

DISTRIBUTION OF SALVINIA AND AZOLIA IN SOUTH AMERICA AND AFRICA,  
IN CONNECTION WITH STUDIES FOR CONTROL BY INSECTS

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In 1961, Dr. Fred D. Bennett, Commonwealth Institute of Biological Control, Trinidad, W.I., made observations on the insects attacking Salvinia spp. in British Guiana and North Brazil. In 1963, he made another trip to South America and made observations in Brazil (Belem, Recife, Rio de Janeiro, Sao Paulo, Curitiba, Porto Alegre, Pelotas, Obidos and Manaus) and in Uruguay (Fuerte de San Miguel near Chuy). From October to December, 1964, Dr. Bennett conducted feeding tests with insects attacking Salvinia auriculata at Belem, Brazil.

The ultimate aim of these investigations by Dr. Bennett was to obtain some organism capable of effecting control of Salvinia auriculata in Kariba Lake, in South Rhodesia, Africa. An editorial, entitled "Weed Helps River Fight Zambezi Power Dam", in the Baltimore Evening Sun (p. 3, Nov. 18, 1961), released by the Associated Press, recalls the old African legend that the great Zambezi River could never be conquered. Shortly after the engineers had blocked the Zambezi River with the Kariba Dam to create a huge lake to store hydroelectric power and to provide a sportsman's paradise, the Zambezi River began feeding Salvinia auriculata into the Kariba Lake. Salvinia was first found in the lake early in 1959 and by 1961 it had covered 200 of the lakes 1500 square miles. The article states that this small plant (a surface floating plant, with leaves about one inch in diameter, the leaves connected in chains as long as three feet) clogs boat propellers, kills fish and could eventually turn the lake into a swamp, since it is so thick in places that a man can walk on it and trees and shrubs can grow on it. Salvinia was first discovered in this area of Africa near Victoria Falls in 1949 and was identified at that time as the harmless species, Salvinia hastata.

In South America, Dr. Bennett found that huge areas of lakes and reservoirs and other sources of drinking water are being covered by Salvinia auriculata. Also water-ways are being clogged by Pistia stratiotes L., Eichhornia crassipes Solms and Alternanthera philoxeroides Griseb. There, these species, although not entirely held in check by insect enemies, do have a

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complex of insects which attack them and which in turn are attacked by parasites and predators. In the various reports from 1961 to 1965, Dr. Bennett found that there are four species of insects that feed on Salvinia and appear by their feeding habits or by their biology to be restricted to an aquatic environment. These are Paulinia acuminata (DeGeer) (Acrididae; Pauliniidae by some authors), Cyrtobagous singularis Hust. (Curculionidae), Samea multiplicalis (Guenée) (Pyraustidae) and Lipostemmata purpurata (Distant) (Lygaeidae). Esuris is a synonym of Lipostemmata.

Paulinia acuminata normally attacked Salvinia auriculata and Pistia stratiotes around Belem. In Trinidad adults were found on Lemna and Azolla, as well as Salvinia and Pistia. In Uruguay, Carbonell (1964) reported this species on Azolla filiculoides Lam., as well as Hydromyteria stolonifera F.G.W.Mey. (Hydrocharitaceae), Spirodela intermedia W. Koch and Salvinia auriculata. In the laboratory this insect also attacked Eichhornia crassipes and Nymphaea sp., and to a limited extent a species of Commelina.

Samea multiplicalis was found to attack Pistia stratiotes in the field in Trinidad, British Guiana and Brazil. In the laboratory it also laid eggs on Salvinia and Pistia, and the larvae fed mainly on Eichhornia crassipes. Those feeding on Lemna died in six days.

Cyrtobagous singularis is known from Corumba, Matto Grosso (S.W. Brazil, orig. loc.), British Guiana and Recife (found on Salvinia). This species seems to prefer Salvinia; it does not attack Pistia or other aquatic plants; and the larvae did not feed on and died within seventy-two hours when placed among roots of Pistia and Eichhornia. Lipostemmata purpurata was not used in the tests at Belem.

The tests conducted at Belem in 1964 indicate that Paulinia acuminata and Samea multiplicalis do little or no damage to the crop plants tested at the same time (rice, lucerne, watercress, cotton and sugarcane). Hence, introduction of these species of insects into the Kariba Lake would not endanger any agricultural crops either near the lake or farther down the watercourse. Cyrtobagous singularis appears to be very restricted on its feeding habits and is recorded as having destroyed stands of Salvinia in small ditches near Georgetown, British Guiana.

