East Indian Hygrophila (*Hygrophila polysperma*)

A Technical Review of Distribution, Ecology, Impacts, and Management

May 2009

Michelle E. Nault
Alison Mikulyuk

Document citation:
Nault, M.E. and A. Mikulyuk. 2009. East Indian Hygrophila (*Hygrophila polysperma*): A Technical Review of Distribution, Ecology, Impacts, and Management. Wisconsin Department of Natural Resources Bureau of Science Services, PUB-SS-1049 2009. Madison, Wisconsin, USA.

WISCONSIN
DEPT. OF NATURAL RESOURCES

Hygrophila polysperma

Front cover photo: A. Murray, University of Florida/Center for Aquatic & Invasive Plants.
Back cover photo: F. Hrusa, CalPhotos
Inside image: L. Line, University of Florida/Center for Aquatic & Invasive Plants.
All images used with permission.

East Indian Hygrophila (*Hygrophila polysperma*): A Technical Review of Distribution, Ecology, Impacts, and Management

Michelle E. Nault and Alison Mikulyuk
Bureau of Science Services

This literature review was commissioned by the nonprofit Centre for Agricultural Bioscience International (CAB International; http://www.cabi.org/index.asp) as part of a larger invasive species compendium. We completed eight literature reviews for the project, and due to the large number of requests for this information, we have decided to make the reviews available as DNR miscellaneous publications. Species reviewed include:

- Carolina fanwort (*Cabomba caroliniana*) – [PUB-SS-1047 2009]
- European frog-bit (*Hydrocharis morsus-ranae*) – [PUB-SS-1048 2009]
- Indian swampweed (*Hygrophila polysperma*) – [PUB-SS-1049 2009]
- African elodea (*Lagarosiphon major*) – [PUB-SS-1050 2009]
- Yellow floating heart (*Nymphoides peltata*) – [PUB-SS-1051 2009]
- Curly leaf pondweed (*Potamogeton crispus*) – [PUB-SS-1052 2009]
- Water spangles (*Salvinia minima*) – [PUB-SS-1053 2009]
- Water chestnut (*Trapa natans*) – [PUB-SS-1054 2009]

In completing the literature reviews, we preferentially consulted peer-reviewed primary literature and supplemented the reviews with secondary sources where necessary. The outline for the reviews is identical for each species and was provided as part of the CAB International commissioning. This effort compliments work conducted during the development of the WDNR's proposed invasive species identification, classification and control rule; a more exhaustive list of species and accompanying reviews can be found on the DNR website at: http://dnr.wi.gov/invasives/

Identity

Taxonomy and Nomenclature

The genus *Hygrophila* (family Acanthaceae) contains approximately 80 species, most of which occur in the tropics (Spencer and Bowes, 1985). The genus name comes from the Greek *hygro* meaning 'moist, wet' and *phil* meaning 'loving', referring to the species' affinity for a wet habitat (Ramey, 2001). *Hygrophila polysperma* was first named *Justicia polysperma* Roxb. in 1820, was revised to *Hemidelphis polysperma* (Roxb.) Nees. in 1832, and further revised to its current accepted scientific name, *Hygrophila polysperma* T. Anderson, in 1867 (Tropicos.org, 2009). The English common name 'Miramar weed' refers to the town of Miramar, Florida, where during the 1970s a naturalized population that established there first brought public and scientific attention to the expanding problem.

Summary of Invasiveness

H. polysperma is an aquatic, mostly submerged, partly emersed plant that can grow to form dense stands and floating mats which cause many negative environmental and economic impacts (Doyle et al., 2003). Some of these impacts include displacing native plant species, reducing biodiversity, decreasing water quality and flow, clogging irrigation pumps, impeding recreational activities, and diminishing aesthetic value (Cuda and Sutton, 2000). *H. polysperma* is extremely difficult and costly to control, and its ability to

form new plants vegetatively facilitates its spread to new locations. The trade and potential escape of *H. polysperma* through the aquarium and water garden industries play a large role in its spread to new locations, as does the transportation of this plant by flowing water, on recreational equipment, or by wildlife moving between water bodies (Kay and Hoyle, 2001; Owens et al., 2001; Robinson, 2003). *H. polysperma* is declared a noxious weed in the United Sates (USDA-NRCS, 2009), and is currently well established in Florida and parts of Texas. *H. polysperma* has also been reported in Mexico (Kasselmann, 1994; Mora-Olivo et al., 2008). There are records of *H. polysperma* in Virginia, though current status of this population is unknown (Sutton, 1995). *H. polysperma* has recently been recorded for the first time in Europe (Hussner et al., 2007), and has the potential to spread to new locations throughout the continent.

