RESURRECTION OF THE MAUI ENDEMIC *WALTHERIA PYROLIFOLIA* (STERCULIACEAE, HERMANNIEAE)

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Abstract. Saunders, J. G. 2011. Resurrection of the Maui endemic *Waltheria pyrolifolia* (Sterculiaceae, Hermannieae). *Darwiniana* 49(1): 76-85.

Old and new morphological characters confirm that *Waltheria pyrolifolia* is abundantly distinct from *W. indica* s.l., not its synonym, nor teratological material of it. The first illustrations of *W. pyrolifolia* are presented. It is here IUCN global category assessed as critically endangered, tagged possibly extinct. The earliest lectotypifications of *W. indica* and *W. americana*, realized by Gillis in 1974, are clarified.

Keywords. Maui, taxonomy, *Waltheria,* Wilkes Expedition.

Resumen. Saunders, J. G. 2011. Resurrección de la especie endémica de Maui, *Waltheria pyrolifolia* (Sterculiaceae, Hermannieae). *Darwiniana* 49(1): 76-85.

Caracteres morfológicos viejos y nuevos confirman que *Waltheria pyrolifolia* es una especie distinta, y no un sinónimo o material teratológico de *W. indica*. Se presentan por primera vez ilustraciones de *W. pyrolifolia*. Su categoría de conservación a nivel global es evaluada como en peligro crítico de extinción, posiblemente extinguida. Se esclarece que las lectotipificaciones más antiguas para *W. indica* y para *W. americana* fueron realizadas por Gillis en 1974.

Palabras clave. Expedición de Wilkes, Maui, taxonomía, *Waltheria*.

INTRODUCTION

Waltheria L. is comprised of 60 subtropical to tropical species, 53 spp. limited to America, 6 spp. limited to the paleotropics, and 1 species pantropical. Paleotropical species are respectively endemic to Australia (*W. virgata* Ewart & Cookson), the Islas Marquesas and Society Islands (*W. tomentosa* (J.R. & G. Forster) St. John), Madagascar (*W. madagascariensis* Hochreutiner), West Africa (*W. lanceolata* R. Brown ex Masters in Oliver) or Hainan and Malaysia (*W. arenaria* Ridley). The genus occurs as obligate heliophytes in semiarid zones in savannas sensu lato, including coastal or riverine dunes and thorn-scrub.

Major taxonomic revisions coincide with its regions of highest diversity and endemism: the Brazilian species revised by Saint-Hilaire (1825), by Schumann (1886), and by Saunders (1995); the Mexican ones revised by Rose (1899), by Standley (1923), and by Saunders (1993, 1995). Other less extensive treatments were made by de Carvalho & da Vinha (1983); Berry et al. (2007), Saunders (2005, 2007); Verdcourt (1995), Cristóbal et al. (1995, 2005); Cristóbal (1998); Cristóbal & Saunders (2006, 2008); Saunders and Pozner (2007) and Amorim et al. (2009). Only two sections have been formally described for the genus (Schumann, 1886), resulting in the segregation of three species under sect. Stegowaltheria.

Up to now, either two or one *Waltheria* species have been considered to occur in Hawaii: *W. indica* L., and *W. pyrolifolia* A. Gray. In the course of the first monograph for the genus *Waltheria* it was necessary to re-examine the status of *W. pyrolifolia*. The aim of this work is to evaluate considering

Original recibido el 14 de diciembre de 2010, aceptado el 25 de febrero de 2011.

W. pyrolifolia as either a distinct species and very restricted local endemic to Maui in the Hawaiian Islands (Gray, 1854; Müller, 1857; Hillebrand, 1888; Mann, 1867; Drake de Castillo 1890; Degener, 1935; St. John, 1973; Saunders, 1993, 1995) or as a synonym of pantropical *W. indica* (St. John, 1976, 1985; Wagner et al., 1990, 1999).

