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## Old World Climbing Fern (*Lygodium microphyllum*), a Dangerous Invasive Weed in Florida

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**ABSTRACT.**—*Lygodium microphyllum*, a native of the warm and wet regions of the Old World, was first detected to be naturalized in southeastern Florida in 1965. This fern has become an aggressive invader of natural vegetation in many different habitats that are frequently dominated by the weed. Aerial surveys conducted in 1993, 1995, and 1997 detected increasing densities and continued expansion of its distribution in Florida. The fern is expected to continue to increase in Florida and could spread by spores to suitable habitats in Texas and Mexico. No effective method of control for the plant exists.

*Lygodium microphyllum* (Cav.) R. Br. (Schizaeaceae), or Old World climbing fern, is native to wet tropical and subtropical regions of the Old World. It has become a serious weed in southeastern Florida, where it is increasing in density and range. In the present paper we discuss the ecological problems associated with the fern and its naturalization and spread, probable origin, and potential to spread, and the control attempts to date. The companion paper (Pemberton, 1998) discusses the potential of biological control to reduce populations of this plant and to limit its spread. The fern's native distribution and taxonomic relations, both essential information for a biological control program, are also reported.

### THE PROBLEM

*Lygodium microphyllum* is a “kudzu-like” vine that invades many freshwater and other moist habitats in Florida (Fig. 1). The “stems,” which are actually single compound fronds with indeterminate growth, climb high into and over the tops of trees. The fern's ability to grow over trees and shrubs and to run horizontally smothers whole communities of plants (Fig. 2). It is difficult for other plants to grow through the thick fern mats. The dominant fern growth reduces plant diversity. It is common in bald cypress (*Taxodium distichum* (L.) Rich.) stands, but also infests pine flatwoods, wet prairies, saw grass (*Cladium jamaicense* Crantz) marshes, mangrove communities, Everglades tree islands, and disturbed areas. Some Everglades tree islands are so completely blanketed by the fern that it not possible to see the trees and other vegetation beneath it. *Lygodium microphyllum* also threatens rare plants. In Loxahatchee Slough in Palm Beach County, the fern is an “imminent danger” to *Tillandsia utriculata* L. and other rare bromeliads (Craddock Burks, 1996).



FIG. 1. *Lygodium microphyllum* showing its sterile unlobed pinnae with entire margins and fertile pinnae with sporangia bearing teeth.

Infestations of this fern alter the impact of fire, which is a naturally occurring element and a management tool in many Florida communities (Roberts, in press). Thick skirts of old fronds enclose trees and serve as ladders that carry fire into tree canopies. Trees that can withstand ground fires are killed when the fire is brought to the canopy. Fires that usually terminate at the margins of cypress sloughs during the wet season can burn into and through cypress sloughs infested with the fern. Portions of the burning fern can also break free and kite the fire to new areas. The fern appears to be long-lived and persistent. At the Reese Groves property in Palm Beach County, the fern has been present for 20 years. A mat composed of above ground stems and underground root mass has formed that is more than one meter deep.

*Lygodium microphyllum* can occupy a large proportion of suitable habitats



FIG. 2. Infestation of *Lygodium microphyllum* in a cypress grove at Dickinson State Park in southeastern Florida. Note the fern's horizontal mat of growth smothering the understory vegetation in the foreground and its climbing growth on trees in the background.

in a relatively short time. It was first collected from Jonathan Dickinson State Park in Palm Beach County in 1966 (Beckner, 1968), and by 1993 it was present on 1,233 acres (11%) of the park and the Loxahatchee National Wild and Scenic River (Roberts, in press). In 1995, the plant was present on 17,000 acres (12%) of the Loxahatchee National Wildlife Refuge (Palm Beach County), where it was undetected in 1990 (Sue Jewel, pers. comm).

*Lygodium microphyllum* is also known to be weedy in Malaysia (Holttum, 1959). It is classified as a principal weed in that country and a weed of unknown importance in Vietnam (Holm et al., 1979).