My interest in this project has been the identification of the various specimens of Salvinia and Azolla found by Dr. Bennett in his investigations. Many new localities for these genera in South America now may be recorded, based upon his collections in Trinidad, Brazil, Uruguay and British Guiana. Since Dr. Bennett's studies were being made in conjunction with control of Salvinia



auriculata in Africa, specimens were also sent to me by the Kariba Lake authorities for identification. Additional records for some of the species concerned, represented in the Reed Herbarium, are also included.

In South America three species of Salvinia are frequently confused, namely, Salvinia auriculata Aubl., Salvinia radula Baker and Salvinia rotundifolia Willd. Frequently, S. auriculata and S. radula are found growing together. However, S. radula and S. rotundifolia rarely form extensive mats, as S. auriculata usually does. Also the leaves of S. radula and S. rotundifolia are half the size of those of S. auriculata. Weatherby (1937) pointed out the differences among these three species, indicating that the taxonomy had become quite entangled and confusing. He discussed the problems and indicated the following characteristics as clarifying the species.

Salvinia rotundifolia Willd. -- Floating leaves comparatively thin, average 1 cm. in diameter and drying dull green; some gradation from small, flat leaves to much larger, folded leaves, without any reduction in papillae or addition in development of supplementary trichomes in the smaller, flatter leaves; the regular rows of elongated conical protuberances with four jointed hairs, which are wholly free and somewhat spreading; the hair-tips tapering and colorless; sporocarps containing the macrospores sessile.

Salvinia auriculata Aubl. -- Floating leaves thick, boat-shaped or conduplicate, prevailingly widest at the broadly cordate base, distinctly broader than long, ordinarily 1.5-3 cm in diameter, becoming yellowish or brownish when dried; the regular rows of elongated conical protuberances with four jointed hairs, which, though otherwise free, are grown together at their tips, the terminal cells being united into a relatively thick dark-colored body, and, unless broken, remains so until entirely withered; papillae well-developed, 1 mm. or more high in the center of the leaf; leaf-tissue usually glabrous between the papillae; sporocarps containing the macrospores stalked.

Salvinia radula Baker -- Floating leaves flat, averaging much smaller than in S. auriculata, broadly elliptic or oblong-elliptic to obovate, widest at or above the middle; papillae low or sometimes nearly obsolete; leaf-tissue often with single trichomes between the rows of papillae. Other than these characteristics, none of which are based on the structure of the fruiting bodies, S. radula appears to be a shade-form of S. auriculata, as suggested by Weatherby. Some specimens appear intermediate between it and S. auriculata. None of the specimens I have studied listed below are fruiting, and most of them were collected in shaded areas, or completely intermingled with



S. auriculata, which could provide a shade situation by itself. The geographic ranges for S. auriculata and S. radula completely overlap in South America, and all the specimens of S. radula I have seen in this study have occurred with or very near S. auriculata. When the complete life cycle of S. auriculata is thoroughly studied, S. radula may prove to be nothing more than a growth phase in its life cycle.

Salvinia auriculata Aubl.

TRINIDAD: #3. Collected in the sea, Balandra Bay, Trinidad, W. I. Sept. 8, 1961. Small quantities of Salvinia have been noted on beaches on the east coast of Trinidad on several occasions recently. I have not discovered the source of this material, but it may be washed out to sea from the Oropouche Swamp in Trinidad, or conceivably from the Orinoco River in Venezuela. F.D.Bennett. (Reed Herb. 39379).

#4. Collected from the "Old Pond", St. Mary's Estate, Bonasse in Southern Trinidad. Aug. 27, 1961. This pond of considerable size many years ago, is now overgrown with grass; small quantities of Salvinia being present. F.D.Bennett. Herb. Trin. No. 16405. (Reed Herb. 39380).

#2. Botany Greenhouse tank. July 15, 1961. W.D.Richardson. Herb. Trin. No. 16271. (Reed Herb. 38782).