MATERIALS AND METHODS

All of the original material of *Waltheria pyrolifolia* that was studied by both Gray and St. John has been re-examined and compared to representative material of *W. indica* from Hawaii. *Waltheria pyrolifolia* specimens were borrowed from GH, US, and P. No additional examples of *W. pyrolifolia* were located by consultations to or monograph loans from A, ARIZ, B, BAB, BBS, BH, BHCB, BISH, BKL, BM, BR, C, CAS-DS, CAY, CEPEC, CTES, DAV, DNA, E, F, FCQ, G, GUA, HAL, HB, HUEFS, INPA, JE, K, KW, LE, LIL, LK, LPB, M, MA, MBM, MEXU, MICH, MO, MPU, MSC, NY, PH, PR, PTBG, RB, S, SI, SING, SP, SPF, TEX, TI, U, UCR, UFMT, UPBC, UPS, and W. Herbaria are listed according to acronyms given in Index Herbariorum (Thiers, 2010).

Hawaiian material of *Waltheria indica* was verified in loans from BISH. The plants of *W. indica* s.l. from Kanaha Beach, near the type locality of *W. pyrolifolia*, were used to illustrate *W. indica*. Leaf, floral and fruit characters were examined with a Wild Heerbrugg M4A dissecting microscope with camera lucida (CL) attachment. Micrographs were made with a Nikon Digital Sight DS Fi1 mounted on a Nikon SMZ 800 Microscope. Leaf shapes follow Radford et al. (1974), modified from SACDBT (1962a, b). Stigma types follow Schumann (1886). Only characters found to differ between the two species are given here.

RESULTS

Many of Gray´s characters (1854) were confirmed to be distinguishing between *Waltheria pyrolifolia* and *W. indica* in Hawaii; most of them are listed in italics in Table 1, with new characters non-italicized, and shown in Figure 1. Capsule type, stigma type, calyx venation type and seed type, which are important grouping characters sensu Saunders (1995), are different between the two species. The striae along veins of abaxial leaf surfaces, the nearly simple stigma, and the petals slightly cucullate and 8-nerved from the base in *W. pyrolifolia* were found to be its four unique characters within the genus (Figs. 2 and 3). Together, all these characters indicate there is a very significant difference between *W. pyrolifolia* and *W. indica*.

My results concur with Asa Gray´s opinion upon founding *Waltheria pyrolifolia* that it is abundantly distinct from *W. indica* s.l. (Gray, 1854). Gray considered his new species to be perhaps only closely related to *W. tomentosa* (J.R. & G. Forst.) H. St. John (as *W. lophanthus* G. Forst.).

To combine *Waltheria indica* and *W. pyrolifolia*, St. John (1976) mostly used leaf shape and its adaxial surface being "nearly glabrous" in some *W. indica*, vs. "subglabrate" adaxial leaf vestiture attributed to *W. pyrolifolia*. This is complicated by the presence of misidentified species mixed in with material of *W. indica* s.l. in global herbarium material. In this study, *W. indica* adaxial leaf vestiture was found to be sparsely to densely pubescent rather than nearly glabrous, and often densely pubescent, tomentose or velutinous. Leaf apices and lamina shape can be used in the field to discriminate between these species for most cases (Table 1).

Wagner et al. (1990) noted the different leaves of *Waltheria pyrolifolia* saying it "apparently was described from an aberrant leaf form of one collection." A hypothesis derived from their observation that the type specimen of *W. pyrolifolia* could represent abnormal floral material of *W. indica* caused by disease or insect damage previously reported for *W. indica* in Brazil and Africa (Schumann, 1886; Scott, 1978; Verdoorn, 1981; Thulin, 1998; Cheek and Dorr, 2007) and personally observed from Africa and Australia can be discarded. Characteristic features illustrated or described for abnormal material of *W. indica* (Schumann, 1886; Scott, 1978; Verdoorn, 1981; Thulin, 1998) were: cymes heteromorphic, calyces unorderly, half (Scott, 1978) to none (Scott, 1978; Thulin, 1998) of the normal nearly completely fused stamen filament fusion lengths, a stipitate distended arcuate pistil, ovary abnormally shaped and stigma composite-nodular. Stamen and free filament lengths are sometimes variable within a single flo-

Table 1. Characters that distinguish *Waltheria pyrolifolia* from *W. indica* s.l. in Hawaii. Characters in italics are equal or similar to those of Gray (1854). See Fig.1.

