

Unraveling *Clinostigma* in Samoa

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Field work has revealed that Samoa is home to three species of *Clinostigma*, the handsome, highly ornamental, quintessential palms of the South and West Pacific. Two species, *C. samoense* and *C. warburgii*, occur on 'Upolu while the third one, *C. savaiiense*, is found on Savai'i.

Samoa includes nine inhabited islands and two political regions in the Pacific Ocean between 13 to 15° south and 168 to 173° west, about 4200 kms south of Hawaii, 2200 kms west of Tahiti, and 2900 kms northeast of New Zealand. The two largest islands, Savai'i and 'Upolu, comprise the independent state of Samoa (formerly Western Samoa) while Tutuila and several smaller islands in the eastern part of the archipelago comprise the U. S. territory of American Samoa. Polynesians settled and inhabit the islands and enjoy a year-round, wet, tropical climate. Centuries of human activity and a series of strong tropical cyclones in the last 20 years devastated much of Samoa's fragile forests. Undisturbed, closed-canopy primary forest is uncommon while highly disturbed and altered primary and secondary forests, typically with many exotic, invasive weed species, predominate.

Six genera of palms are recorded for Samoa: *Balaka* (2–4 species); *Clinostigma* (3 species); *Cocos nucifera* (coconut); the mysterious and enigmatic *Drymophloeus whitmeeanus*; *Metroxylon* (1 or 2 species); and the rather shy *Solfia samoensis*. All genera and species occur in Samoa while only the coconut occurs in American Samoa (*Clinostigma* and *Metroxylon* have been recorded from Tutuila although it is thought that they are cultivated and were brought from Samoa).

The focus of this paper is on *Clinostigma*, which includes about 11 or so species native in a

great, sweeping arc from the Ogasawara and Caroline Islands in the west Pacific Ocean to New Ireland, Solomon Islands, Vanuatu, Fiji, and Samoa in the south Pacific. While unusual, this vast, insular distribution is not unique among the palms. The coconut, *Heterospatha*, *Metroxylon*, and *Pritchardia*, among others, have a similar distribution. *Clinostigma* are highly ornamental and typically have a handsome, smooth, waxy-white, ringed trunk topped with a conspicuous, lime-green crownshaft and splendid crown of spreading leaves with elegantly pendulous pinnae.

Samoa *Clinostigma* differ from other members of the genus on nearby island groups, such as *C. exorrhizum* (Fiji) and *C. harlandii* (Vanuatu), in the lack of prominent stilt roots at the base of the trunk and black rather than red fruits.

In Samoa *Clinostigma* has had a long and somewhat tortured and complex taxonomic history comprising up to six taxa and eight names. In December 1978 I visited Samoa and made four collections of seeds of *Clinostigma* from 'Upolu, two each of what I called *C. samoense* and *C. onchorhynchum*, and distributed them to several botanical gardens in Hawaii and palm growers in Hawaii, California and Florida. At the time, I based these species determinations entirely on fruit shape and size and position of the stigmatic remains because the most current information in the literature at that time (Moore and Fosberg 1956, Moore 1969) and personal

communication with the late Dr. Harold E. Moore, Jr. suggested that these were the most important and reliable characters for distinguishing species of *Clinostigma*.

Near sea level along the northern and southern coasts of 'Upolu I made collections in two localities where the fruits were rounded, 7–10 mm diam., and with the stigmatic remains about midway between the top and bottom. I referred to these two collections as *Clinostigma samoense*. In the central highlands of 'Upolu I made collections in two localities where the fruits were markedly longer than broad, 15–18 mm long, and with the stigmatic remains near the top. I referred to these two collections as *C. onchorhynchum*.

At least one each of my *Clinostigma onchorhynchum* and *C. samoense* collections from 'Upolu have been flowering and fruiting for several years at Ho'omaluhia Botanical Garden of the Honolulu Botanical Gardens system in Hawaii. While visiting Ho'omaluhia in 2004, I examined these collections carefully and was able to distinguish the two taxa based solely on fruit size and shape, as I had done more than 25 years earlier on 'Upolu in Samoa. However, I was surprised to notice that the branching pattern or architecture of the inflorescences of the two taxa was markedly different as well, a character to which I and others had given little, if any, attention. The *C. onchorhynchum*, with larger fruits longer than broad, had broom-like inflorescences branched to two orders and thick, coarse, narrowly diverging rachillae. The *C. samoense*, with smaller, rounded fruits, had diffuse inflorescences branched to three orders and slender, widely spreading rachillae.

My surprise at the differences in inflorescence architecture between what I and others had referred to as *Clinostigma samoense* and *C. onchorhynchum* was due in part to the fact that Cox and Moore (1986) had thoroughly discounted fruit shape and size as reliable characters for distinguishing these two species. Indeed, in their paper, they relegated *C. onchorhynchum* to a synonym of *C. samoense*, a fact to which I was aware during visits to Hawaii in 1998 and 2000. At those times I informed the staff at Ho'omaluhia Botanic Garden about this nomenclatural change and, based on my recommendation, they adjusted the labels accordingly.

The rather dramatic differences in inflorescence architecture I had noticed between the two taxa in 2004 at Ho'omaluhia

Botanical Garden, and a subsequent visit in 2005, though, prompted me to investigate further *Clinostigma* on 'Upolu. Based on inflorescence architecture alone, there are clearly at least two taxa, but the appropriate application of names to these taxa remained elusive.

In October 2005 I again visited Samoa and other islands in the southwestern Pacific to gather information and take photographs as part of a project I am leading that will result in a publication on the palms of Pacific Islands. This paper summarizes the findings about *Clinostigma* in Samoa from that trip as well as information gleaned from the cultivated plants in Hawaii that were grown from seeds I collected in Samoa in 1978, examination of specimens in several herbaria, and a review of the literature.

History of *Clinostigma* in Samoa

The tortured and complex taxonomic and nomenclatural history of *Clinostigma* in Samoa begins and is centered on the island of 'Upolu (Table 1). Hermann Wendland (1862) established *Clinostigma* when he named and described *C. samoense* from material that Pickering (*Pickering s. n.*) had collected on 'Upolu during the United States South Pacific Exploring Expedition of 1833–1842. Asa Gray of Harvard University, who was preparing the botanical account of the Expedition, had forwarded Pickering's material to Wendland, one of the leading palm botanists of the time.