#### NATURALIZATION AND SPREAD

The earliest collection of *L. microphyllum* as a naturalized plant in the New World was in Jamaica in 1958 (Proctor 18421, NY). The collection was near Castleton Gardens, where an earlier specimen was taken from a cultivated plant in 1926 (Maxon 10511, NY, misidentified as *L. flexuosum* (L.) Sw.). The fern was also found to be naturalized in Guyana in 1992 (Hoffman and Capellaro 776, NY). It was first collected as a naturalized plant in Florida at two Martin County locations in 1965 and 1966 (Beckner, 1968). In 1973, the fern was collected in Highlands County to the northwest across Lake Okeechobee from Martin and Palm Beach County (Alvarez s.n.; Avery 1427, FLAS). In "The

Ferns of Florida," Lakela and Long (1977) stated that this plant was rare and that a sporulating specimen had been recorded from Martin County. In 1978, *L. microphyllum* was known from 16 localities in Martin County and 23 in Palm Beach County (Nauman and Austin, 1978). At the time, this fern occurred in great abundance for several miles along the Florida Turnpike in Martin and Palm Beach County (Godfrey 76935, FLAS, specimen notes). In 1973, the plant was collected in Highlands County (Alvarez P7718, FLAS) and in Polk County to the north of Highlands County (Willson 353, FLAS) in 1979. In 1981, it was documented to be naturalized in Collier County on the Gulf of Mexico coast in southwestern Florida (Robinson, Wunderlin, Hansen & Tloenke 207, USF).

In 1993, the South Florida Water Management District initiated biennial aerial surveys to determine the distribution, density, and spread of four invasive weeds: *Melaleuca quinquenervia* (Cav.) S.T. Blake, *Schinus terebinthifolius* Raddi, *Casuarina* spp., and *L. microphyllum*. Fifty flight lines were established for the entire area south of the north rim of Lake Okeechobee. The lines were spaced at 2.5 mile intervals, in an east/west pattern across the state. The beginning and end point of each line is a precise point of latitude and longitude to permit repeat surveys.

Surveys were conducted in 1993, 1995, and 1997. Observers were trained in detecting the exotic plant survey targets from the air. Each survey team consisted of two observers and a pilot. The fixed-wing aircraft (a 172 Cessna) was equipped with three Global Positioning Systems (GPS) units and two data recorders. The pilot used one GPS unit to navigate along the calculated flight line. The observers—stationed on opposite sides of the plane—recorded the occurrence and density of the target species at eight second intervals. *Lygodium microphyllum* has a characteristic light green color, which enables it to be easily seen from the air.

Figures 4–6 show the occurrence of *L. microphyllum* in 1993, 1995, and 1997. For comparative purposes, we created a pseudo-survey map for 1978 (Fig. 3) by transposing the Nauman and Austin (1978) locality data for Martin and Palm Beach County onto the flight lines used for the surveys. These four figures provide a time sequence of the spread and increase in density of this fern in southern Florida.

In 1978, *L. microphyllum* was limited to eastern third of Martin and Palm Beach Counties (and Highlands County to the north of the survey area). By 1993, the fern expanded into western Martin County, central Palm Beach County, and was detected in Glades County, northwest of Lake Okeechobee. The total estimated infested area in 1993 was 11,213 hectares (27,686 acres). In 1995, *L. microphyllum* was first detected to the south in Broward County, to the west in Hendry County (in the west central south Florida), and in Sarasota and Collier Counties on the west coast. The infested area was estimated to be 11,831 hectares (29,212 acres) in 1995. In 1997, the fern was detected in Lee and Charlotte Counties, and had covered an estimated 15,892 hectares (39,240 acres). Populations detected at four well separated sites in Charlotte County, where none were detected in 1995, are particularly striking.