	Waltheria pyrolifolia	*Waltheria indica*. s.l.
LEAVES	*Commonly both retuse at apex and nearly as broad or broader than long in obovate, elliptic or ovate series*, mature apices never acute or obtuse. Length/width ratio (1.2)1.1-0.8:1	Never retuse, apices acute, emarginate, usually obtuse or rounded; usually much longer than broad. Length/width ratio (4.0)2.9-1.0(0.8):1
	Adaxial surface *soon subglabrate* in most areas but apex and base	Densely to sparsely stellate pubescent, tomentose, or velutinous throughout
	Coriaceous in age, castaneous dried	Chartaceous, olive, red-olive or umber driede
FLOWERS	Ca. 8 mm diam., presumably distylous, pin-like	4-6 mm diam., homostylous, stamens and pistil sub-equal in length
CALYX LOBES IN BUD	Adjacent lobes contiguous, lobe tips concolorous, interlobe sinus absent when petals imbricate, unopen; *never hirsute*	Adjacent lobes free, lobe tips free, red, not contiguous, with interlobe sinus obtriangular; hirsute or so on veins
CALYX LOBES IN FLOWER	*Lanceolate, broadly linear, the apex* acute *nearly obtuse*	Triangular-acuminate
CALYX LOBES IN FRUIT	Non-areolate between costal veins	Areolate between costal veins
PETAL	Obovate with base widely cuneate	Unguiculate
	1.5-1.7 mm wide	0.7-1.4 mm wide
	Slightly cucullate	± flat, incurved sides
	Claw undifferentiated, broad (0.3-0.5 mm) at base, 8-nerved from base	Claw long and slender, 0.9-1.5 x 0.2 mm, 1-3 nerved from base
STAMENS	*Connate only at the base*	Connate most of length
	Tube short, 0.2-1.0 mm, segmenting in age	Tube long, 1.5-3.2 mm, integral
	Free filaments long, 0.9-3.6 mm long	Free filaments very short, 0.1-0.5 mm long
PISTIL	4-5 mm long, superseding stamens by 0.7-1.7 mm (pins)	3.3-3.4 mm long, ± level to stamens, longer by 0.3-0.5 mm (homostyles)
	Stigma nearly *simple*, 0.1-0.2 x 0.1-0.4 mm, denticulate or scant papillose	Stigma penicillate, dissolute-penicillate, plumose, 0.8-1.1 x 0.6-1.1 mm
	Style excentric, 2.6-3.8 x 0.1 mm, *arachnoid-villous*	Style lateral, 1.2-1.3 x 0.3 mm, stellate-tomentose

Table 1. (Continuation)

	Waltheria pyrolifolia	*Waltheria indica*. s.l.
CAPSULE	Obovoid in lateral view, 3.2-4.0 mm long	Obconical in lateral view, 2.0-2.8 mm long
SEED	Obovoid in lateral view, 2.4-2.7 mm long, in apical view 2-lobulate near raphe; seed cover thick, striate-fibrous	Obconical in lateral view, 1.8-2.1 mm long, apically unequally 3-5-lobulate; seed cover thin

wer in *Waltheria pyrolifolia* but none of the other characteristics are present. Abnormal leaves were not noted for the teratological examples given above. Leaves of *W. pyrolifolia* are similar in shape to leaves of *W. cinerescens* A. St. Hil., among others, so its leaves should not be considered as an abnormality, either.

DISCUSSION AND CONCLUSION

Waltheria pyrolifolia is herein resurrected to distinct species status and removed from synonymy with *W. indica* s.l. conferred by St. John (1976), and followed by Wagner et al. (1990, 1999).

Waltheria pyrolifolia A. Gray, U. S. Explor. Exped., Phan.: 190-191. 1854. TYPE: United States of America, Hawaiian Islands [Sandwich Islands], Maui Co., West Maui Island, sandhills near Wailuku, United States Exploring Expedition of the Pacific during the years 1838-1842, under the command of Capt. Charles Wilkes, *U.S.N. s.n.* [Feb. 15-Mar. 9, 1841 here inferred using Wilkes (1856)] (holotype US 13159!; isotypes GH 00057013!, P 00637085!). Figs. 1-3.

