

Piper aduncum

Spiked pepper

Piperaceae

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January, 2003

OVERVIEW

P. aduncum, native to tropical America, is cultivated in tropical regions of the world and has become invasive in Florida, Fiji, and Papua New Guinea (Gann and Bradley 1999, Rogers and Hartemink 2000). In Papua New Guinea, *P. aduncum* forms large thickets in secondary forests from sea level up to 1,800 m (5,905 ft), and the invasion is described as similar to the invasion of *M. calvescens* in Polynesia (Rogers and Hartemink 2000). Others (Leps et al. in press) describe *P. aduncum* as the most successful alien woody plant in New Guinea, occurring from sea level up to 2,000 m (6,562 ft). Studies have shown that *P. aduncum* has an invasive advantage over other pioneer species because of its dominance in the seed bank, extremely rapid growth rates, and high rates of biomass accumulation (Rogers and Hartemink 2000). In addition, seeds of *P. aduncum* are rapidly dispersed by mammals and fruit eating birds, especially by red-vented bulbuls (*Pycnonotus cafer*) in Fiji (Metcalf 1995, PIER 2002, Leps et al. in press). In Hawai'i, *P. aduncum* is listed as a state noxious weed (HDOA 1992). It was not known to be present, until recently when it was reported from Nahiku, Maui. Preliminary surveys of the area have been conducted revealing that the known infestation covers roughly about 50 acres comprised of a small thick core area surrounded by smaller infestations located both up and down slope. Most plants were observed in disturbed areas along roads, in light gaps, forest margins, and clearings. *P. aduncum* was not found deep into the surrounding forests. This is the only known naturalized location of *P. aduncum* in the state of Hawai'i to date. Though there are now reports of *P. aduncum* being cultivated at botanical gardens on O'ahu. *P. aduncum* is a listed Hawai'i noxious weed and it is a known invader in other tropical regions. If feasible, *P. aduncum* should be eradicated from Maui. In addition, the plant should be looked for during other weed surveys on Maui and other Hawaiian Islands, and the public should be discouraged from planting or spreading it.

TAXONOMY

Family: Piperaceae (pepper family) (Wagner et al. 1999).

Latin name: *Piper aduncum* L. (PIER 2002).

Synonyms: *P. angustifolium* Ruiz & Pav., nom. illeg., *P. celtidifolium* Kunth, *P. elongatum* Vahl (GRIN 2002). Institute for Systematic Botany (Wunderlin and Hansen 2002) lists 27 synonyms, including: *Artanthe aduncum* (L.) Miq., *A. celtidifolia* (Kunth) Miq., *Piper aduncifolium* Trel., *P. aduncum* L. var. *laevifolium* C. D.C., *P. anguillaespicum* Trel., *P. celtidifolium* Kunth, *P. disparispicum* Trel., *P. elongatum* Vahl var. *laevifolium* (C. D.C.) Trel., *P. fatoanum* C. D.C., and *P. flavescens* (C. D.C.) Trel.

Missouri Botanical Garden (2002) lists 79 synonyms, including: *Artanthe adunca* (L.) Miq and *Steffensia adunca* (L.) Kunth.

Common names: Spiked pepper (PIER 2002, Wunderlin and Hansen 2002).

Taxonomic notes: *Piper* is a pantropical genus of more than 2,000 species (Wagner et al. 1999). The genus is comprised of shrubs, climbers, and small trees from many different tropical habitats of the world (Brickell and Zuk 1997). Some of these have pungent aromas and are cultivated as spice crops (Brickell and Zuk 1997).

Nomenclature: The genus name, *Piper*, is derived from the Greek word for pepper, *peperi*, which is derived from an Indian name (Wagner et al. 1999).

Related species in Hawai'i: *Piper methysticum*, 'awa, is a related species from Hawai'i. This is the true 'awa, indigenous probably to eastern Malesia or possibly the New Hebrides, introduced to Hawai'i by the Polynesians, and cultivated for medicinal purposes as well as to make a special drink (Wagner et al. 1999). Another species recently being cultivated in Hawai'i (at least on Maui and probably on other islands) is *Piper auritum*, false 'awa. This species is commonly mistaken as the real 'awa, though it apparently does not have the same properties and is much more aggressive and fairly difficult to control (Robert Hobdy pers comm.). *P. auritum* is reported as invasive in Florida, Tonga, and Samoa (Langeland and Stocker 2002, PIER 2002). On Maui, *P. auritum* is cultivated in several locations along the Hana Hwy. and near Nahiku. Other areas where *P. auritum* has been observed include Waiehu, Kahului, and Pukalani. A complete island wide survey has not been done yet for *P. auritum* on Maui, though from initial surveys, it appears fairly widespread in cultivation. It has become a nuisance in several yards in Nahiku where it forms a thicket through vegetative spread and is difficult to control as every piece needs to be removed. It has yet to be found in natural areas.