According to Christophersen (1935) and Moore and Fosberg (1956), Wendland had commented that the material upon which he based the new genus and species was incomplete and contained fragments from Savai'i. Wendland's specimen consisted of part of a leaf, one of the main branches of an inflorescence with fertilized pistillate flowers, and the tips of some rachillae with immature fruits, the latter labeled "Savai'i" and with the stigmatic remains midway between the base and apex (Christophersen 1935). Although Wendland's material was incomplete and perhaps mixed, Moore and Fosberg (1956) felt that "the major part of the description corresponds with what appears to be a duplicate specimen at the Gray Herbarium" (GH).

The specimen at GH consists of part of a leaf, a branch of the inflorescence, and loose immature and rounded, nearly mature fruits, all labeled as being from 'Upolu and annotated

Table 1. Summary of names of *Clinostigma* in Western Samoa and their status, 1862 to 2006.

Name	Status	Author & Date	Collection cited	Location
<i>Clinostigma samoense</i>	new species syn. of <i>Cyphokentia samoensis</i> as <i>Clinostigma onchorhynchum</i>	Wendland (1862) Rechinger (1907, 1910) Langlois (1976); Whistler (1992)	<i>Pickering s. n.</i>	'Upolu
<i>Cyphokentia samoensis</i>	new name (combination) based on <i>Clinostigma samoense</i> syn. of <i>Clinostigma samoense</i> syn. of <i>Clinostigma onchorhynchum</i>	Warburg (1898)		
<i>Clinostigma warburgii</i>	new species as <i>Clinostigma samoense</i> syn. of <i>Clinostigma samoense</i> as <i>Clinostigma</i> sp. "Eastern 'Upolu"	Beccari (1910) Burret (1928) Beccari (1934) Langlois (1976); Whistler (1992) Whistler (1992); Hodel (1999) Hodel (2006)	<i>Reinecke 322</i>	Lake Lanoto'o, Upolu
<i>Clinostigma onchorhynchum</i>	new species syn. of <i>Clinostigma samoense</i>	Beccari (1913) Cox and Moore (1986); Hodel (2006)	<i>Whitmee s. n.</i>	Lake Lanoto'o, Upolu
<i>Clinostigma powellianum</i>	new species synonym of <i>Clinostigma samoense</i>	Beccari (1913) Martelli (1935); Whistler (1992); Hodel (2006)	<i>Powell 246</i>	Western Samoa (no locality cited)
<i>Clinostigma savaiiense</i>	new species	Christophersen (1935)	<i>Christophersen 2267</i>	Matavanu, Savai'i
<i>Exorrhiza vaupelii</i>	new species	Burret (1935)	<i>Vaupel ???</i>	Maugaloo, Savai'i
<i>Clinostigma vaupelii</i>	new name (combination) based on <i>Exorrhiza vaupelii</i> synonym of <i>Clinostigma savaiiense</i>	Burret (1935) Whistler (1992); Hodel (1999, 2006)		



1. Holotype of *Clinostigma samoense* (GH).

with an unpublished name in Wendland's handwriting (Moore and Fosberg 1956). The name "Savai'i" does not appear on the

specimen. The inflorescence is distinctive in its broom-like appearance with thick, coarse, narrowly diverging rachillae (Fig. 1).

Over 35 years later, Warburg (1898) examined material that Reinecke (*Reinecke 322*) had collected at Lake Lanoto'o in the central highlands of 'Upolu in 1894. Warburg compared it to Wendland's *Clinostigma samoense*, and, while he stated that *Reinecke 322* was probably referable to *C. samoense*, he also enumerated several differences between the two. Warburg then apparently proposed the new name *Cyphokentia samoensis* although his intentions are far from clear.

His actions raise these questions: Had he decided that *Cyphokentia samoensis*, based on *Reinecke 322*, was distinct from *Clinostigma samoense* and, thus he was naming a new species; or, had he decided that *Clinostigma* was an incorrect genus for this species and,

thus, he was transferring it to *Cyphokentia* and proposing the new combination?

One might argue that Warburg was, indeed, naming a new species because he cited "*n. 322*," obviously referring to *Reinecke 322*, and enumerated several differences between the two. If so, then two different types are involved and *Cyphokentia samoensis* must be a new species name, not a combination, and the names are considered heterotypic (based on different types). It is unfortunate, though, that Warburg chose the epithet "*samoensis*" for *Reinecke 322* because it offers only confusion, not clarity, to the situation.

However, I feel that *Cyphokentia samoensis* must be regarded as a new combination, based

2. Holotype of *Clinostigma onchorhynchum* (K).



on *Clinostigma samoense*, rather than a new species because Warburg used the epithet “*samoensis*” and he did not use the abbreviation “*n. sp.*” (new species) after the new name or provide a Latin description, as he did for other, obviously new species he named in the same article. Because he was not naming a new species, he was not designating a type when he referred to *Reinecke 322*; thus, the names *Cyphokentia samoensis* and *Clinostigma samoense* must be considered homotypic (based on the same type).

Regardless, Warburg’s illustration of inflorescences and a branch of the inflorescence with narrowly diverging rachillae appear broom-like and somewhat similar to that of *Clinostigma samoense* but the rachillae are much more slender. (We shall see later that a duplicate of *Reinecke 322* discovered at the Bishop Museum, Honolulu, Hawaii (BISH) has slender rachillae like that in the illustration, but they differ dramatically in their spreading nature.) Fruits of *Reinecke 322*, as depicted in Warburg’s description and illustration, are immature with the stigmatic remains near the apex.

Several years later, Rechinger (1907, 1910) listed *Cyphokentia samoensis* from ‘Upolu and cited two of his collections from higher elevations in the central part of the island, including Lake Lanoto’o, and noted it also occurred on Savai’i. Rechinger stated that *Clinostigma samoense* was probably a synonym of *Cyphokentia samoensis*.

Shortly thereafter Beccari (1910), after examining the sparse material composing *Reinecke 322* at Breslau, took the opposite position and listed *Cyphokentia samoensis* as a synonym of *Clinostigma samoense*, indicating that he thought the two were heterotypic and Warburg was naming a new species in 1898.