BRITISH GUIANA: #10. Botanic Gardens, Georgetown. Oct. 11, 1961. Drainage trench. Sporocarps present. F.D.Bennett. (Reed Herb. 39931). #14. Canals and ditches, same loc. Oct. 13, 1961. F.D.Bennett. (Reed Herb. 39928); #16. Same loc. Oct. 15, 1961. F.D.Bennett. (Reed Herb. 39926; US).

#12 and #15. Canals, Ogle Sugar Estates, about 5 mi. from Georgetown. Oct. 12, 1961. F.D.Bennett. (Reed Herb. 39934 and 39927).

BRAZIL: #19. Belem, Inst. Agron. Small stream. Oct. 20, 1961. F.D.Bennett. (Reed Herb. 40342); #25. Large pond No. 1, surface about 2 acres completely covered. Oct. 25, 1961. F.D.Bennett. (Reed Herb. 40352 and 40353; US); #27. In drainage ditch. Oct. 27, 1961. F.D.Bennett. (Reed Herb. 40350); #26. Large pond, along edge. Oct. 26, 1961. F.D.Bennett. (Reed Herb. 40349). #37. Belem, Inst. Agron. do Norte. May 1963. Sporocarps abundant. F.D.Bennett. (Reed Herb.).

Belem. Museu Goeldi, Para. #21. Artificial pond. Oct. 21, 1961. F.D.Bennett. (Reed Herb. 40343); #18. Artificial fish tank. Oct. 18, 1961. F.D.Bennett. (Reed Herb. 40344); #23.



Artificial pond. Oct. 22, 1961. F.D.Bennett. (Reed Herb. 40351); #24. Artificial pond. Oct. 23, 1961. F.D.Bennett. (Reed Herb. 40348); #43. In tanks, sporocarps present. Feb. 1963. F.D.Bennett. (Reed Herb.); #38. In pond. April 1963. F.D.Bennett. (Reed Herb.).

Rio de Janeiro, Botanic Gardens. #29. Ponds. Nov. 4, 1961. F.D.Bennett. (Reed Herb. 40345); June 12, 1940. J.G. Kuhlmann 6042. (Reed Herb. 39062); #35. In swampy area in pasture field near Universidad Rural "Km 47", Rio de Janeiro. Mar. 1963. F.D.Bennett. (Reed Herb.).

Curitiba, Parana. #33. In small lake. Mar. 26, 1963. F.D.Bennett. (Reed Herb. 45291).

#28. Museu Nacional, Quinta Boa Vista, small concrete ponds, Rio de Janeiro. Nov. 3, 1961. F.D.Bennett. (Reed Herb. 40347).

Sao Paulo. #34. In small lake about 1 mi. from Institute Butantan. Mar. 20, 1963. F.D.Bennett. (Reed Herb.); in garden pool in garden of director, Instituto de Botanico, Parque de Estado. Nov. 1961. F.D.Bennett. (Reed Herb. 35321).

Recife. #36. In pond in Recife, Pernambuco. Sporocarps present. Fungus fructifications on the leaves. Feb. 1963. F.D.Bennett. (Reed Herb. 45292).

Porto Alegre to Pelotes. #32a. In rice growing in ditches. Apr. 9, 1963. F.D.Bennett. (Reed Herb. 54725).

Obidos. #45 and 46. In Lake Marauri. Sporocarps present. Apr. 1963. Azolla filiculoides also present. F.D.Bennett (Reed Herb. 45289).

Manaus, Amazonas. #50 and 52. In small cross channel between Rio Negro and Rio Solimoes. May 1963. F.D.Bennett. (Reed Herb. 45290).

ZAMBIA (Northern Rhodesia): Floating, very abundant in Zambezi at Katambora, Dist. Katambora. Nov. 5-11, 1949. O.West 3050. (Reed Herb. 42764; GHSR-34026); upstream end of Kandakan Island, near Victoria Falls, Dist. Livingstone. July 25, 1958. G.F. Cunningham van Someren. (Reed Herb. 42766; GHSR-87309); floating, forming extensive mats on surface; acres of surface covered. Estuary of the Chibwe River, Lake Kariba, Southern Province. A.Angus 2221. (No date). (Reed Herb. 42743); Kazungula, Zambezi River, Southern Prov. Apr. 11, 1955. A.W.Exell, F.A.Mendonca & H.Wild 1457. (GHSR); Chesia Estuary, Kariba Lake, abundant aquatic weed. Aug. 4, 1960. J.B.Phipps 2810. (GHSR).