Leaves widely obovate to widely depressed obovate, widely elliptic to oblate, widely ovate-circular, very widely ovate to widely depressed ovate, length/width ratios 1.2-0.8:1; apices commonly retuse, sometimes rounded; crenate-dentate; leaves when yet unfolded adaxially subglabrous, with minute glandular hairs throughout, pubescent and tomentose over teeth, and puberulent here and there on surface, pubescent from a few teeth apices, tufted on midvein and some secondary veins, when newly unfolded adaxially subglabrate except at apex and base; abaxially pubescent (rays planar), golden-tomentellous, later glabrate, glabrescent, gray trichomes, with primary to fifth order veins raised; white striae (wax?) along veins. Stipules narrowly triangular. Calyx lobes contiguous and without sinuses while in bud, later lanceolate, broadly linear, silky short villulose. Petals of unknown color fresh, dark castaneous dried, pale-pustulate, thickened, obovate, slightly cucullate, concave; petal base adnate to stamen tube base for 0.2 mm and 0.3-0.5 mm wide; nerves thick, eight from base to apex, basally contiguous where 0.3-0.4 mm wide. Stamens of uneven lengths within flower. Capsule utricle-like but loculicidal, partially dehiscent ventrally at apex and dorsally at apex, retaining seed; endocarp coriaceous, only near suture slightly sclerified.

Distribution and habitat. Known only from the type collections. The only habitat known (Sand hills) consists of calcareous lithified dunes, used for grazing then (Wilkes, 1856) so that it may have been introduced locally. The species has never been relocated at the type locality though recently searched for by local botanists. More rigorous searches in Maui are necessary. New localities or other types for it have not appeared in herbarium searches either (see acknowledgments).

Conservation assessment. Using the Guidelines for the IUCN Red List Categories (IUCN Standards and Petitions Working Group, 2008), *Waltheria pyrolifolia*, lies within the critically endangered (CR) global conservation category, and should be tagged possibly extinct. This is by