The known distribution of the fern in Florida is shown in Fig. 7. The map

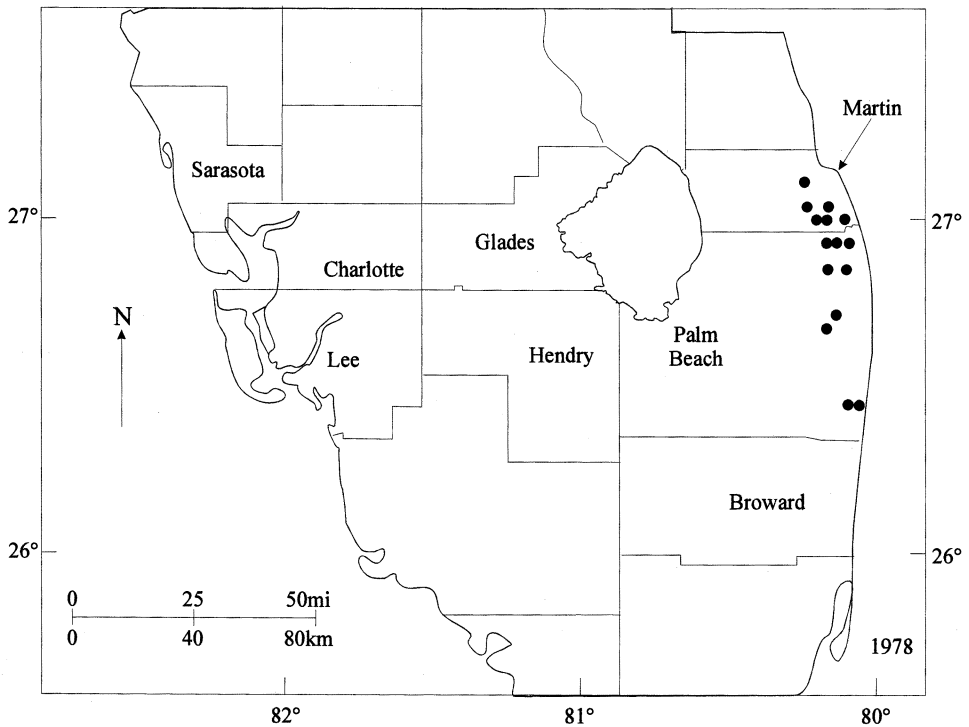


FIG. 3. Distribution of *Lygodium microphyllum* infestations in southern Florida in 1978. Data from Austin and Nauman (1978) transposed onto flight lines flown during aerial surveys during 1993, 1995, and 1997.

indicates sites detected during the aerial surveys and by collections documented by herbarium specimens. The herbarium records not discussed above are: Polk County in 1981 (*Lindsey & Upchurch 457*, USF); Desoto County in 1991 (*Mears s.n.*, USF 202986); Lee County in 1992 (*Clark s.n.*, USF 204553); Manatee County in 1992 (*Cole WC0087*, USF), and Hardee County in 1996 (*Ferriter s.n.*, USF 218483). Recently, in 1997, the fern was detected in Brevard County (M. A. Poole, pers. comm.), about 50 miles (ca. 80 km) north and east of known populations. *Lygodium microphyllum* appears to be rapidly expanding its range and increasing in density.

The apparent pattern of spread from the east coast inland to sites northwest and west, and then west to west coast sites is the pattern expected if the spores were carried by the prevailing winds of spring, summer, and autumn. The prevailing winds in Palm Beach and Martin Counties during the spring and summer are from the southeast and those of the autumn are from east northeast (Henry et al., 1994). Although spore production appears to occur year round, spore production and dispersal patterns are unknown. Preliminary data suggest that there are large numbers of *L. microphyllum* spores in the air. In one Martin County infestation, 724 spores/m<sup>3</sup>/hour were captured with a Burkhardt portable personal pollen and spore sampler (Pemberton, unpublished