DESCRIPTION

"Small tree to 7 m tall, with short silt roots and soft, brittle wood; foliage and twigs aromatic. Branches erect, but with drooping twigs and swollen, purplish nodes. Leaves alternate, distichous, elliptic, 12-22 cm long, shortly petiolate; lamina scabrid above, with sunken nerves, softly hairy beneath. Inflorescence a leaf-opposed, curved spike on a 12-17 cm peduncle, white to pale yellow, turning green with maturity. Flowers crowded in regular transverse ranks. Perianth absent; usually 4 stamens. Fruit a 1-seeded berry, blackish when ripe. Seeds brown to black, 0.7-1.25 mm long, compressed, with a reticulate surface." (Waterhouse and Mitchell 1998).

BIOLOGY & ECOLOGY

Cultivation: *P. aduncum* is native to tropical America from Mexico to Bolivia (Rogers and Hartemink 2000). It is cultivated in tropical regions and was introduced to Indonesia by 1860 (Rogers and Hartemink 2000). It is also known from Malaysia, Fiji, Papua New Guinea, and the Soloman Islands in the Pacific, from Christmas Island in the Indian Ocean, and from the United States (PIER 2002). In the United States, it is known from the warm regions of southern Florida (Wunderlin and Hansen 2002, PLANTS 2002). In Hawai'i, *P. aduncum* has recently been documented from Nahiku, Maui, a warm, wet, lowland residential area.

Invasiveness: *P. aduncum* is a common pantropical weed throughout the world. It has readily escaped from cultivation in many places where it is planted to become a dominant part of the landscape. Smith (1981) reports that, "In Fiji, it is a weed of disturbed rainforest and margins at low elevation, and an aggressive weed from sea level to 400 m (1,312 ft), most often along roadsides and in thickets, but also sometimes in secondary forest or on forested ridges, rarely in intact rain forest." In Papua New Guinea, *P. aduncum* now dominates much of the secondary fallow vegetation up to 1,800 m (5,905 ft) elevation (Rogers and Hartemink 2000). Studies in Papua New Guinea revealed that *P. aduncum* had a superior seed bank compared to other pioneer species, as well as superior growth rates. They concluded that *P. aduncum* has a competitive advantage over other species and poses a serious threat to the indigenous flora (Rogers and Hartemink 2000). Leps et al. (in press) report that *P. aduncum* has become probably the most successful alien woody plant in New Guinea, occurring from sea level to 2,000 m (6,562 ft), where it attains high cover and becomes the dominant species. *P. aduncum* seeds are dispersed by birds, most notably by red-vented bulbuls (*Pycnonotus cafer*) in Fiji (PIER 2002, Metcalfe 1995). In Hawai'i, *P. aduncum* is listed as a state noxious weed (HDOA 1992).

Pollination: *P. aduncum* is possibly wind pollinated (Metcalfe 1995). On Maui, *Apis mellifera* (honey bee) were observed on flower spikes.

Propagation: *Piper* species can be propagated by seeds or cuttings (Brickell and Zuk 1997). *P. aduncum* is propagated by seeds.

Dispersal: *P. aduncum* seeds are dispersed by birds and other animals that are attracted to the succulent fruits (Metcalfe 1995). In Fiji, *Pycnonotus cafer* (red-vented bulbuls) are the primary dispersal agents of *P. aduncum* (Metcalfe 1995). Leps et al. (in press) report that *P. aduncum* germinated in feces of bats in Brazil and of birds, flying foxes, cuscus, and dogs in Papua New Guinea.

Pests and Diseases: *Piper* species are susceptible to fungal root rot, pepper weevil, and pepper flea beetle (Brickell and Zuk 1997).