Distribution, Introduction, and Spread

Distribution

H. polysperma is native to Tropical Asia, and has been found in the regions of: India, Malaysia, Bangladesh, Bhutan, Nepal, Cambodia, Laos, Myanmar, Thailand, and Vietnam (USDA-GRIN, 2009). In India, *H. polysperma* is found in wet areas to an altitude of 1600 m (Weeds in Florida, 2006). It is also present in southern China, and is very rare in the lowlands of Taiwan (Flora of Taiwan, 1998).

H. polysperma is currently naturalized in Florida and Texas in the southern United States (Cuda and Sutton, 2000), and is also established in northern Mexico (Kasselmann, 1994). *H. polysperma* has been reported as being established as far north as Virginia, though the current status of this population is unknown (Sutton, 1995). *H. polysperma* has recently been reported in Europe for the first time, where plants were found in North Rhine-Westphalia, Germany (Hussner et al., 2007).

History of Introduction and Spread

H. polysperma was imported to the United States as 'oriental ludwigia' through the aquarium trade from India and Malaysia in 1945, and was first collected in 1965 as an escape from cultivation along a roadside north of Tampa, Florida (Les and Wunderlin, 1981), though it wasn't correctly identified until 1977. In 1979, reports of populations came from Able Canal, which drained the Caloosahatchee River in western Florida, as well as from Miramar and City of Margate canals, which are part of the Everglades drainage in eastern Florida (Jacono, 2009). During the 1980s, populations were found at 29 additional sites, including the Loxahatchee River in 1986 and Withlacoochee River in 1989. By 1989, the range of *H. polysperma* extended northward through central Florida to the Santa Fe River, and also disjunctively spread westward to Tallahassee in the Florida Panhandle (Jacono, 2009). In 1999, *H. polysperma* was known from at least 22 rivers/streams, 13 lakes, 2 ditches, and 7 canal systems in Florida, distributed over 20 counties and 17 water drainages in the state. *H. polysperma* is replacing the extremely aggressive non-native *Hydrilla verticillata* in some southeast Florida canals, due to the tolerance of *H. polysperma* towards herbicides and grass carp that are usually used to control hydrilla in these locations (Duke et al., 2000).

In Texas, *H. polysperma* specimens were first collected in the San Marcos River in 1969, and additional locations in the San Marcos drainage, including Sessoms Creek, were recorded in the 1970s (Jacono, 2009). The herbarium specimens were incorrectly identified as *Hygrophila lacustris* (Schlecht. and Cham.) Nees or *Ludwigia repens* Forst., and were not correctly identified as *Hygrophila polysperma* until 25 years later

(Angerstein and Lemke, 1994). In 1994, *H. polysperma* was recorded in spring fed portions of the Comal River system, and in 1998 was recorded at San Felipe Springs in western Texas (Jacono, 2009).

H. polysperma was reported as being introduced in the Richmond, Virginia area during the 1950s, and quickly established itself for 15-20 years, until extremely cold winter temperatures during the 1970s diminished the population. The current status of this population is unknown (Sutton, 1995).

H. polysperma was first recorded in Europe very recently, with the discovery of a population in the Kasterer Muhlenerft in Germany (Hussner et al., 2007). Populations of *H. polysperma* have also been recently reported in Tamaulipas, Mexico (Mora-Olivo et al., 2008).