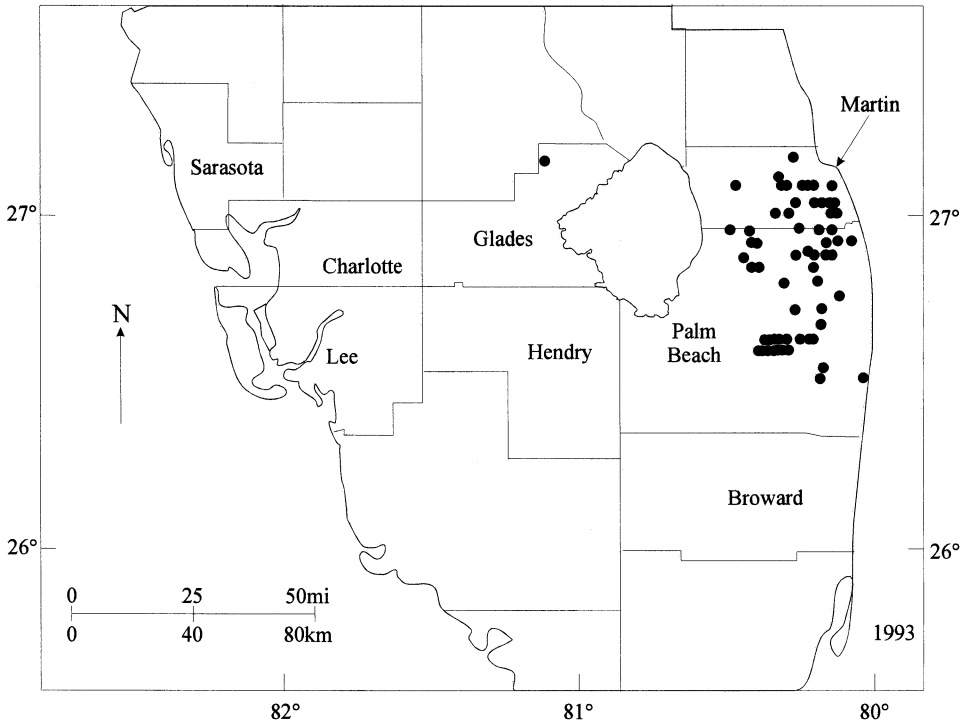


FIG. 4. Detected *Lygodium microphyllum* infestations in aerial surveys over southern Florida (from Lake Okeechobee south) in 1993.

data). Multiple naturalization events of this plant in different areas are also possible.

#### PROBABLE ORIGIN

*Lygodium microphyllum* has been cultivated as an ornamental plant for many years. It appears in the Royal Palm Nurseries (Manatee County, FL) 1888–89 catalogue. It was sold by this nursery for 30 years during 1888–1930 (Reasoner Brothers, 1887–1930). Royal Palm Nurseries, which operated from 1881 until the 1930's, was one of the most important importers and distributors of subtropical and tropical ornamental plants in Florida (and the United States) (Pinardi, 1980). It is possible that the plant they sold was, however, *L. japonicum* (Thunb. ex Murray) Sw. and not *L. microphyllum*, as the two were often confused in early horticultural literature. *Lygodium japonicum* is also a naturalized weed in Florida and the southeastern United States (Nauman, 1993), but to date is not as serious a problem as *L. microphyllum*. A photograph of *L. microphyllum* in the 1905 catalogue appears to be *L. japonicum*. Statements in these early catalogues indicate that the fern they sold is more hardy than other ferns (which “should be kept from hard frost”), which also suggests that the fern sold was *L. japonicum* rather than *L. microphyllum*. The