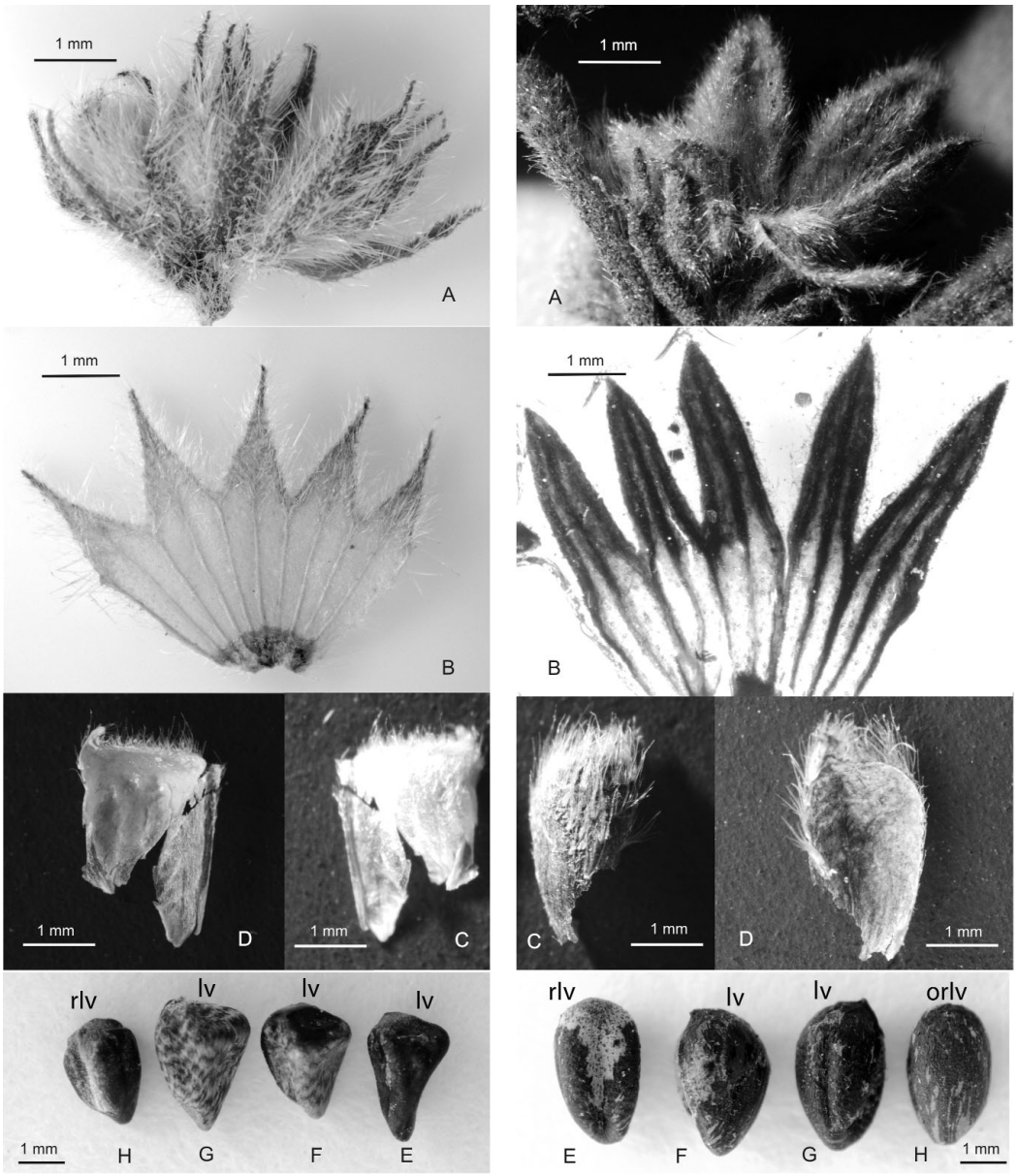

Fig. 1. Structures with new distinguishing characters between *Waltheria indica* s.l. and *W. pyrolifolia*. **A,** floral buds of two primary cymes. **B,** opened adaxial calyx from fruit. **C***,* exterior capsule. **D,** interior capsule, halved, diagonally torn below corneous endocarp in *W. indica*. **E-H,** seeds. **E,** apical inner layers shown. **F,** dark testa visible. *Waltheria indica* from *Starr & Starr 060305-01* (BISH, A-D) and *Fosberg 13532* (BISH, E-H). *Waltheria pyrolifolia* from GH isotype. Abbreviations: lv, lateral view; rlv, raphe-lateral view; orlv, opposite raphe-lateral view.

criteria D, subcategory D1 (< 50 individuals) or D2 (number of locations only 1 with area of occupancy <20 sq. km) both apply. A total population estimated to number less than 50 mature individuals is inferred by its being collected from only one locality and not seen there or elsewhere for over 150 years.