Risk of Introduction

H. polysperma is continuing to expand its range and become more abundant around the world. *H. polysperma* is a very popular aquarium and water garden plant, and the ability to order this plant over the internet and through mail order facilitates its travel to all parts of the world (Kay and Hoyle, 2001; Ramey, 2001). It has escaped confinement and has been intentionally or accidentally introduced on several occasions outside of its native range. In the locales in which it has been introduced, it has often become the dominant plant species, outcompeting both native and previously established exotic species. *H. polysperma* is a highly competitive plant which is capable of rapid growth and spread. In one case, *H. polysperma* grew from 0.1 acre to over 10 acres in one year (Vandiver, 1980). *H. polysperma* has been shown to be less susceptible to herbicides and grass carp grazing than the extremely invasive *Hydrilla verticillata,* and in parts of Florida *H. polysperma* has replaced *Hydrilla verticillata* as the major aquatic nuisance weed (Van Dijk et al., 1986).

Biology and Ecology

Description

Hygrophila polysperma is an herbaceous rhizomatous perennial aquatic plant with squarish stems that are ascending or creeping. The stems are mostly submerged, and are usually rooted in the substrate, though can also root freely at floating nodes. The submerged stem is very brittle, and can grow up to 10 feet long (Ramey, 2001). The submerged leaves are opposite along the stem, and are sessile with the bases joined at the nodes by ciliated flanges of tissue. The leaves are elliptic to oblong, light green, sparsely hairy, and usually broader towards the tip. Leaves are up to 8cm long and up to 2cm wide (UFL-IFAS, 2005), and the leaves on the submersed stem tend to be considerably larger, wider, and lighter in color than those on emersed stem. The small bluish-white flower is nearly hidden by leaves in the uppermost leaf axils, and is 2-lipped, with the upper lip being 2-lobed and the lower lip 3-lobed. The fruit is a narrow hairy capsule up to 9mm long, containing 20-30 seeds, each seed being approximately 0.4-0.6mm long, 0.3-0.5mm wide, and 0.002-0.06mm thick. The seeds are compressed, obovate to elliptic to round, with the entire margin narrowly winged. The seed coating is minutely pebbled, glistening, orangish-yellow to brownish-yellow, and translucent where the seed is particularly thin (Scher, 2007).

Similarities to Other Species
H. polysperma may be confused with other small, opposite-leaved plants that are sometimes found submersed. *Ludwigia repens* has a 4-petaled yellow flower, blunt leaf tips, often has a purple pigment in the submersed leaves, and lacks flanges at the nodes (Robinson, 2003). *Hygrophila costata* is entirely emersed or terrestrial, larger and taller, with flowers along the entire stem. *Hygrophila lacustris* (Schlecht. & Cham.) Nees is larger and more erect in habitat, with larger flowers in axillary clusters along the upper stems (UFL-IFAS, 2005). *H. polysperma* is also similar to *Alternanthera philoxeroides* (Mart.) Griseb., though large white papery flowers distinguish this species from *H. polysperma*, which has subtle blue flowers (Ramey, 2001). *Diodia* spp. have flat-bristled flanges (UFL-IFAS, 2005).

Habitat
H. polysperma can grow as a submersed plant in water up to 3m (10 ft) deep, as well as an emersed plant along banks. *H. polysperma* prefers flowing waters, but is also found growing in slow-moving systems such as lakes, marshes, canals, rivers, swamps, wetlands, and irrigation ditches (Scher, 2007). Rarely, a terrestrial growth form can grow in moist soil (Ramey, 2001). The leaves of *H. polysperma* are uniquely adapted to draw CO_2 directly from either the water or the atmosphere (Bowes, 1987), allowing the plant to inhabit a wide range of amphibious conditions. It prefers warmer climates and tends to grow much more vigorously in flowing water, producing approximately 5 times more biomass than that observed in static water (Van Dijk et al., 1986). Ambient temperature, nutrients in the sediments, and day length are the major factors that influence the growth of *H. polysperma* (Cuda and Sutton, 2000).

Genetics
H. polysperma has a haploid chromosome number of n=16 (Löve, 1980).

Reproductive Biology
H. polysperma has the ability to prolifically reproduce vegetatively through brittle stem fragments and even detached leaves which are capable of rooting and developing into new plants (Kasselmann, 1994; Sutton, 1995). *H. polysperma* also can reproduce sexually, though production of viable seeds does not appear to have been reported in North America (Doyle et al., 2003), and the extent of the role that seeds play in population expansion is uncertain (Sutton, 1995).