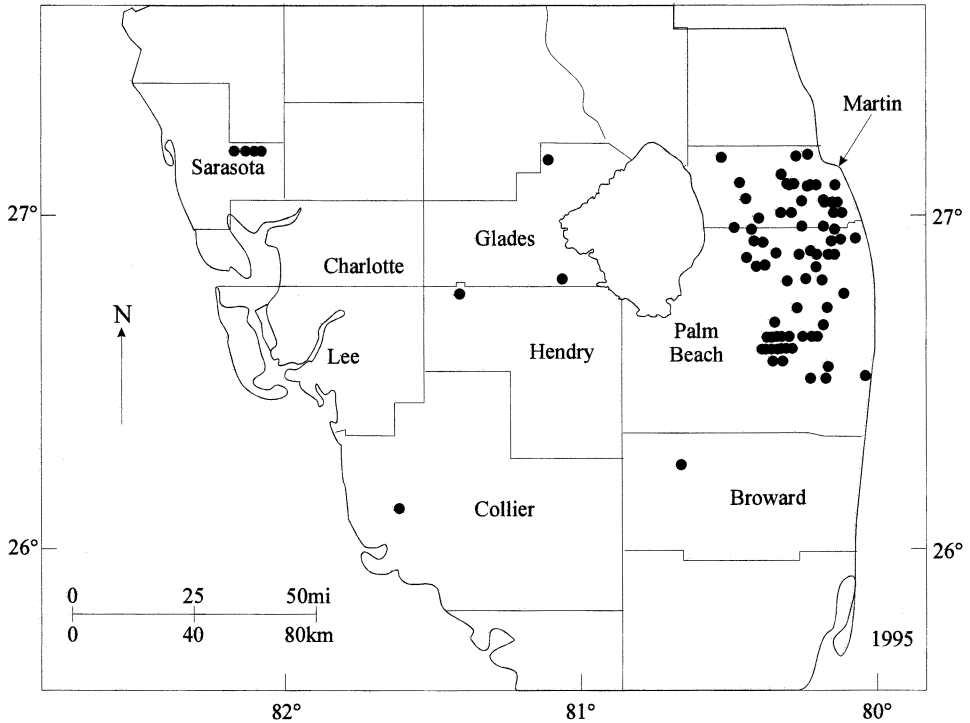


FIG. 5. Detected *Lygodium microphyllum* infestations in aerial surveys over southern Florida (from Lake Okeechobee south) in 1995.

native range of *L. microphyllum* is tropical and subtropical. Beckner (1968) thought that a clue to the fern's naturalization in Martin County was a collection from a nursery in Palm Beach county in 1958. The fern was also sold at a Polk County nursery in 1958 (Florida Division of Plant Industry, Gainesville, FL, Plant Disease Collection records), where it was found to be naturalized in 1979.

#### POTENTIAL TO SPREAD

Most of the natural areas in the southern third of Florida appear vulnerable to the invasion of *L. microphyllum*. The two major zones of the Everglades system, cypress swamps in the west and sawgrass with tree islands in the east, could be easily invaded and dominated by the fern. Pine flatwoods occupying large areas of the south central part of the state and many other areas are also susceptible to this fern. What the northern limit of *L. microphyllum* can be is unknown. The aboveground portion of the plant is killed by frost, but it can recover if the temperatures are not low enough to kill the roots. Roots growing in water, as they frequently do, experience additional protection from frost. The coolest areas *L. microphyllum* now occupies are interior sites in Polk, Hardee, and Highlands Counties (ca. 28°N). This suggests that the fern should