Development and removal of the regionally

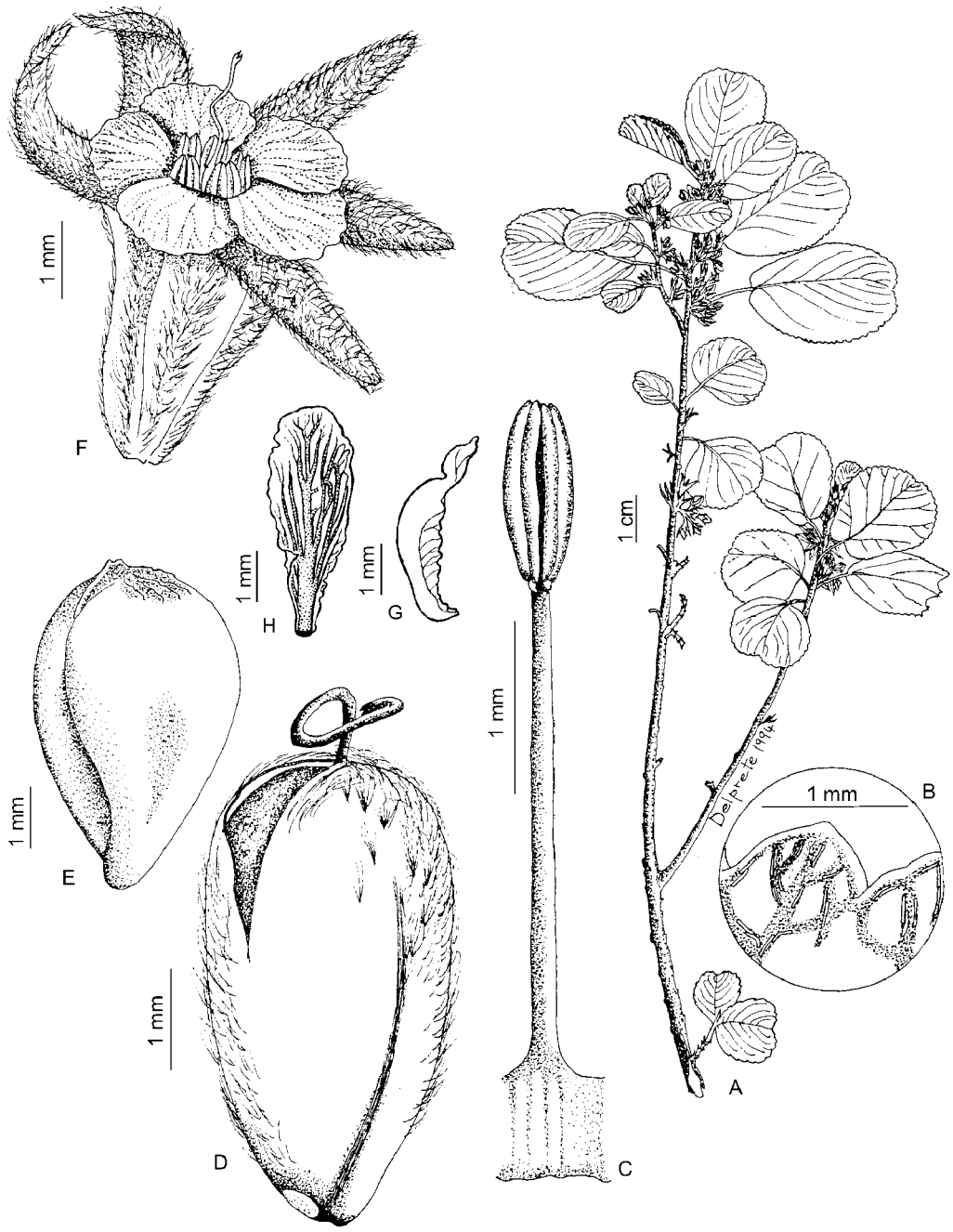

Fig. 2. *Waltheria pyrolifolia*. **A,** habit. **B,** abaxial leaf margin, striae on veins. **C,** abaxial stamen. **D,** capsule, skewed lateral view, with partial ventral and dorsal (apical only) dehiscence, only partial ventral dehiscence shown. **E,** seed, skewed lateral view. **F,** flower: calyx lobe and petal attitudes when fresh are presumed. **G-H,** petals (rehydrated) in lateral profile, in natural attitude (**G**) and flattened adaxial view (**H**). From GH isotype, A-F drawn by Piero Delprete, G-H drawn by Francisco Rojas.

scarce resource, sand, necessary for construction has reduced available habitat areas for this species.

According to Forest Starr, "one of the last remnants of the consolidated lithified dunes formed