Physiology and Phenology
H. polysperma grows year round in south Florida (Sutton, 1996). Plant growth begins in the spring (March-May), and submersed shoots reach the surface in late spring. The growth rate of *H. polysperma* increases in relation to water temperature and daylight, and maximum biomass occurs in the summer and early fall (June-October). Throughout the summer, fragments with numerous advantageous roots break away from the mats, and during extremely hot weather in late summer (August), the whole shoot will break off near the root crown, creating large floating mats of vegetation. Flowers form in the fall (late October) and continue throughout the winter (October-March), with a high percentage of seeds produced in Florida populations (UFL-IFAS, 2005). There is significantly less biomass present in winter; however, enough is present so that *H. polysperma* is able to occupy its niche year round in systems that it inhabits.

Associations
It is possible that chemical treatments for the control of non-native *Hydrilla verticillata* may leave an open niche for *H. polysperma* invasion (Spencer and Bowes, 1985).

Environmental Requirements
The optimum temperature of *H. polysperma* is 22-28°C (71-82°F), with a minimum temperature of 4°C (39°F), and maximum temperature of 30°C (86°F) (Kasselmann, 1995; Ramey 2001). *H. polysperma* is most commonly found in waters with pH between 5-7 (Spencer and Bowes, 1985; Doyle et al., 2003), while sources dealing with aquaria specimens find that *H. polysperma* can tolerate a pH range of 6.5-7.8 and water hardness conditions of 30-140ppm (FNZAS, 1988). *H. polysperma* prefers a light intensity of 110 micro-einsteins/m^2/h (Cobb and Haller, 1981).

Movement and Dispersal

Natural dispersal
Hydrochory, the dispersal of disseminules by water currents, seems to be the main dispersal mode of vegetative fragments within a watershed.

Vector Transmission
H. polysperma can be transported by wildlife and carried to new locations (Robinson, 2003).

Accidental Introduction
H. polysperma can be spread accidentally to new locations by the movement of boats, trailers, nets, sea planes, and other recreational equipment between water bodies (Robinson, 2003). It is also possible for *H. polysperma* to be a 'hitchhiker' plant with other species ordered through water garden catalogs (Kay and Hoyle, 2001). *H. polysperma* has been introduced through hobbyists emptying unwanted aquarium species directly into surrounding waterways, and can also be accidentally introduced by ornamental ponds flooding into surrounding natural waterways.

Intentional Introduction
The trade of *H. polysperma* as an aquarium plant through the internet and mail order has greatly increased its availability and ease of spread into new environments. In a study examining the top 100 internet websites associated with *H. polysperma,* 30 of them were commercial in nature, which was three times higher than that seen for any of the other eleven highly invasive species examined. Twenty-four of the 100 websites were associated with hobbyists dealing with the sale and swapping of aquatic plants, which was also approximately three times higher than that seen for the other species (Kay and Hoyle, 2001).

Natural Enemies
Surveys of natural enemies of *H. polysperma* are needed due to the lack of information currently available on biological controls (Buckingham, 1994; Pemberton, 1996). It is possible that *H. polysperma* could be controlled by the larva of an agromyzid fly *Melanagromyza* sp., which bores into the stems of *H. auriculata* (Schumach.) Heine (Lucknow), visibly damaging the plant (Sankaran and Rao, 1972; Sankaran, 1990). Virus-like particles have been found on the leaves of *H. polysperma*, but the pathogen has not been isolated or identified (Proeseler et al., 1990).

Impacts

Economic Impact

H. polysperma has limited water flow in irrigation channels and flood-control systems (UFL-IFAS, 2005). *H. polysperma* is also reported as being a threat to rice fields (Krombholz, 1996). In addition, the reduction in recreational and aesthetic value associated with *H. polysperma* can also cause a decline in waterfront property values, as well as possible declines in tourism related revenue for the community (Robinson, 2003).

Herbicides typically used in controlling *H. polysperma* are estimated at costing between $988 to $1482 per hectare ($400 to $600 per acre), and total costs are even higher when labor and equipment are included (Cuda and Sutton, 2000). In an extreme case involving the use of fluridone in flowing water, control was achieved for a period of 20 months at a cost of $34,580 per hectare ($14,000 per acre) (Sutton, 1996).

