pricing details for the conference and the pre- and post-tours. All the activities and meals will be included in the registration.

CALL FOR PAPERS

Persons wishing to present papers or posters at the 19th Heliconia Society International Conference in Ubatuba, Brazil should submit their topic to the Organizing Committee at admin@heliconia.org as soon as possible. Your submission should include an abstract of at least 100 words and be delivered by 30 June 2016.

Topics should relate to any of the eight families of the order Zingiberales and can include systematics, floriculture, propagation, breeding, plant pathology, travel and exploration, art, ethnobotany, ecology or any other pertinent area of research.

Presentations are to be in English and should be 20 to 30 minutes long. A PowerPoint projector and computer will be available during the conference. Printed handouts will be the responsibility of the speaker.

Following the conference, a manuscript suitable for publication in the HSI Bulletin will be greatly appreciated.

HSI Awards (Continued from page 13)
will be informed of the Committee's decision regarding their proposals 1-3 months after submission. In addition to the requested funds not to exceed $1,000 (US), awardees will receive one year's free membership to the HSI, and a summary of their research proposal will be published in the HSI Bulletin.

Successful applicants must submit a final report within 12 months of receiving funding that describes the results of the project and includes a brief accounting of the funds spent. Awardees are also required to submit an article for publication in the HSI Bulletin upon conclusion of their research.

TO APPLY: please submit via email the following 4 documents, attached as a single PDF. The completed documents should be sent to *cdspecht@berkeley.edu*

(1) Description of the proposed research emphasizing the research questions to be answered and detailing any methods associated with data collection and analysis. The text should not exceed two single-spaced typed pages (excluding Budget and C.V.) and should include Background and Justification, Objectives, Materials and Methods, and Anticipated Results;

(2) An itemized budget with justification for the requested expenses. Please mention availability of existing funds, facilities and equipment that will facilitate the research. The budget should not exceed $1,000(US) but can be for less.

(3) Curriculum Vitae;

(4) A statement of eligibility from research supervisor or graduate department, indicating student or postdoctoral status.

Please contact Dr. Chelsea Specht (cdspecht@berkeley.edu) if you have any questions concerning application materials or criteria for funding.

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Advertisement

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I would like you to look for fresh seeds of *Heliconia subulata* 'Cock of the Rock' from September to December, to send to me, please. The seeds of *Heliconia subulata* 'Cock of the Rock' are ripe in September, October, November, and December, in Cusco, Peru. This cultivar had never been in cultivation before and needs new overseas homes as insurance against extinction. Please contact me before sending me the seeds at:
subtropicalslorikeet@hotmail.com
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