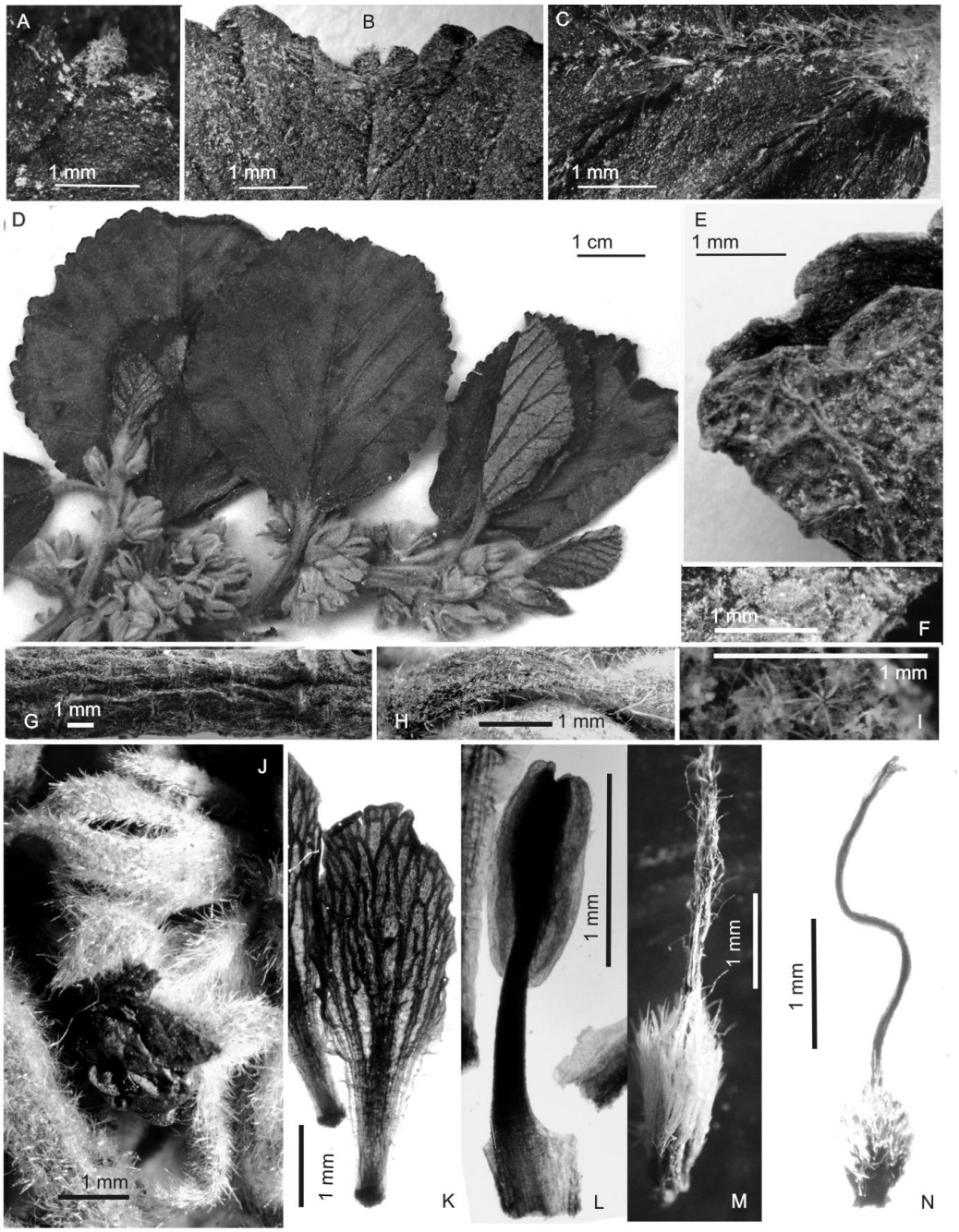

Fig. 3. *Waltheria pyrolifolia*. **A-B, E,** leaf apices. **A,** new, adaxial view; **B,** young, retuse apex, adaxial view. **E**, mature (view off-center, adaxial at top; abaxial below). **C,** young leaf base, adaxial view. **D,** branch. **F, I,** new leaf, abaxial view. **G,** stem. **H,** stipule. **J,** floral pair (open bud and flower) from above. **K, L, N,** permanent slides. **K,** adaxial petals. **L,** adaxial stamen. **M,** lower style and ovary, dry. **N,** pistil. From GH isotype, with permission from Gray Herbarium.

that used to stretch from Waihee to Waikapu" (about 16 km distance), "that includes the historical locality `sand hills of Wailuku´ is found in Keopuolani Sand Dunes in the Keopuolani Regional Park in Wailuku, Maui." That quote and an aerial photograph taken by Forest Starr, selecting

Keopuolani Sand Dunes, are available on the website: *http://www.hear.org/naturalareas/keopuolani/index.html*. That dune is estimated to be less than 1 sq. km. Lithified dunes near Wailuku from Waihee Beach Park, Keopuolani Park, and the Kahului Community Center in West Maui can be reviewed from the HEAR site (http://www.hear-/org/starr/images/search/?q=lithified&o=plants).

Etymology and Nomenclature. The orthographic correction of *Waltheria pyrolaefolia* A. Gray, that K. Gandhi interpreted as being formed from the genus *Pyrola*, genitive form Pyrolae, has been made in IPNI by Gandhi in 2008 (pers. comm., Gandhi; IPNI online).

Waltheria indica L., Sp. Pl. 2: 673. 1753. TYPE: Sri Lanka (Ceylon), "Althaea, *Waltheria foliis lanceolatis*, *serratis*" Herb. Hermann vol. 3: 5, upper right, Fl. Zeyl. no. 244 [on Fl. Zeyl. p. 110] (lectotype BM-00621807 image!, designated by Gillis, Rhodora 76: 100. 1974). Fig. 1.