DISTRIBUTION

Native range: *P. aduncum* is native to the West Indies and tropical America (PIER 2002). These areas are typically tropical rainforests with average annual rainfall approximately 60 to over 80 in (150 to over 200 cm) (Hammond 1986). Average annual temperatures in these areas are typically 68 - 86 F (20 - 30 C) in January and about the same in July (Hammond 1986). Average elevation ranges from sea level up to as high as 3,356 m (328-11,010 ft) in Ecuador (Missouri Botanical Garden 2002). Rogers and Hartemink (2000) note, "*P. aduncum* is indigenous to tropical America where it is found from Mexico to Bolivia. Its habitat in Central America is restricted to evergreen vegetation and near watercourses in seasonally deciduous forests, from sea level to about 1,500 m (4,921 ft)". Specific countries listed within the native range include: from southern Mexico to South America, including Barbados; Belize; Bolivia; probably Brazil and Columbia; Costa Rica; Cuba; Dominica; Ecuador; El Salvador; French Guiana;

Grenada; Guatemala; Guyana; Hispaniola; Honduras; Jamaica; Martinique; Nicaragua; Panama; Peru; Puerto Rico; St. Vincent and Grenadines; Suriname; and Venezuela (GRIN 2002). The Missouri Botanical Garden (2002) specimen database has numerous collections of *P. aduncum* from its native range with the following elevation ranges for each country: Belize: 75-305 m (246-1,000 ft), Costa Rica: 1-1,700 m (3-5,577 ft), El Salvador: 700-900 m (2,297-2,953 ft), Guatemala: 35-1,500 m (115-4,921 ft), Honduras: 10-2,000 m (33-6,562 ft), Mexico: 300-1,700 m (984-5,577 ft), Nicaragua: 0-1,700 m (0-5,577 ft), Panama: 0-2,134 m (0-7,000 ft), Bolivia: 150-680 m (492-2,231 ft), Brazil: 150-700 m (492-2,297 ft), Colombia: 0-1,480 m (0-4,856 ft), Ecuador: 100-3,356 m (328-11,010 ft), Paraguay: 100-150 m (328-492 ft), Peru: 120-1,100 m (394-3,609 ft), Suriname: 30 m (98 ft), Venezuela: 50-990 m (164-3,248 ft), Cuba: 250-350 m (820-1,148 ft), Dominican Republic: 1,450 m (4,757 ft), and Puerto Rico: 160-250 m (525-820 ft).

Global distribution: *P. aduncum* is cultivated in many tropical regions of the world and is now considered a pest in Florida, Fiji, and Papua New Guinea (Rogers and Hartemink 2000, Langeland and Stocker 2002, PIER 2002). In southern Florida, *P. aduncum* forms thickets in woodland margins from sea level to 20 m (66 ft) elevation. *P. aduncum* invades disturbed dry and rockland hammock habitat in the following Florida Preserves: Big Cypress National Preserve, Castellow Hammock Environmental Education Center, and R. Hardy Matheson Preserve (Gann and Bradley 1999). In these hardwood hammocks, *P. aduncum* tends to invade margins and canopy gaps (Langeland and Stocker 2002). PIER (2002) lists the following areas where *P. aduncum* is present: Fiji, Papua New Guinea, Solomon Islands, Indonesia, Malaysia, Christmas Island, and the United States. In Fiji, Smith (1981) describes the invasion of *P. aduncum* as follows: "In Fiji, an aggressive weed from sea level to 400 m (1,312 ft), most often along roadsides and in thickets, but also sometimes in secondary forest or on forested ridges, rarely in intact rain forests." In Fiji, the primary dispersal agent of *P. aduncum* seeds are red-vented bulbuls (*Pycnonotus cafer*) and they are said to advance together on newly disturbed roads (Metcalf 1995). In Papua New Guinea, *P. aduncum* was first documented from the Morobe Province in 1935 (Rogers and Hartemink 2000). It is now found in many parts of the humid lowlands at elevations up to 600 m (1,968 ft) and in the highland provinces up to elevations of 1,800 m (5,905 ft) (Rogers and Hartemink 2000). Others (Leps et al. in press) report that *P. aduncum* occurs from sea level to 2,000 m (6,562 ft) in Papua New Guinea. Average annual rainfall at one of the invaded sites in the Madang area of Papua New Guinea is 3,558 mm (140 in). It is commonly observed along logging tracks and fallow sites forming monotypic stands (Rogers and Hartemink 2000). Though not known to invade a closed primary forest in Papua New Guinea, *P. aduncum* does readily invade naturally disturbed areas such as landslides, tree fall gaps, and flooded streambanks (Leps et al. in press).