Three years later Beccari (1913) named and described two species of *Clinostigma* from Samoa, both with apparently mature fruits, the first known for the genus. One, *C. onchorhynchum* (*C. “onchorhyncha”*), was based on material Whitmee (*Whitmee s. n.*) had collected at Lake Lanoto’o on ‘Upolu in 1875. Beccari noted it had broom-like inflorescences (he used the term “*scopaeformis*”) branched to two orders. While Whitmee’s sparse, incomplete type at Kew (K) does not show the broom-like architecture, the rachillae are thick, coarse, and narrowly diverging (Fig. 2) and are rather similar to those of *C. samoense*. Fruits of

the type, similar to those of *C. samoense*, are mostly rounded with the stigmatic remains midway between the base and apex or toward the apex. Strangely, Beccari’s illustration in the literature clearly shows the fruits to be longer than broad with the stigmatic remains very near the apex.

Beccari’s other new species, *Clinostigma powellianum* (*C. “powelliana”*), was based on material without a specific locality in Samoa that Powell (*Powell 246*) had collected. Beccari noted it had more spreading inflorescences (he used the term “*diffuses*”) branched to two orders and nearly rounded fruits. Examination of Powell’s type material at K, though, shows the thick, coarse rachillae to be narrowly diverging and scarcely different from those of *C. samoense* and *C. onchorhynchum* (Fig. 3). Fruits, very similar to those of *C. onchorhynchum* and even *C. samoense*, are mostly rounded with the stigmatic remains near the apex.

Some years later, Burret (1928), after examining Rechinger’s collections from Lake Lanoto’o, concluded that *Cyphokentia samoensis* was best placed with *Clinostigma onchorhynchum*, not *C. samoense*, as earlier workers had suggested or concluded.

Later, Beccari had apparently become skeptical about listing *Cyphokentia samoensis* as a synonym of *Clinostigma samoense*. In a posthumously published paper that Martelli prepared after Beccari’s death in 1920, Beccari (Martelli 1934) reversed himself and resurrected *Cyphokentia samoensis* from synonymy with *Clinostigma samoense* and renamed it *Clinostigma warburgii* (the epithet *samoense* already being taken by Wendland), stating it differed sufficiently in the nature of the fibers of the fruit mesocarp.

Obviously, Beccari’s interpretation of Warburg’s intentions when he named *Cyphokentia samoensis* over 35 years earlier differs from mine. Although he provided a Latin description, Beccari used the abbreviation “*n. nov.*” (new name), indicating he was not naming a new species but simply proposing a new name for Warburg’s existing species. Thus, Beccari clearly regarded *Cyphokentia samoensis* and *Clinostigma samoense* as heterotypic, believing when Warburg named *Cyphokentia samoensis* he did so as a new species rather than a new combination. Also, there was no need for Beccari to designate a type formally because a “*n. nov.*” is typified by the name it



4. Isotype of
Clinostigma warburgii
(BISH).

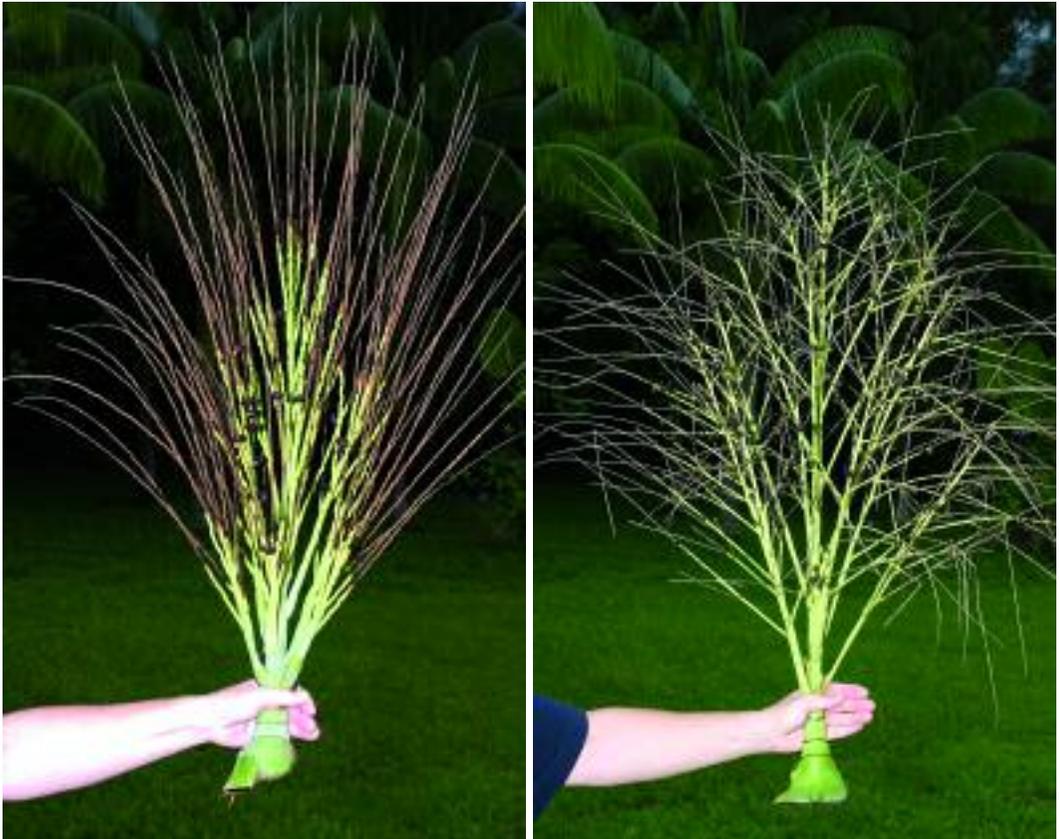
replaces, which in this case is *Cyphokentia samoensis*; thus, under Beccari's interpretation, the type for *Clinostigma warburgii* is automatically *Reinecke 322*.

However, some might contend, as I do, that, if Warburg (1898) were not naming a new species but simply making a new combination when he proposed the new name *Cyphokentia samoensis*, then Beccari would have been obliged to name *Clinostigma warburgii* as a new species and state "*n. sp.*," rather than "*n. nom.*" as he had done, and designate a type, because there would have been no existing species and type upon which Beccari could have based his new "*n. nom.*"

Although I feel that Beccari erred, his misinterpretation of Warburg's intent is a

relatively minor point because he had clearly come to the correct and appropriate decision that *Reinecke 322* was distinct from Wendland's *Clinostigma samoense*. Whether Beccari employed the terms "*n. nov.*" or "*n. sp.*" in formalizing his position is a minor, irrelevant detail, especially because rules governing such protocol were lacking and unclear at that time. What is important is Beccari's intent, which is clear, and it should render moot whether Warburg was naming a new species or simply making a new combination when he proposed *Cyphokentia samoensis*.