RHODESIA (Southern Rhodesia): Kariba Lake, Lat. 17°S - Long. 28°E. Sample sent to Bennett by Kariba Lake Authorities. (#6). Aug. 1961. (Reed Herb. 39375, 39376, 39377, (39378 in US); a very recent introduction, floating in dam, Dist. Salisbury. Dec. 16, 1954. H.Wild 4667. (Reed Herb. 42762; GHSR); on water in flooded mouth of Bumi River, which enters Lake Kariba, Dist. Kariba, elev. 1500 ft. July 1960. B. Goldsmith 92/60. (Reed Herb. 42763; GHSR); Victoria Falls, rapidly colonizing areas under permanent spray-action in actual water. Dist. Wankie. Oct. 22, 1959. H.Wild 4851. (GHSR); floating water plant, Zambezi near Flying Boat Landing Stage, Victoria Falls. Oct. 20, 1954. O.West 3234. (GSR); aquatic floating weed in masses, Zambezi River, Dist. Wankie, Victoria Falls. Mar. 3, 1955. N.C.Chase 5773. (GHSR); Park River, Umtali, Dist. Umtali, alt. 3600 ft. Aug. 22, 1955. N.C.Chase 5730. (GHSR); aquatic herb floating in pool, Umtali, Dist. Umtali, alt. 3600 ft. Aug. 6, 1952. N.C.Chase 4615. (GHSR-note by Alston, "native of America", Nov. 6, 1953); abundant on drying one acre dam at Schanara farm near Odzi and on a small dam at Alma farm near Odzi, also about 11 mi. west of Odzi, Dist. Umtali, alt. 3300 ft. Aug. 20, 1959. J.B.Phipps 3171. (GHSR); on bank at mouth of Sengave, Kariba Dam, a floating plant forming dense mats in protected areas, abundant, alt. 1500 ft. Sept. 1, 1960. D.S.Mitchell 580. (GHSR); floating down the Zambezi, at Chirundu since Kariba flow increased about 10 days ago, Dist. Urungwe. July 16, 1959. G.R.Bates 97192. (GHSR); Harleigh Farm (E.C.Harrington), Silverbow Road, Rusape, planted in irrigation dam, Dist. Makoni. March 1957. H.Booy 74372. (GHSR).

CAPE PROVINCE: Kuysua, Gouna Forest Preserve, introduced, abundant in pool near the preserve. Apr. 1957. D.S.Mitchell 190. (GHSR).

Salvinia radula Baker

TRINIDAD: Floating in Botany Pond, Trinidad. July 15, 1961. W.D.Richardson. Herb. Trin. No. 16272. Alt. 100 ft. (Reed Herb. 38781).

BRITISH GUIANA: #9. Botanic Gardens, Georgetown. Drainage trench, juvenile plants. Oct. 11, 1961. F.D.Bennett. (Reed Herb. 39930); #13. Canals, ditches and ponds. Oct. 13, 1961. F.D.Bennett. (Reed Herb. 39929). #11. Ogle Sugar Estates, about 5 mi. from Georgetown. Oct. 12, 1961. F.D.Bennett. (Reed Herb. 39932). Azolla filiculoides also present. #17. Mon Repos Estate, Dept. of Agric. Oct. 16, 1961. F.D.Bennett. (Reed Herb. 39935). Azolla filiculoides also present. Basin of Rupumuni River, floating on swampy lake, in flooded forest, Karenambo. Oct. 9-13, 1937. A.C.Smith 2229. (Reed Herb. 39061).



BRAZIL: #42. Belem, in pond at Museu Goeldi. Apr. 1963. F.D. Bennett. (Reed Herb. 45293). #44. In Lake Marauri, about 15 miles from Obidos. Apr. 1963. F.D. Bennett. (Reed Herb.). #47 and 48. Same loc. Mixtures of S. radula and S. auriculata. (Reed Herb.).

Salvinia rotundifolia Willd.

BERMUDA: #5. Collected from an unspecified location in Bermuda by I.W. Hughes, Dept. Agr., Hamilton. Aug. 1961. (Reed Herb. 39381; US).

BRAZIL: Rio de Janeiro, Catumbi, in stagnant water. Oct. 15, 1874. J.G. Mosén 2738. (Reed Herb. 39060).