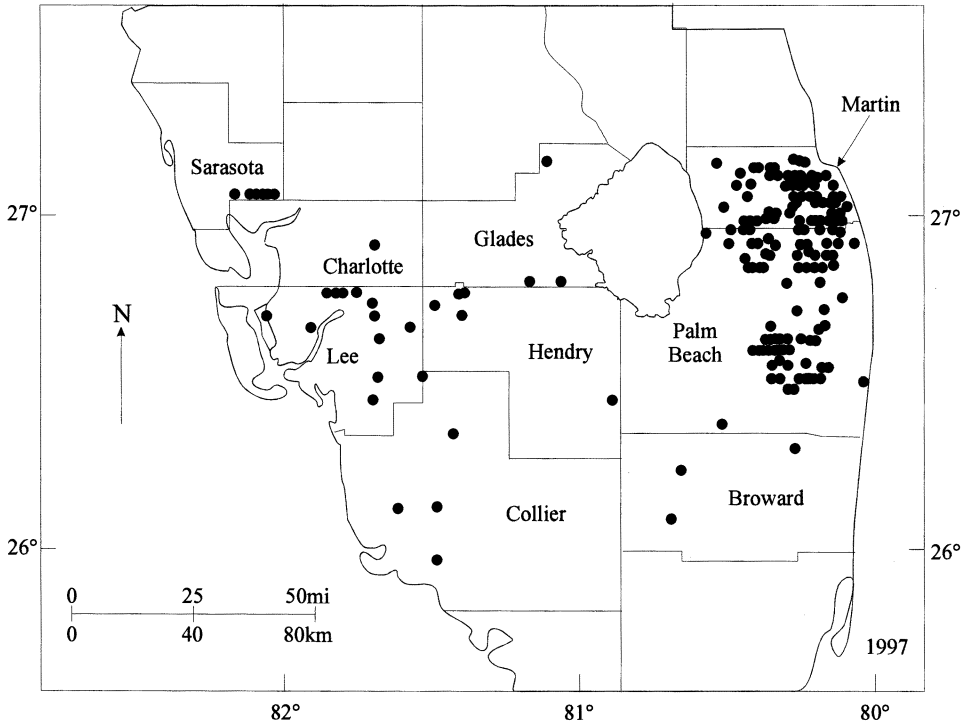


FIG. 6. Detected *Lygodium microphyllum* infestations in aerial surveys over southern Florida (from Lake Okeechobee south) in 1997.

be able to extend northward up both coasts (which are milder than the interior) to at least an equivalent winter low temperature zone that it occupies in Polk and Highland Counties. Polk and Highland Counties are in USDA Plant Hardiness Zone 9b which has average annual minimum temperatures of  $-3.9$  to  $-6.6^{\circ}\text{C}$  (Cathéy, 1990). Zone 9b extends to Nassau County just south of the Georgia border on the east coast and Citrus County on the west coast. If the fern did reach Nassau County, it would be a 300 km and more than a  $2^{\circ}$  latitude extension of its current distribution. This would extend the plant farther into the temperate zone than it occurs in its native range. Florida appears to be warmer for its latitudes because of the Gulf of Mexico and the Gulfstream current flowing along the east coast. Mangroves (*Rhizophora* spp.) are usually limited to about  $25^{\circ}$  north or south latitude (Good, 1953), but reach  $29^{\circ}$  north latitude in Florida (Odum and McIvor, 1990).

It is possible for *L. microphyllum* spores to be carried by prevailing spring and summer winds from Florida across the Gulf of Mexico to Louisiana and Texas. The natural occurrence of this fern on some of the world's most remote islands, such as Mauritius and Tahiti (*Lorence 2227*, K; *MacDaniels 1284*, US), suggests an ability to disperse over very long distances. It may, however, take a long time for the fern to successfully colonize such remote places. The Gulf coast zone of southern Louisiana and Texas is in Cold Hardiness Zone 9b and