State of Hawai'i distribution: *P. aduncum* is a state noxious weed in Hawai'i and was previously not known to be naturalized. It was recently (2002) reported from the island of Maui where it is locally established in the Nahiku area. There is also a specimen of *P. aduncum* housed at Bishop Museum. According to George Staples of the Bishop Museum, "*Piper aduncum* has been cultivated in Hawaiian botanical gardens for some

time; the voucher (circa 1986) is from Waimea Arboretum and it is reported to be at Lyon Arboretum as well." The status of these populations at this time is uncertain and needs further investigation. Other Hawaiian Islands should be on the look out for *P. aduncum*.

Island of Maui distribution: On Maui, *P. aduncum* was recently reported to the Department of Agriculture by a resident of Nahiku, Maui, who has been trying to control it on his property. The property, which seems to be the center of the infestation, is located in Nahiku at 400 ft (122 m) elevation in a disturbed wet residential setting. This area typically receives an average annual rainfall of 120-160 in (305-406 cm) (Juvik and Juvik 1998). Initial surveys revealed that *P. aduncum* covers an area of about 50 gross acres. The infestation is dense near the epicenter, a core area of about 10-15 acres. Beyond this core area are less densely scattered patches extending mostly down towards the ocean and a few located upslope. These smaller outlier patches occur in openings in yards, along roads, and in cleared areas. Many seedlings and young trees were observed, especially near core infestations. *P. aduncum* was not found in dense forested areas, but rather along roads, disturbed sites, and light gaps. The plant can be rather tall with typical stands up to 2-3 m (7-10 ft), forming dense thickets of small trees. Some of the largest plants, possibly the originals, were located within the epicenter of the infestation, just behind the residence. These trees attained heights of about 8 m (26 ft), with trunks that measured 4 in (2 cm) across, and formed a dark canopy overhead. The infestation at the residence is growing alongside a patch of *P. auritum*, which is also becoming a nuisance in the area due to aggressive vegetative growth. Based on information from the neighbor located just downstream from the infestation's epicenter, the *P. aduncum* originally arrived approximately 25 years ago, though the exact date was not known. The infestation began locally and first jumped the road to her place about 10 years ago. About 7 years ago, it began sprouting vigorously when a road was bulldozed through her property. Next door to her there is another property where *P. aduncum* lines both sides of the access road. Plants are mostly directly adjacent to the access road and do not appear to be present in the dense jungle just beyond the disturbed borders of the road. Based on information from native and invaded ranges elsewhere, it seems likely that *P. aduncum* could eventually occupy large areas of wet disturbed forests on Maui from sea level up to 2,000 m (6,562 ft).

CONTROL METHODS

Physical control: Small seedlings and plants to 2 m (7 ft) can be hand pulled. Larger plants that are not easily hand pulled can be pulled out using a weed wrench or other mechanical means. Residents in the Nahiku area report that *P. aduncum* does not spread vegetatively nor does it re-root after it is pulled out of and left on the ground. Plants that are merely cut and left with their roots in the ground will re-sprout. Plants that are too large to remove mechanically may be chemically controlled.

Chemical control: If hand pulling is not possible or not feasible, use chemical control methods, including basal bark application of 20% Garlon 4, or cut stump application with 50% Garlon 3A (Langeland and Stocker 2002). In Nahiku, Maui, one resident with *P. aduncum* on his property reports that he has successfully controlled it with the herbicide, Remedy, but has had trouble keeping up with the numerous seedlings that germinate.

Biological control: No information on biological controls were found.

Cultural control: Do not plant *P. aduncum*. Remove any plants that come up in the yard. Wash clothing and gear after use in infested areas.

Noxious weed acts: *P. aduncum* is listed on the Hawai'i state noxious weed list (HDOA 1992), making it illegal to possess, propagate or sell in the state of Hawai'i.

MANAGEMENT RECOMMENDATIONS

P. aduncum is a proven aggressive invader in several tropical regions throughout the world. It's invasiveness in Papua New Guinea has been compared to that of *Miconia calvenscens* in Polynesia. *P. aduncum* forms thick infestations mostly in disturbed areas along roads and in clearings. It has not yet been found invading deep into the forest. *P. aduncum* was previously not known to be present in Hawai'i, until recently when it was reported from Nahiku, Maui and found in herbarium specimens at Bishop Museum. If feasible, the Maui population should be eradicated and steps should be taken to prevent future re-introductions. Other areas nearby the infestation should be searched, including yards and botanical gardens. The status of *P. aduncum* on O'ahu needs to be assessed. Other islands in the state should be on the look out for *P. aduncum*.