Martelli (1935), in a listing of palm genera and species, followed Beccari and continued to recognize *Clinostigma warburgii* but placed *C. powellianum* as a synonym of *C. samoense*.



5 (left). *Clinostigma samoense* has broom-like inflorescences branched to two orders with thick, coarse, narrowly diverging rachillae, Ho'omaluhia Botanical Garden (HBG 78.0891) ex Tiavi, 'Upolu, Samoa (Hodel 469). 6 (right). *Clinostigma warburgii* has "bushy" inflorescences branched to three orders with slender, widely spreading rachillae, Ho'omaluhia Botanical Garden (HBG 78.0889) (Hodel 2008) ex Salelesi, 'Upolu, Samoa (Hodel 462).

Christophersen (1935) named and described the first *Clinostigma* from Savai'i, *C. savaiiense*, based on material he had collected (*Christophersen & Hume 2267*) above Matavanu Crater. Nearly simultaneously, Burret (1935a) named and described another species from Savai'i, *Exorrhiza vaupelii*, from material that Vaupel had collected near Maugaloo ("Mangaloo"), and almost immediately suggested transferring it to *Clinostigma* (Burret 1935b).

Although the naming of new species of *Clinostigma* from Samoa ceased after 1935, subsequent workers continued to interpret and reinterpret these earlier works and meager collections. Despite the fact that many of the earlier collections had immature fruits, later workers placed much emphasis on fruit size and shape and the position of the stigmatic remains, either in the middle or towards the top of the fruit, in distinguishing species. Little or no significance was given to inflorescence architecture.

For example, Christophersen (1935) felt that Pickering's and Reinecke's material had differences at least of specific value because the fruits, while immature in both cases, were different, rounded in Pickering's and somewhat oblong in Reinecke's. Moore and Fosberg (1956) and Moore (1969) stated that *Clinostigma onchorhynchum* and *C. savaiiense*, with fruits having apical stigmatic remains, differed at a specific level from *C. samoense*, with fruits having stigmatic remains midway between the base and apex.

In contrast, Cox and Moore (1986) lost favor with fruit size and shape as reliable, distinguishing characters and, after examining collections with immature fruits from several localities on 'Upolu, relegated *Clinostigma onchorhynchum* to synonymy with *C. samoense*. Unfortunately, they did not address the disposition of any other names of Samoan *Clinostigma*.

Whistler (1992), returning to fruit size and shape as reliable, distinguishing characters,

stated that there were two species on 'Upolu, *C. onchorhynchum* (with large oblong fruits) and *C. samoense* (with small rounded fruits), and one species on Savai'i, *C. savaiiense* (with small oblong fruits). He listed *C. warburgii* and *C. powellianum* as synonyms of *C. samoense* and *C. vaupelii* as a synonym of *C. savaiiense*.

A few years later in a very short, popular summary of the genus (Hodel 1999), I recognized only one species in Samoa, *Clinostigma samoense*, and listed all the other names from Samoa as synonyms.

Recently, after examining *Clinostigma* in Samoa, my living collections in Hawaii, types of *C. samoense*, *C. onchorhynchum*, and *C. powellianum*, and the literature, I recognized three species in Samoa based entirely on inflorescence architecture, two on 'Upolu and one on Savai'i (Hodel 2006). On 'Upolu I recognized *C. samoense* (inflorescence branched to two orders with thick, coarse, narrowly diverging rachillae) and *C. sp. "Eastern 'Upolu"* (inflorescence branched to three orders with slender, widely spreading rachillae). I considered *C. onchorhynchum*, *C. powellianum*, and *C. warburgii* as synonyms of *C. samoense*. I recognized *C. savaiiense* and its synonym *C. vaupelii* as restricted to Savai'i.

However, the recent discovery of authentic material of *Reinecke 322* (Fig. 4) at BISH was key to unraveling the *Clinostigma* puzzle in Samoa because I could clearly see that, with its slender, widely spreading rachillae, it represented *Clinostigma sp. "Eastern 'Upolu"*; thus, the best name for this species is *C. warburgii*.

Summary of *Clinostigma* in Samoa

In summary, there are clearly three species of *Clinostigma* in Samoa, two on 'Upolu and one on Savai'i, and we can now apply names to them with some degree of confidence. On 'Upolu, *C. samoense* has broom-like inflorescences branched to two orders with thick, coarse, narrowly diverging rachillae (Fig. 5) and typically larger, oblong fruits with the stigmatic remains toward or near the apex. Also on 'Upolu, *C. warburgii* has "bushy" inflorescences branched to three orders with slender, widely spreading rachillae (Fig. 6) and typically smaller, rounded fruits with the stigmatic remains near the middle. On Savai'i, *C. savaiiense* has open inflorescences sparsely branched to three orders with slender, spreading rachillae, smaller oblong fruits, and abaxial surface of pinnae moderately covered with small scales (lepidia).

While fruit shape and size and, to some extent, rachilla size, by themselves are helpful in distinguishing the three species, they can vary a little. Thus, it is better to rely on inflorescence architecture and the presence or absence of lepidia on the abaxial surface of the pinnae for identification. Unfortunately, this information, especially about inflorescence architecture, is lacking in nearly all collections of Samoan *Clinostigma*. As was typical of many palm collections of the era, the early collections of Samoan *Clinostigma*, including types, are rather poor. Many recent collections are of similar quality. They are meager, sparse, and incomplete, often lacked mature fruits, and label data and other information, especially about diagnostic characters of taxonomic value that are difficult or impossible to encompass on the herbarium sheet, are scant or non-existent.