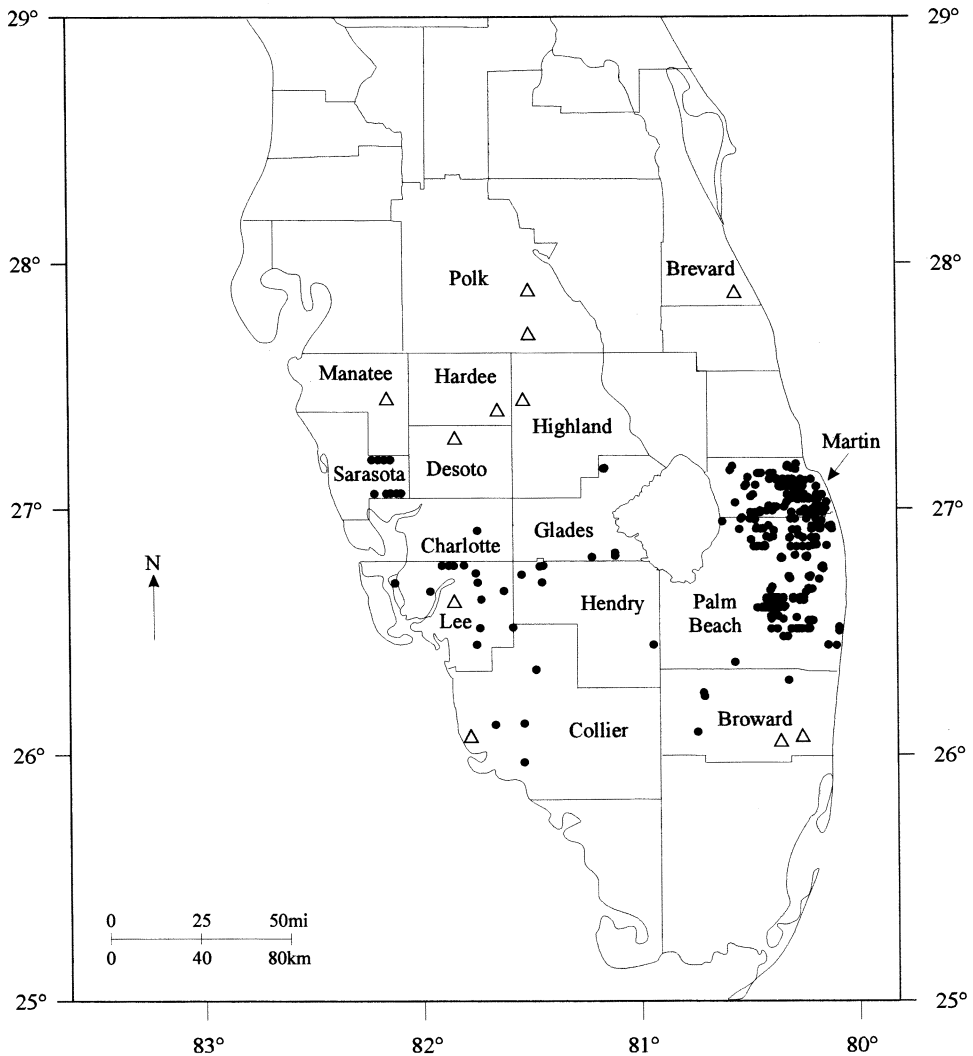


FIG. 7. Known total distribution of *Lygodium microphyllum* in 1997 in Florida. The black dots are aerial survey detection points and the triangles are herbarium specimen localities outside Martin and Palm Beach County.

the southern area of Texas is in zone 9a (Cathey, 1990). Mexico's Gulf coast is even warmer. The presence of abundant freshwater habitats in these areas, coupled with mild climates, suggests that much of the northwestern and western coast of the Gulf of Mexico are suitable for establishment, should *L. microphyllum* reach these areas. The West Indies and the Americas south of Florida seem less likely to be invaded because the prevailing winds are in the opposite direction (Henry et al., 1994). Spores might be carried southwest to Cuba by prevailing northeastern winds in the winter and perhaps by large

spiraling hurricanes. The populations of *L. microphyllum* in Jamiaca and Guyana could undergo local expansion and could be the source of spores that carry the fern to new areas in those regions.

#### CONTROL

Limited research on possible control methods for this fern has been done to date. Work at Dickinson State Park indicates that fire alone is not a good control method, but herbicide treatments, biomass removal, and follow-up herbicide applications show promise in controlling the fern (Roberts, unpublished report). The cost for this approach was about \$9,000/acre, and there was significant damage to the native vegetation. Herbicide research is continuing (Stocker et al., 1997) but it will probably be difficult to control this vine with herbicides without damage to the valued native vegetation with which it grows. Biological control offers the most promise to control this species.

#### OTHER *LYGODIUM* SPECIES IN THE UNITED STATES

Two other *Lygodium* species occur in the United States. *Lygodium palmatum* (Bernh.) Sw. is a native to the eastern part of the country from Mississippi to New Hampshire (Nauman, 1993). It is distinguished from *L. microphyllum* by its deeply and palmately lobed sterile pinnae versus the unlobed usually oblong lanceolate shaped sterile pinnae in *L. microphyllum* (Fig. 1). *Lygodium japonicum* was found to be naturalized in Georgia at the turn of this century (Clute, 1903). This species occurs from eastern Texas through the southern states to North Carolina and Florida (Nauman, 1993). It is distinguished from *L. microphyllum* by its triangular sterile pinnae, which usually have an acute tip, proximate lobes, and serrate margins. *Lygodium japonicum*, native to temperate and tropical Asia (Ohwi, 1965; Singh and Panigrahi, 1984), can be invasive and is spreading, but it does not appear to be nearly as dangerous as *L. microphyllum*.

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