Pelotas, R.G.S. #31. Collected in small pond near Inst. Agron. do Sul. Apr. 8, 1963. F.D. Bennett. (Reed Herb.); #32. Collected in rice growing area between Pelotas and Porto Alegre, R.G.S. Apr. 9, 1963. In ditches. F.D. Bennett. (Reed Herb.).

Belem. Museu Goeldi. #39 and 40. In small tanks. Feb. 1963. Sporocarps present. F.D. Bennett. (Reed Herb.); #41. Same loc., collected by Dr. Paulo Cavalcante. Mar. 23, 1963. Sporocarps abundant. (Reed Herb.); #22. Museu Goeldi, in concrete fish tank. Oct. 21, 1961. F.D. Bennett. (Reed Herb. 40341); #20. Same loc. In artificial pond. Oct. 21, 1961. F.D. Bennett. (Reed Herb. 40346).

Obidos. #49. In Lake Marauri. Growing among Salvinia auriculata. Apr. 1963. Dupl. Aug. 24, 1963. F.D. Bennett. (Reed Herb.).

Manaus, Amazonas. #51. In small cross channel between Rio Negro and Rio Solimoes. Apr. 1963. Dupl. Aug. 24, 1963. F.D. Bennett. (Reed Herb.).

In South America the most frequent species of Azolla associated with Salvinia is Azolla filiculoides Lam. In Africa either Azolla nilotica Decaisne or Azolla pinnata var. africana (Desv.) Baker has been found associated with Salvinia auriculata and Pistia stratiotes.

Azolla filiculoides Lam.

TRINIDAD: Watercress beds, 100 ft. elev. Watercress has been grown here since 1959; probably the Azolla was brought into the area with it. Aripo Valley Road. May 8, 1961. F.D. Bennett.



Herb. Trin. No. 16380. (Reed Herb. 39549; US); collected at West Indian Station, Imperial College of Tropical Agriculture. Sept. 21, 1961. (Reed Herb. 39550).

BRITISH GUIANA: In canals, Ogle Sugar Estate near Georgetown. Oct. 12, 1961. F.D.Bennett #11a. (Reed Herb. 39933); Old Water pond, Mon Repos Estate, Dept. of Agriculture. Oct. 16, 1961. F.D.Bennett #17a. (Reed Herb. 39936).

BRAZIL: In small channel between Rio Negro and Rio Solimoes, Manaus, Amazonas. May 1963. F.D.Bennett #52a. (Reed Herb.); in Lake Maraurú near Obidos, Amazonas. Apr. 1963. F.D.Bennett #48a. (Reed Herb.); in Lake Maraurú, near Obidos, Para. Apr. 1963. F.D.Bennett #49a. (Reed Herb.); pond near Inst. Agr. do Sul, Pelotas, R.G.S. Apr. 8, 1963. F.D.Bennett #31a. (Reed Herb.).

URUGUAY: In stagnant water, on granite, Pocitos, Dept. Montevideo. Apr./Jun. 1924. Guil. Herter 70518. (Reed Herb.); in stagnant water, Layago, Dept. Montevideo. Oct. 1924. Guil. Herter 79125. (Reed Herb.).

CHILE: Valparaiso, Laguna bei Vina del Mor. Jul. 1900. Dr. Otto Buchtien. (Reed Herb. 1082 - as A. magellanica).

ARGENTINA: Cordoba, prope urbem. Sept. 19, 1877. G. Hieronymus (Reed Herb. 33909 - as A. magellanica); in Wasserlachen am Rio Primero bei Cordoba. Sept. 10, 1877. G. Hieronymus. (Reed Herb. 33910 - as A. magellanica; Herb. U. Coimbra).

PERU: In pond near Calca. Apr. 20, 1915. O.F.Cook. & G.B. Gilbert 241. (U. Minn-433740; US).

### Azolla nilotica Decainse

NYASALAND: Chiromo, Shine River. July 1957. W.S.Lacey. (GHSR-87005); Dist. Port Herald, Chiromo, floating on water at edge of Shine River, alt. 250 ft. Mar. 22, 1960. J.B.Phipps 2601. (GHSR); Dist. Lower Shine, Chiromo, junction of Shine and Riro Rivers, at ferry, alt. 150 ft. July 18, 1958. S.C.Seagrief 3163 (GHSR; Reed Herb. 54730).