Social Impact

H. polysperma can form dense mats that impede recreational activities such as boating, fishing, swimming, water skiing, canoeing, and kayaking. In addition, unsightly mats of vegetation decrease aesthetic values. These declines in recreational and aesthetic values decrease tourism, which can be a major source of livelihood within the community. Surface mats may also provide breeding habitat for mosquitoes, which could potentially transmit diseases that could have public health implications (Cuda and Sutton, 2000).

Impact on Habitat

The dense stands and mats of vegetation that are characteristically formed when *H. polysperma* is introduced outside of its native range can decrease the oxygen levels by limiting water circulation and increased decomposition of dead plants. Increased sediment levels are observed with increasing *H. polysperma* abundance (Robinson, 2003). Dense mats of *H. polysperma* also have the ability to change water hydrology and quality, negatively affecting the ecosystem in which it occurs. Due to the relatively low seasonality of *H. polysperma*, it is able to maintain shoot biomass and occupy its niche throughout the entire year (ISSG, 2005).

Impact on Biodiversity

H. polysperma reduces biodiversity by competing with and displacing native vegetation, and is capable of changing the fauna and flora of an ecosystem. *H. polysperma* can form dense monocultures which exclude all native plants and do not provide habitat or food for wildlife. *H. polysperma* is an excellent competitor due to its low light compensation and saturation points, which allow it to start growing in low light conditions before other native plants do. *H. polysperma* is also able to rapidly change resource acquisition in response to changing environmental conditions, allowing it to outcompete many other species (Spencer and Bowes, 1985). Decomposing mats of *H. polysperma* also have the ability to cause fish kills by creating low oxygen levels in the water (Robinson, 2003).

Management

Economic Value
Ornamental plants of *H. polysperma* are sold for aquariums and water ponds (USDA-GRIN, 2009), though the specific economic value of this particular species in the ornamental plant trade is undocumented.

Social Benefit
The seeds of *H. polysperma* are said to be used as a medication in India (Ramey, 2001). Species of the Hygrophila genus have also been utilized in studies of apical dominance and in grafting experiments (Spencer and Bowes, 1985).

Environmental Services
In severely disturbed ecosystems where exotics are the only plants capable of surviving, removal of plants such as *H. polysperma* can further degrade the habitat.

Invasive Species Management

Prevention
As with all invasive aquatic plant management, prevention is better and more cost-effective than control.

Detection and Inspection Methods
Infestations of aquatic invasive species are often first reported at boat launches, and these areas should be monitored frequently in order to eradicate or control new invasions at an early stage. Users should inspect all recreational equipment before leaving any water body, and any visible plants, animals, or sediment should be removed. In addition, rinsing gear with hot water or steam may help in removing any additional non-visible organisms.

Rapid Response
Early detection and eradication are essential in the prevention of future invasions and spread of *H. polysperma*. Smaller, localized populations have better success at being controlled than those which have the opportunity to spread and become well-established.

Public Awareness
Several publications have been produced in areas with *H. polysperma* populations regarding the impacts of invasive species such as *H. polysperma*, and the steps that lake recreationists need to take in order to prevent introducing and spreading aquatic invasives.

Control

Cultural Control and Sanitary Measures
In several regions where aquatic invasives have established, governmental organizations have started requiring that recreationists drain all water and clean off all gear (boats, trailers, fishing equipment, etc.) used on water bodies in order to minimize the chance of spreading aquatic invasive species, such as *H. polysperma*, to other areas.

Physical and Mechanical Control
Control of *H. polysperma* has had limited efficacy due to its ability to propagate vegetatively through fragments. Attempts to mechanically harvest only serve as means of creating and introducing more plant fragments, and potentially aiding in dispersal to new locations (Ramey, 2001).

The sensitivity of *H. polysperma* to water level fluctuation requires investigation as a possible control methodology. A biomass decline was observed after severe spring flooding of the Suwannee River in north Florida, and *H. polysperma* populations did not recover to pre-flood conditions (Spencer and Bowes, 1985).

Movement Control
Several countries have banned the importation or sale of exotic plants, such as *H. polysperma,* in an attempt to minimize the chance of introduction to non-native regions.