Waltheria americana L., Sp. Pl. 2: 673. 1753. TYPE: "Habitat in Bahama, Barbiches, Surinamo", sine leg. (lectotype LINN 852.1 image! designated by Gillis, Rhodora 76: 101. 1974) .

Distribution and habitat. Subtropical and tropical zones worldwide. For Hawaii, it is given in Wagner et al. (1990).

Observations. The species is in need of revisionary study (Bahadur & Srikanth, 1983; Cristóbal et al., 2005).

Representative specimens examined

UNITED STATES OF AMERICA. **Hawaii.** Hawaii Co.: Hawaii Is.: Hawaii National Park, Kilauea, 1868 crack, 16-III-1939, *Judd & Christ s.n.* (BISH 497314); Honolulu Co.: Oahu Is.: Makapuu Point, 8-X-1926, *Degener & Horner 7119* (BISH); Kahakaaulana Is., Keéhi Lagoon, 30-IV-1978, *Herbst & Walker 6077* (BISH); Kauai Co.: Lehua Is.: 18-20-IV-1931, Caum 3 (BISH); Niihau Is.: N. Kona Cliff, I-1912, *Stokes s.n.* (BISH 70281); Maui Co.: Lanai Is.: Awalua, +75 ft., 22-III-1961, *Kondo 4* (BISH); Palawai, 1150 ft, *Munro 367* (BISH); Koele, VI-1913, *Forbes 175*.L (BISH); Kahoolawe Is.: central plateau, 250-450 m, 13-II-1931, *Bryan, Jr. 722* (BISH); Smugglers Cove, 26-XI-1978, Char 78,085 (BISH); 10-II-10-III-1913, *Stokes et al. s.n.* (BISH 70312); cut slopes, Kanapou Bay, *Stokes s.n*., ex parte, (BISH 70278A); Maui Island: Waiopai, S slope of Haleakala, 5-III-1920, *Forbes 1852*.M (BISH); Waihee, W side of Kahului, dunes, 16-X-1974, Fosberg 55610 (BISH); W Maui, near Papawai Point, 50 ft., 28-VI-1969, *Henrickson 3806* (BISH); W Maui, Hulu Island, Kahakuloa, 20-VIII-1981, *Kepler 37* (BISH); Molokini Islet: slopes, 100-120 ft., 13-VIII-1925, *Palmer 5* (BISH); E Maui, Kanaha Beach, 5-III-2006, *Starr & Starr 060305-01* (BISH); Molokini Islet, 10-II-1913, *Stokes et al. s.n.* (BISH 70279); Kahului, Kanaha Beach, 1 m, 6-IV-2006, *Wood et al. 11821* (PTBG image); Molokai Is.: near Hakina Gulch, 26-IV-1928, *Degener 7117* (BISH); Mapulehu Valley, near mouth, dry hillside, 75 m, 31-XII-1936, *Fosberg 13532* (BISH); Co. or Is. Unknown: SANDWICH ISLANDS [Hawaiian Islands]: Capt. *C. Wilkes s.n.*, 1838-1842, (US no. 00013147, Barcode 595768, image).

ACKNOWLEDGEMENTS

For previous or current loans, scans of Wilkes Expedition notebooks or specimens, permission to photograph the GH type, or information for *Waltheria pyrolifolia* I thank the curators and staff of the Gray Herbarium (GH), the Muséu National d'Histoire Naturelle (P) at Paris, and the herbarium (US) and library of the Smithsonian Institution. I thank those of the Bernice Bishop Museum (BISH), especially George Staples, and Napua Harbottle for *W. indica* screenings and loan, and David Lorence of the Pacific Tropical Botanic Garden (PTBG) for scans and information. I am also grateful to Piero Delprete, Francisco Rojas, for illustrations, Raúl Pozner for micrograph collaboration; to Charles Jarvis, Fred Barrie, and Kanchi Gandhi for nomenclatural information and advice; to Beryl Simpson, María Múlgura and anonymous reviewers for helpful manuscript comments; and Neil Snow, Bob Hobdy, Ken Wood, Kim and Forest Starr, and Scott Fischer for trying to find more *Waltheria pyrolifolia* in Hawaii, since it was not feasible for me to go there. This study was based upon previous work supported by National Science Foundation dissertation grant

NSF-BSR-880899, and the Plant Resources Centre of the University of Texas at Austin.

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