Key to Species of Samoan *Clinostigma*

1. Inflorescences broom-like, typically branched to two orders, rarely branched to three orders; rachillae thick, coarse, narrowly diverging 1. *C. samoense*

1. Inflorescences not broom-like, typically branched to three orders; rachillae slender, widely spreading 2

2. Abaxial surface of pinnae moderately covered with gray to brownish, circular to nearly linear lepidia; fruits typically oblong 2. *C. savaiiense*

2. Abaxial surface of pinnae lacking lepidia; fruits typically +/- rounded 3. *C. warburgii*

1. *Clinostigma samoense* H. Wendl., Bonplandia 10: 196. 1862. *Cyphokentia samoensis* (H. Wendl.) Warb., Bot. Jahrb. Syst. 25: 588. 1898. Type: Samoa, 'Upolu, *Pickering s. n.* (holotype GH).

Clinostigma onchorhynchum Becc., Webbia 4: 284. 1914. Type: Samoa, 'Upolu, *Whitmee s. n.* (holotype K; isotype FI).

Clinostigma powellianum Becc., Webbia 4: 286. 1914. Type: Samoa, *Powell 246.* (holotype K; isotype FI).

Solitary, unarmed, pleoanthic, monoecious, forest palm 15–20 m tall (Fig. 7). Trunk erect, green with white waxy glaucous indument, aging to grayish white or brownish, ringed, 25–30 cm diam., internodes 2.5–7.5 cm. Leaves 15, ascending to spreading; sheath 1.5 m long, lime green with slight glaucous bloom, forming a conspicuous and prominent

7. *Clinostigma samoense*,
Tiavi, 'Upolu,
Samoa.



crownshaft; petiole 30 cm long, concave adaxially, rounded abaxially; rachis 2.6–2.8 m long, flat adaxially, rounded abaxially; pinnae up to 75 per side, elegantly and pendulous, regularly arranged, lower middle the largest, to 65–85 × 3–4 cm, proximal pinnae to 30 × 1 cm, distal pinnae to 20 × 1.5 cm, prominently 3-nerved adaxially, tan medifixed ramentae to 1 cm long on prominent midrib abaxially near rachis, otherwise glabrous. Inflorescences 6–9, infrafoliar, to 1.3 × 0.9 m, broom-like, branched to 2 orders (rarely branched to 3 orders and then with more moderately diverging branches and rachillae), most proximal branches the largest and most complex with up to 7 rachillae each, branches becoming progressively smaller and less

complex distally until most distal represented by up to 15 simple rachillae; peduncle 10–15 cm long, 20–25 cm wide at base and ± bulbous and swollen, 7 cm wide and 3–4 cm thick at prophyll scar, light green with glaucous bloom; prophyll 1.5 m long, equaling crownshaft, attached 4–5 cm above base; peduncular bracts 2, attached 1 and 3 cm respectively distally of prophyll attachment, short, rudimentary, 1–3 cm long, triangular, brown, typically caducous; rachis 20–43 cm long with simple rachillae distally and up to 15 branches proximally, most proximal first order branches with unbranched portion 6.5–15 cm long, rachis of first order branches 5–15 cm long; rachillae 45–75 cm long, white in flower, greenish in fruit, narrowly diverging, 1.0–2.5 mm diam.

distally with staminate flowers only and there slightly filiform, attenuate and \pm flexuous, 3–5 mm diam. proximally with triads and later fruits, coarse; proximal branches subtended by brown, long-lanceolate bracts to 60 cm long, typically caducous, more distal branches and rachillae subtended by rudimentary bracts 1–3 cm long. Flowers borne in triads in cleft-like depressions in proximal one-half to two-thirds of rachillae, solitary or paired staminate flowers only in distal one-third to one-half of rachillae, each triad subtended proximally by a lip-like bracteole, triads 3–6 mm distant in 2 spiraling rows; floral bracteoles 5–6, unequal in size, 3 inner ones broadly triangular to crescent-shaped, 0.3×1.5 mm, imbricate, 3 outer ones often more prominent, the 2 outer lateral ones 0.5×0.4 mm, tooth-like, outer middle (proximal) one especially conspicuous and exceeding the triad bracteole, triangular, 1×1.3 mm with prominent briefly acute apex, white. Flowers not seen. Fruits 10–20 \times 7–13 mm, typically oblong, less frequently somewhat rounded, black or purplish black with glaucous bloom, stigmatic remains near apex, beak-like; perianth 5×10 mm, cupular; sepals 5 mm high, imbricate nearly to acute apex, broadly rounded, petals 5 mm high, imbricate nearly to apex, broadly rounded;

staminodes 6, 1 mm long, tooth-like, acute, 4–6 toward side of fruit with stigmatic beak.

Specimens Examined. SAMOA. *Powell 246* (holotype of *Clinostigma powellianum*, K; isotype FI); 'Upolu: *Pickering s. n.* (holotype GH); Malololelei, 550 m elev., 17 Aug. 1929, *Christophersen 303* (BISH); Lake Lanoto'o, *Whitmee s. n.* (holotype of *Clinostigma onchorhynchum*, K; isotype FI); 700 m elev., 22 Aug. 1929, *Christophersen 383* (BISH); 24 June 2001, *Whistler 11532* (HAW); 29 Aug. 2004, *Whistler 11791* (HAW); Tiavi, 600 m elev., 13 June 1976, *Whistler 3506* (BISH); 740 m elev., 16 July 1971, *Moore 9978* (BH); Magiagi, 600 m elev., 27 Aug. 1991, *Whistler 8117* (HAW); Afiamalu, 510 m elev., 25 Sept. 1991, *Whistler 8388* (HAW); west of Afulilo, 300 m elev., 30 July 1977, *Whistler 3873* (HAW); E of Afulilo, 275 m elev., 30 July 1977, *Whistler 3875* (HAW); 5 km E of Afulilo Dam, 450 m elev., 17 May 1996, *Whistler 10036* (HAW).

Distribution and Ecology. *Clinostigma samoense* primarily occurs in the central highlands of 'Upolu in the districts of East and West Faleata, West Vaimauga, Safata, and Si'umu, from 300 to 800 m elevation in moist to wet, usually disturbed, often open forest. It has also been collected a few times in eastern 'Upolu near

8. A possible hybrid of *Clinostigma samoense* and *C. warburgii*, which might be *C. powellianum*, is this plant at Ho'omaluhia Botanical Garden (HBG 78.0891). It has more spreading inflorescences branched to three orders but with thick, coarse, moderately diverging rachillae.



Afulilo Dam in the district of Va'aofonoti. Typically, *C. samoense* occurs as scattered, emergent individuals on steep slopes or in more level areas.