Biological Control
Triploid grass carp, *Ctenopharyngodon idella* Val, will feed to a limited extent on submersed *H. polysperma* in the absence of preferred food plants, though very high stocking rates of large fish are necessary (Sutton, 1995). However, introduction of grass carp can negatively impact the coexisting native submerged vegetation, and introduction is even prohibited in some countries.

Chemical Control
H. polysperma is very difficult to control with herbicides currently used in the control of hydrilla (e.g. fluridone), and is resistant to many other herbicides registered for aquatic use (Sutton, 1996). Temporary control of both the submersed and emersed forms of *H. polysperma* has been achieved with endothall, but regrowth occurs 4 to 8 weeks after treatment during peak biomass production, and multiple applications are required to keep populations under maintenance control (Sutton, 1995). Fast et al. (2009), found that of the 10 other herbicides registered for aquatic use, imazapyr and triclopyr both provided the most efficient and consistent control of *H. polysperma*.

References

Angerstein MB, Lemke DE, 1994. First records of the aquatic weed *Hygrophila polysperma* (Acanthaceae) from Texas. SIDA, Contributions to Botany, 16:365-371.

Bowes G, 1987. Aquatic plant photosynthesis: strategies that enhance carbon gain. pp. 49-98 *in* Crawford RMM (ed.). Plant Life in Aquatic and Amphibious Habitats. Special Publication No. 5, British Ecological Society. Blackwell Scientific Publications, Palo Alto, USA.

Buckingham GR, 1994. Biological control of aquatic weeds. pp. 413-480 *in* Rosen G, Bennett FD and Capinera JL (eds.). Pest management in the subtropics: biological control - a Florida perspective. Intercept Ltd., Andover, U.K.

Cobb JE, Haller W, 1981. Annual Report, Florida Cooperative Agreement, Integrated Management of Aquatic Weeds 1980-1981. USDA/SEA/AR – University of Florida.

Cuda JP, Sutton DL, 2000. Is the aquatic weed hygrophila, *Hygrophila polysperma* (Polemoniales: Acanthaceae), a suitable target for classical biological control? pp.337-348 *in* Spencer NR (ed.). Proceedings of the X International Symposium on Biological Control of Weeds. 4-14 July 1999, Bozeman, USA: Montana State University.

Doyle RD, Francis MD, Smart RM, 2003. Interference competition between *Ludwigia repens* and *Hygrophila polysperma*: two morphologically similar aquatic plant species. Aquatic Botany, 77:223-234.

Duke D, O'Quinn P, Sutton DL, 2000. Control of hygrophila and other aquatic weeds in the Old Plantation Water Control District. Aquatics, 22(3):4-8.

Fast BJ, Gray CJ, Ferrell JA, MacDonald GE, 2009. Efficacy of 10 Broadcast Foliar-Applied Herbicide Treatments on Emergent Hygrophila (*Hygrophila polysperma*). Journal of Aquatic Plant Management, 47:155-157.

Flora of Taiwan, 1998. Vol. 4, 2nd ed. National Science Council of the Republic of China. Taipei, Tawain. pp.660-661.

FNZAS, 1988. Federation of New Zealand Aquatic Societies. *Hygrophila polysperma*. http://www.fnzas.org.nz

Hussner A, Josephs M, Schmitz U, 2007. Occurrences of *Hygrophila polysperma* (Roxb.) T. Anderson, *Pontederia cordata* in North Rhine-Westphalia. Floristische Rundbriefe, 40:25-30.

ISSG, 2005. Global Invasive Species Database. Invasive Species Specialist Group, IUCN. Auckland, New Zealand: University of Auckland. http://www.issg.org

Jacono CC, 2009. *Hygrophila polysperma*. USGS Nonindigenous Aquatic Species Database. Gainsville, USA. http://nas.er.usgs.gov/

Kasselmann C, 1994. Decorative aquarium plants: *Hygrophila polysperma* (Roxburgh) T. Anderson. The Aquatic Gardener: Journal of the Aquatic Gardeners Association, 7:107-113.