MOZAMBIQUE: Dist. Gorongosa, on open pool among scrubby palm trees, alt. 300 ft. Sept. 26, 1953. N.C.Chase 5079. (GHSR-44120; Reed Herb. 54732); on mud banks, Uruna River and pools, Gorongosa Game Reserve. July 13, 1957. N.C.Chase 6616. (GHSR); on river bank on mud or floating on water, Zambezi River, alt. 900 ft. Dist. Buroma Prov. Aug. 7-8, 1950. N.C.Chase 2628.



(GHSR; Reed Herb. 54731); on surface of muddy pool, Urema Flats, Gorongosa Game Reserve. July 14, 1957. N.C. Chase 6619 and 6620. (GHSR).

UGANDA: Lake Kioga, Namasagali, shallow water in sheltered bays and gulleys where it forms a covering layer with Pistia stratiotes. Nov. 8, 1951. Mrs. E.M. Norman-S29. (Reed Herb. 33914).

Azolla pinnata var. africana (Desv.) Baker

CONGO: Stanley pool, alt. 900 ft. Sur les flaques d'eau embie les rochers. 1888. Fr. Hens No. 5. (Hb. Univ. Coimbra).

ZAMBIA: Edge of Bulosi Plain, below Mongu, Dist. Mongu. Nov. 9, 1959. R.B. Drummond & A.J. Cookson 6272. (GHSR); upstream end of Kandaker Island, near Victoria Falls, Dist. Livingstone. July 25, 1958. G.F. Cunningham van Someren. (GHSR-87308; Reed Herb. 54728).

MOZAMBIQUE: On Lake Nhauvine, Gorongosa Game Reserve. Sept. 27, 1953. N.C. Chase 5080. (GHSR; Reed Herb. 54729).

SOUTH WEST AFRICA: Inseln des Ouavange. Aug. 3, 1958. H. Merxmüller 1970. (GHSR; Reed Herb. 54726).

BAROTSELAND: Bulosi Plain, Dist. Mongu. Jan. 10, 1960. W. Gilges 971. (GHSR; Reed Herb. 54727). Seems to be same locality as in Zambia.

GOLD COAST: On surface of mud in seasonal pond, alt. 10 m., 16 mi. on Ada Road. P. Cudjoe, Oct. 22, 1951. Collected for C.D. Adams 983. (Reed Herb. 33907).

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### MATERIALS TOWARD A MONOGRAPH OF THE GENUS LIPPIA. III

Harold N. Moldenke

#### LIPPIA CHEVALIERII Moldenke

Leaves subsessile; leaf-blades chartaceous, often rather thin, bright-green above, grayish-green beneath, oblanceolate, 4--6 cm. long, 1.3--2 cm. wide, acute at the apex, cuneate-attenuate at the base, sharply serrate except at and near the base, the teeth small and rather obtuse, antrorse, rather sparsely strigose above, much more densely so beneath; midrib very slender, usually plane above, prominent beneath; secondaries very slender, 4 or 5 per side, ascending, almost indiscernible above, prominent beneath; vein and veinlet reticulation indiscernible above, rather obscure beneath, flat; inflorescence axillary only, 3--6 per node at the uppermost 2 or 3 nodes, usually shorter than the subtending leaves; peduncles slender, 5--15 mm. long, densely white-pubescent with antrorse hairs; heads oblong, cylindric, 4--11 mm. long, 5--6 mm. wide, very densely yellow-tomentose, all save the lowest bractlets completely hidden by the yellow tomentum; lowest bractlets ovate, about 3 mm. long and 2 mm. wide, acuminate at the apex, densely tomentose on the back; corolla about 4 mm. long in all, its limb about 2 mm. wide.

The type of this species was collected by August J. B. Chevalier (no. 67) — in whose honor it was named — at Toukoto, Soudan, Mali, on December 28, 1898, and is deposited in the herbarium of the Jardin Botanique de l'Etat at Brussels. Vernacular names recorded for the plant are "bush tea" and "sichelinyamo". In Gambia beehives are smoked with this fragrant herb before being placed up in trees. It is claimed that the fragrance thus imparted to the hives attracts the bees to settle in the hives. Herbarium material has been misidentified and distributed in herbaria under the name L. adensis Hochst.





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