To a great extent altitude and location on 'Upolu separate the ranges of *Clinostigma samoense* and *C. warburgii*. They do overlap somewhat in the central highlands near Lake Lanoto'o and apparently again near Afulilo in the eastern part of the island. The altitudinal distribution of the two species is dramatically demonstrated along the southern half of the cross-island road from Apia to Si'umu. Near Tiavi at the summit at about 800 m elevation and down to about 600 m elevation one finds *C. samoense*. From about 600 m down to sea level at Si'umu one finds *C. warburgii*. The two species are easy to distinguish from the auto as one passes along the road because of the differences in inflorescence architecture. The changeover from one species to the other occurs rather quickly around 600 m elevation.

That their ranges briefly overlap raises the possibility of hybrids. Indeed, I suspect that *Clinostigma powellianum* might actually be a hybrid, and its placement with *C. samoense* is somewhat problematic. It has the thick, coarse rachillae of *C. samoense* but Beccari described the inflorescence as spreading (he used the term "diffuses") and possibly branched to three orders. Also, he did not use the term "scopaeformis," meaning broom-like, as he had done for *C. onchorhynchum*. Unfortunately, the meager nature of Powell's type tells us nothing about the inflorescence architecture. However, one plant out of about 25 cultivated at Ho'omaluhia Botanical Garden in Honolulu originating from my collection of *C. samoense* (broom-like inflorescence branched to two orders; thick, coarse, narrowly diverging rachillae; elongated fruits) in December 1978 (HBG 78.0891) has more spreading inflorescences branched to three orders with thick, coarse, moderately diverging rachillae (Fig. 8). Moore 9978 (here referred to *C. samoense*) and 9983 (here referred to *C. warburgii*) also depict this hybrid nature in their inflorescence architecture. In both the cultivated plant in Honolulu and Moore's collections, the inflorescences are spreading because of the wider angle of the proximal primary branches. In all case the secondary branches and rachillae of the primary branches are only moderately diverging.

Some might contend that this hybrid is actually an intermediate form that ties the two

species, *Clinostigma samoense* and *C. warburgii*, together, making a case for just one highly variable species. However, there does not appear to be a continuum of variation with a multitude of intermediate forms from one species to another, which one would expect if there were just one highly variable species. Rather, there are the two distinct species with one additional taxon more or less exactly intermediate between the two with no other variation present. Perhaps future study employing DNA will be able to sort these taxa out more satisfactorily.

Several of Whistler's *Clinostigma* collections from Upolu housed at HAW are difficult to assign to species because they are incomplete, consisting only of pieces of fruiting rachillae, which, by themselves, are hardly diagnostic. These include Whistler 3873, 3875, and 10036 from Afulilo, which is in the middle of the range of *C. warburgii*, and Whistler 8387 and 8388 from Afiamalu, which is in the middle of the range of *C. samoense*. Based on fruit shape alone, I have tentatively included the collections from Afulilo and Whistler 8388 with *C. samoense* and Whistler 8387 with *C. warburgii*.

While Whistler (1992) was correct in determining that two species of *Clinostigma* occurred on 'Upolu and could be distinguished by fruit size and shape, what he referred to as *C. onchorhynchum* (with large oblong fruits) is actually *C. samoense* and what he referred to as *C. samoense* (with small rounded fruits) is actually *C. warburgii*.

The palm illustrated in Langlois (1976, fig. 49, p. 47), captioned as *Clinostigma onchorhynchum*, is actually *C. samoense*.

2. *Clinostigma savaiiense* Christoph., Bernice P. Bishop Mus. Bull. 128: 28. 1935. Type: Samoa, Savai'i, Matavanu Crater, *Christophersen 2267* (holotype BISH; isotypes K, US).

Exorrhiza vaupelii Burret, Occas. Pap. Bernice P. Bishop Mus 11(4): 4. 1935. *Clinostigma vaupelii* (Burret) Burret, Notizbl. Bot. Gart. Berlin-Dahlem 12: 593. 1935. Type: Samoa, Savai'i, Maugaloa, *Vaupel 605* (holotype B?).

Solitary, unarmed, pleonanthic, monoecious, forest palm 10–20 m tall (Fig. 9). Trunk erect, green with white waxy glaucous indument, aging to grayish white or brownish, ringed, 15–25 cm diam., expanding to 45–55 cm diam. at base and their supported with prominent prop roots to 60 cm long and 1.0–1.5 cm

9. *Clinostigma savaiiense*,
Matavanu,
Savai'i, Samoa.



diam., internodes to 10 cm. Leaves 10–15, ascending to spreading; sheath 75 cm long, lime green with slight glaucous bloom, forming a conspicuous and prominent crownshaft; petiole 30 cm long, concave adaxially, rounded abaxially; rachis 1.8–2.1 m long, flat adaxially, rounded abaxially; pinnae up to 55 per side, slightly pendulous, regularly

arranged, lower middle the largest, to 55–80 × 2.2–4.0 cm, slightly falcate, tips splitting and becoming tattered, prominently 3-nerved adaxially, tan medifixed ramentae to 1 cm long on prominent midrib abaxially near rachis, pinnae moderately covered abaxially with brownish, circular to nearly linear, raised lepidia or wart-like structures to 0.4 mm long