REFERENCES

Brickell, C. and J. D. Zuk. 1997. *The American Horticultural Society A-Z Encyclopedia of Garden Plants*. DK Publishing, Inc., NY.

HDOA (Hawai'i Department of Agriculture). 1992. *List of Plant Species Designated as Noxious Weeds for Eradication or Control Purposes* (June 18, 1992). Hawaii Department of Agriculture. Available: <http://www.botany.hawaii.edu/cpsu/strawgua/other/noxious/noxious.html> (Accessed: July 25, 2001).

Gann, G.D. and K.A. Bradley. 1999. *The Exotic Plants of Southern Florida*. The Institute for Regional Conservation, Miami, FL. Available: http://www.home.earthlink.net/~mark_phagan/sfexotics/sfhome.html (Accessed: October 30, 2002).

GRIN (Germplasm Resources Information Network). 2001. Online Database. United States Department of Agriculture, Agricultural Research Service, National Germplasm Resources Laboratory, Beltsville, MD. Available: <http://www.ars-grin.gov/> (Accessed: October 30, 2002).

Hammond Incorporated. 1986. *Hammond Citation World Atlas*. Hammond Incorporated, Maplewood, NJ.

Hartemink, A.E. 1999. *Piper aduncum* fallows in the lowlands of Papua New Guinea. In press in Cairns, M (ed.) *Indigenous strategies for intensification of shifting cultivation in Southeast Asia*. ICRAF, Bogor.

Juvik S.P and J.O. Juvik. 1998. *Atlas of Hawai'i*. 3rd ed. Department of Geography, University of Hawai'i press, Honolulu, HI.

Langeland, K.A. and R.K. Stocker. 2002. Control of Non-native Plants in Natural Areas of Florida. Institute of Food and Agricultural Sciences, University of Florida, FL. Available: http://www.edis.ifas.ufl.edu/BODY_WG209 (Accessed: October 30, 2002).

Leps, J., V. Novotny, L. Cizek, K. Molem, B. Isua, W. Boen, R. Kutil, J. Auga, M. Kasbal, M. Manumbor, and S. Hiuk. In press. The habitat preferences of *Piper aduncum*, an invasive species in Papua New Guinean rainforests.

Metcalf, P. 1995. The Place of Indigenous Plant in Pacific Landscapes. Department of Science, Technology & Mathematics Education, University of New England. Available: <http://fehps.une.edu.au/F/s/curric/pMetcalf/DOCS/OverseasReflections/PacificLandscape.html> (Accessed: October 30, 2002).

Missouri Botanical Garden. 2002. W3TROPICOS: Specimen database. Available: http://mobot.mobot.org/cgi_bin/search_vast (Accessed: November 1, 2002).

PIER (Pacific Islands Ecosystems at Risk). 2002. Invasive Plant Species: *Piper aduncum*. Available: <http://www.hear.org/pier> (Accessed: October 30, 2002).

PLANTS (National Plants Database). 2001. Online database. United States Department of Agriculture, Natural Resources Conservation Services, National Plant Data Center, Baton Rouge, LA. Available: <http://plants.usda.gov> (Accessed: October 30, 2002).

Rogers, H.M. and A.E. Hartemink. 2000. Soil seed bank and growth rates of an invasive species, *Piper aduncum*, in the lowlands of Papua New Guinea. *Journal of Tropical Ecology* 16: 243-251.

Smith, A.C. 1981. Flora vitiensis nova: A new flora of Fiji. Pacific Tropical Botanical Garden, Lawai, Kauai, HI. Vol. 2, p. 58.

Wagner, W.L., D.R. Herbst, and S.H. Sohmer. 1999. *Manual of the Flowering Plants of Hawai'i*. 2 vols. Bishop Museum Special Publication 83, University of Hawai'i and Bishop Museum Press, Honolulu, HI.

Waterhouse, B.M. and A.A. Mitchell. 1998. Northern Australia quarantine strategy weeds target list. Australian Quarantine & Inspection Service, Miscellaneous Publication No. 6/98. P. 59-60.

Wunderlin, R. and B. Hansen. 2002. Atlas of Florida Vascular Plants. Institute for Systematic Botany, University of South Florida, Tampa, FL. Available: <http://www.plantatlas.usf.edu/> (Accessed: October 30, 2002).