Kasselmann C, 1995. Aquarienpflazen. Egen Ulmer GMBH & Co., Stuttgart, Germany, 472 pp. (In German)

Kay SH, Hoyle ST, 2001. Mail order, the Internet, and invasive aquatic weeds. Journal of Aquatic Plant Management, 39:88-91.

Krombholz P, 1996. *Hygrophila polysperma*: an indicator plant. The Aquatic Gardener: Journal of the Aquatic Gardeners Association, 9:135-137.

Les DH, Wunderlin RP, 1981. *Hygrophila polysperma* (Acanthaceae) in Florida. Florida Scientist, 44(3):189-192.

Löve A, 1980. Chromosome Number Reports LXVII. Taxon, 29(2/3): 347-367.

Mora-Olivo A, Daniel TF, Martínez M, 2008. *Hygrophila polysperma* (Acanthaceae), una maleza acuática registrada por primera vez para la flora mexicana. Revista Mexicana de Biodiversidad, 79:265-269.

Owens CS, Madsen JD, Smart RM, Stewart RM, 2001. Dispersal of native and nonnative aquatic plant species in the San Marcos River, Texas. Journal of Aquatic Plant Management, 39:75-79.

Pemberton RW, 1996. The potential of biological control for the suppression of invasive weeds of southern environments. Castanea, 61:313-319.

Proeseler G, Stanarius A, Kontzog HG, Barth H, 1990. Virus infections of aquatic plants. Archiv fur Phytopathologie und Pflanzenschutz, 26(1):19-24.

Ramey V, 2001. *Hygrophila polysperma*. University of Florida, Center for Aquatic and Invasive Plants. http://plants.ifas.ufl.edu/

Robinson M, 2003. Potential Invader East Indian Hygrophila: An Exotic Aquatic Plant. Massachusetts, USA: Department of Conservation and Recreation. http://www.mass.gov/dcr/watersupply/lakepond/factsheet/Hygrophila.pdf

Sankaran T, Rao VP, 1972. An annotated list of insects attacking some terrestrial and aquatic weeds in India with records of some parasites of the phytophagous insects. CIBC Technical Bulletin, 15:131-157.

Sankaran T, 1990. Strategies for controlling noxious growth of aquatic vegetation, pp. 219-236. *In* B. Gopal [ed.], Ecology and management of aquatic vegetation in the Indian subcontinent. Kluwar, Dordrecht, Netherlands.

Scher J, 2007. Federal Noxious Weed Disseminules of the U.S. http://keys.lucidcentral.org/keys/v3/FNWE2/index.html

Spencer W, Bowes G, 1985. Limnophilia and hygrophila: a review and physiological assessment of their weed potential in Florida. Journal of Aquatic Plant Management, 23:7-16.

Sutton DL, 1995. Hygrophila is replacing hydrilla in south Florida. Aquatics, 17:4-10.

Sutton DL, 1996. Life cycle and phenology of hygrophila in relation to development of management strategies, pp.51-68. *In* R.K. Stocker [ed.], Control technologies for use against the submersed aquatic weeds hydrilla and hygrophila. USDA-ARS No. 58-6629-4-008. Center for Aquatic Plants, University of Florida, Gainesville, Florida.

Tropicos.org, 2009. *Hygrophila polysperma* (Roxb.) T. Anderson. St. Louis, USA: Missouri Botanical Garden. http://www.tropicos.org/

UFL-IFAS, 2005. *Hygrophila polysperma*. University of Florida, Center for Aquatic and Invasive Plants. http://aquat1.ifas.ufl.edu/hygpol.pdf

USDA-GRIN, 2009. Germplasm Resources Information Network. Beltsville, Maryland, USA: National Germplasm Resources Laboratory. http://www.ars-grin.gov

USDA-NRCS, 2009. The PLANTS Database Version 3.5. Baton Rouge, USA: National Plant Data Center. http://plants.usda.gov

Van Dijk GM, Thayer DD, Haller WT, 1986. Growth of hygrophila in flowing water. Journal of Aquatic Plant Management, 24:85-87.

Vandiver VV, 1980. Hygrophila. Aquatics, 2:4-11.

Weeds in Florida, 2006. Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida. SP37. http://edis.ifas.ufl.edu

Hygrophila polysperma
Plant, rooting at nodes

PUB-SS-1049 2009