arranged in raised lines parallel to pinnae margins. Inflorescences 5–6, infrafoliar, to 1 × 0.8 m, branched to 3 orders (Fig. 10), most proximal branches the largest and most complex, branches becoming progressively smaller and less complex distally until most distal represented by simple rachillae; peduncle 5–15 cm long, 15 cm wide at base and ± bulbous and swollen, 4 cm wide at prophyll scar, light green with glaucous bloom; prophyll 1 m long, equaling crownshaft, attached 10 cm above base; peduncular bracts 2, attached 2 and 4 cm respectively distally of prophyll attachment, not seen, typically caducous; rachis 75 cm long with simple rachillae distally and up to 15–21 branches proximally, most proximal first order branches with unbranched portion 10 cm long, rachis of first order branches 30 cm long; most proximal second order branches with unbranched portion 8 cm long, rachis of second order branches 5 cm long; rachillae to 45 cm long, white in flower, greenish white in fruit, diffuse, spreading from rachises at angles of 45–90 degrees, 0.8–1.0 mm diam. distally with staminate flowers only and there very slender, filiform, attenuate and flexuous, 1.5–2.0 mm diam. proximally with triads and later fruits; bracts subtending branches not seen, typically caducous. Flowers borne in triads in shallow, cleft-like depressions in proximal one-third to one-half of rachillae, solitary or paired staminate flowers only in distal one-half to two-thirds of rachillae, each triad subtended proximally by a lip-like bracteole, triads 3–5 mm distant in 2 spiraling rows; floral bracteoles 5–6, unequal in size, 3 inner ones broadly triangular to crescent-shaped, 0.3 × 1.5 mm, imbricate, 3 outer ones often more prominent, the 2 outer lateral ones 0.5 × 0.5 mm, tooth-like, outer middle (proximal) one especially conspicuous and exceeding the triad bracteole, triangular, 1 × 1.5 mm with prominent acute tip, white. Staminate flowers 4 × 5 mm, white; sepals 3, distinct, 2.5–2.8 × 0.4–0.5 mm, narrowly triangular, long-acuminate, margins transparent and membranous, briefly connate or imbricate in basal 0.5 mm; petals 3, distinct, 5 × 1.5 mm, valvate, widely spreading, free nearly to base, long-acuminate, lanceolate, strongly ribbed when dry; stamens 6, 2.5–3.0 mm high, filaments distinct, 1.5–2.0 mm long, very slender, anthers 1 mm long, attached in middle; pistillode columnar, 1.0–1.1 mm long. Pistillate flowers 4 × 3.5 mm, ovoid; calyx 3-lobed, sepals 3 × 3 mm, faintly ribbed, imbricate nearly to broadly rounded apex; petals 3 × 3.5 mm, imbricate nearly to

rounded-acute apex, finely ribbed; pistil 2.5 × 1.5 mm, ovoid. Fruits 13–15 × 7–9 mm, oblong, black, stigmatic remains near apex, beaklike; perianth 4–5 × 7 mm, cupular; sepals 3 mm high, imbricate nearly to apex, broadly rounded, margins thin, petals 4–5 mm high, imbricate nearly to apex, broadly rounded; staminodes 6, 1 mm long, triangular, acute.

Specimens Examined. SAMOA. Savai'i: Matavanu Crater, 1300 m elev., 24 Sept. 1929, *Christophersen 808* (BISH); 900 m elev., 10 July 1931, *Christophersen & Hume 1946* (BISH); 15 July 1931, *Christophersen & Hume 2078* (BISH); 5 Aug. 1931, *Christophersen & Hume 2266* (BISH); *Christophersen & Hume 2267* (holotype BISH; isotypes K, US); *Christophersen & Hume 2273* (BISH); 680 m elev., 23 July 1971, *Moore 9982* (BH); above Sala'ilua, 1400 m elev., 8 Sept. 1931, *Christophersen 2565* (BISH); 6 Nov. Sept. 1931, *Christophersen 3088* (BISH); W of Mata-ole-Afi, 1500 m elev., 31 May 1975, *Whistler 2564* (BISH, HAW).

Distribution and Ecology. *Clinostigma savaiiense* occurs on the north, east, and south slopes of Savai'i in the districts of Gagaifomauga III and I, Gaga'emauga III, and West Palauli in wet forest and cloud forest from 900 to 1500 m elevation. I found it in October 2005 at or near the type locality on the steep sides of volcanic craters where it occurred as scattered individuals emerging from the forest canopy. It is probably scattered in a more or less continuous band on the north, east, and south side of the island at the appropriate elevations. Historically, it may have been distributed at lower elevations, perhaps as low as 700 m. The Samoan chief Itutu Avealolo of Fogasavi'i, who guided me into the forest to 700 m elevation above Sala'ilua, said it once occurred at this location, but tropical cyclones and human activity, primarily land clearing and cutting of the trunk for wood, had destroyed all the specimens in the area.

3. *Clinostigma warburgii* Becc., Atti Soc. Tosc. Sci. Nat. Pisa Mem. 44:155. 1934. Type: Samoa, 'Upolu, Lake Lanoto'o, *Reinecke 322* (holotype WRSL?; isotypes BISH, FI).

Clinostigma sp. "Eastern 'Upolu" Hodel, Palm J. 183: 12.

Solitary, gregarious, unarmed, pleonanthic, monoecious, forest palm to 20 m tall (Front Cover). Trunk erect, green with white waxy glaucous indument, aging to grayish white or brownish, ringed, to 25 cm diam., internodes to 10 cm. Leaves 15–20, ascending to



10. *Clinostigma savaiiense*, infructescence, Matavanu, Savai'i, Samoa

spreading; sheath 2 m long, lime green with slight glaucous bloom, forming a conspicuous and prominent crownshaft; petiole 50 cm long, concave adaxially, rounded abaxially; rachis to 3 m long, flat adaxially, rounded abaxially; pinnae up to 75 per side, elegantly pendulous, regularly arranged, lower middle the largest, to 75×4.0 – 4.5 cm, proximal to 45×1.5 cm, distal to 25×1 cm, prominently 3-nerved adaxially, tan medifixed ramentae to 1 cm long on all 3 nerves abaxially near rachis, otherwise glabrous. Inflorescences 9, infrafoliar, to 1.7×1.1 m, branched to 3 orders, most proximal branches the largest and most complex, branches becoming progressively smaller and less complex distally until most distal represented by simple rachillae; peduncle 20 cm long, 22 cm wide at base and \pm bulbous and swollen, 4 cm wide at first branch, light green with slight glaucous bloom and/or grayish brown scales; prophyll 2 m long, equaling crownshaft, attached 10–12 cm above base; peduncular bracts 2, attached 2–3 and 6 cm respectively distally of prophyll attachment, not seen, typically caducous; rachis 1.2 m long with simple rachillae distally and branches proximally, most proximal first order branches with unbranched portion 13 cm long, rachis of first order branches 64 cm long; most proximal second order branches

with unbranched portion 10 cm long, rachis of second order branches 12 cm long; rachillae to 30 cm long, white in flower, light green in fruit, diffuse, spreading from rachises at angles of 45–90 degrees, 0.8–1 mm diam. distally with staminate flowers only and there very slender, filiform, attenuate and flexuous, 1.5–2.0 mm diam. proximally with triads and later fruits; proximal branches subtended by brown, long-lanceolate bracts to 50 cm long, typically caducous, more distal branches and rachillae subtended by rudimentary bracts 1–3 cm long. Flowers borne in triads in shallow, cleft-like depressions in proximal one-third to one-half of rachillae, solitary or paired staminate flowers only in distal one-half to two-thirds of rachillae, each triad subtended proximally by a lip-like bracteole, triads 3–4 mm distant in 2 spiraling rows; floral bracteoles 5–6, unequal in size, 3 inner ones broadly triangular to crescent-shaped, 0.75×1.75 mm, imbricate, 3 outer ones often more prominent, the 2 outer lateral ones 1×0.6 mm, tooth-like, outer middle (proximal) one especially conspicuous and exceeding the triad bracteole, broadly triangular, 1.0 – 1.3×2.0 – 2.5 mm with prominent acute apex, white. Staminate flowers 4×5 mm, white; sepals 3, distinct, 2.0 – 2.5×0.3 mm, narrowly triangular, long-acuminate, membranous toward apex, margins

transparent, briefly connate basally; petals 3, distinct, 3.5–4.0 × 1–2 mm, valvate, widely spreading, free nearly to base, strongly ribbed when dry; stamens 6, 2.0–2.5 mm high, filaments distinct, 1.7–2.5 mm long, very slender, anthers 0.7–1.3 mm long, attached in middle; pistillode conical to columnar, 0.7–2 mm high, to 0.75 mm wide at base, 0.5 mm wide at briefly 3-parted apex. Fresh pistillate flowers 3–4 × 3–4 mm, ovoid, greenish white; calyx 1.5–2.0 × 3 mm, 3-lobed, sepals faintly ribbed, imbricate in proximal half to two-thirds, broadly rounded distally with membranous nearly transparent margins and acute apex; corolla 2.8–3.5 × 3 mm, petals imbricate nearly to mucronate apex, whitish, thin-fleshy nearly transparent, ribbed; pistil 3 × 2.8 mm, ovoid, greenish, 3-parted. Fruits 10 × 10 mm, rounded, black, stigmatic remains slightly distal of middle; perianth 3 × 5–6 mm, cupular; sepals 3 × 2 mm, imbricate nearly to acute apex, broadly rounded to triangular with acute apex, petals 4 × 3 mm, imbricate nearly to briefly acute apex, broadly rounded; staminodes 6, 1 × 0.2 mm, tooth-like.

Specimens Examined. SAMOA. 'Upolu: between Poutasi and Si'umu, 30 m elev., 27 July 1977, *Whistler* 3858 (BISH, HAW); between Falelatai and Lefaga, 150 m elev., 28 July 1977,

Whistler 3870 (BISH, HAW); NE of Sa'agafou, 100 m elev., 23 Aug. 1978, *Whistler* 3923 (HAW); 0.6 miles E. of road into 'O Le Pupu Pu'e National Park, 20 m elev., 25 July 1979, *Teraoka & Kennedy* 88 (BISH); 'O Le Pupu Pu'e National Park, 50 m elev., 23 May 1979, *Cox* 162 (BISH); 40 m elev., 15 March 1980, *Moore* 10540 (BH); upper entrance to cave at Togitogiga, 175 m elev., 13 Sept. 1978, *Whistler* 4004 (BISH, HAW); E of Ti'avea, 220 m elev., 24 April 1979, *Whistler* 4196 (BISH, HAW); mangrove swamp at Mulivai, 28 Aug. 1991, *Whistler* 8134 (HAW); Puntaemo'o swamp, 31 Aug. 1991, *Whistler* 8159 (HAW); Punataemo'o, 300 m elev., 14 Nov. 2001, *Whistler* 11569 (HAW); Lemafa, 360 m elev., 18 March 1980, *Moore* 10541, 10542 (BH); above Sauniatu inland from Salafuata, 200–500 m elev. 27 July 1971, *Moore* 9983 (BH); Apia-Si'umu Road, 450 m elev. 7 July 1968, *Bristol* 2179 (BISH); Afiamalu, 510 m elev., 24 Sept. 1991, *Whistler* 8387 (HAW); Lake Lanoto'o, *Reinecke* 322 (isotype BISH, FI). CULTIVATED: American Samoa, Tutuila, W. of Aloau (A'oloaufou?), 12 March 1980, *Moore* 10539 (BH); Ili'ili Village, 20 m elev., 10 March 1980, *Moore* 10538 (BH). U.S.A., Hawaii, Oahu, Ho'omaluhia Botanic Garden (Honolulu Botanic Gardens 78.0889, originally collected by D.R. Hodel, 9 Dec. 1978,

11. *Clinostigma warburgii*, gregarious population, east of Lemafa Pass, 'Upolu, Samoa.



near Salelesi, 'Upolu, Samoa, 10 m elev., *Hodel 462*, 22 March 2006, *Hodel 2008* (BISH).

Distribution and Ecology. *Clinostigma warburgii* primarily occurs on the eastern part of 'Upolu in the districts of East Anoama'a, Va'aofonoti, Aleipata, Lepa, Lotofaga, Falealili, and Si'umu, from sea level to about 600 m elevation in wet, usually disturbed forest (Front Cover). Indeed, I referred to it in an earlier paper as *Clinostigm* sp. "Eastern 'Upolu" (Hodel 2006). It is especially abundant in the Lemafa Pass region and to the east towards Ti'avea, where it forms vast, gregarious stands on steep, well drained slopes and in low, wet or swampy, poorly drained areas (Fig. 11). It has also been collected twice in the central highlands of 'Upolu, once at Afiamalu, where it was probably cultivated, and at Lake Lanoto'o, the latter represented by Reinecke's type specimen.

Clinostigma warburgii occurs sparingly farther west along the north coast in the districts of West Anoama'a and along the south coast in the districts of Safata, Gaaga'emauga, Lefaga, and Samatau and Falelatai. In these areas, though, it is typically found as a few isolated individuals around human habitation, indicating it is probably cultivated.

When Cox and Moore (1986) concluded that fruit shape was variable and could not be used to distinguish *Clinostigma samoense* and *C. onchorhynchum*, the specimens from Lemafa Pass that formed the basis for their conclusions, *Moore 10541* and *10542*, actually were *C. warburgii*. Furthermore, fruits of both collections were immature and at different stages of development. When fully mature they would likely be the same shape and size.

The palm illustrated in Langlois (1976, fig. 50, p. 48), captioned as *Clinostigma samoense*, is actually *C. warburgii*.

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